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JOURNAL OF Iron & Steel Engineering

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Editorial Notice

Articles in original are invited for publication in this Journal from Works Managers, Production Engineers, Foundrymen, Metallurgists, Plant Engineers, and Chemical Engineers on all subjects relating to Iron and Steel Industry.

Articles should be of a high quality, exhaustive and accompanied by illustrations, wherever possible. Only glossy photographs will be accepted. All contributions intended for publication in any particular issue should reach the Editor 30 days in advance. This Journal is issued twice in a year i. e. May and November.

All copy should be brief and typed as far as possible. Twenty reprints only are supplied to authors free of cost. Used manuscripts and photographs will not be returned.

The Editor is not responsible for the views expressed in the articles. Contributions for publication should be addressed to the "Editor, Journal of Iron and Steel Engineering, Post Box No. 57, 2258, Manojiappa Street, Tanjore (South India)".

JOURNAL OF IRON & STEEL ENGINEERING

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BURNPUR STEEL WORKS—COMMISSIONING OF NEW MILL

The Burnpur Steel Works of the Indian Iron and Steel Co. completed its doubling up programme with the commissioning of the last major unit under the expansion plan. This mill which was formally put into operation by Mr. Biren Mookerjee, Chairman of the Indian Iron and Steel Co. at Burnpur is the first of its kind installed in India and can roll rods, angles and channels at speeds ranging upto 60 miles an hour. Depending on the size of the rods being rolled—they range from five millimetres to 55 millimetres—the mill can deliver finished products at the rate of 30 to 60 metric tons per hour.

MESSAGES

New Delhi,
6th August, 1960

I send my best wishes for the success of your Journal.

VICE PRESIDENT, INDIA

New Delhi
15th September, 1960

I am glad to learn that you are bringing out a technical Journal devoted to "Iron and Steel Industry" from November, 1960. I wish the Journal all success.

AMBASSADOR FOR POLAND

Raj Bhavan,
Chandigarh,
7th August, 1960

Steel today is worth gold. On the production of Steel depends the progress in the industrial sphere in this country. Already Rourkela, Bhilai and Durgapur are marching ahead. Even these will not be enough to assure a steady progress towards industrialisation. A few years ago, there was opposition to starting new steel plants. Today, I am glad to know that there has been fresh thinking. Heavy industries are really the foundation of industrial progress and they cannot be built up without adequate and cheap supply of steel. Importance of steel is only next to power. I am glad that "IRON AND STEEL ENGINEERING JOURNAL" is making its appearance and I am sure it will be both informative and instructive Journal. All good wishes.

GOVERNOR OF PUNJAB

Governor's Camp,
Uttar Pradesh,
Lucknow,
11th August, 1960

I am glad to hear that you intend to bring out a technical half-yearly Journal devoted to the Iron and Steel Industry. I hope it will give a true and clear picture of the great development which this Industry has been making in recent times and of its importance towards the industrial advancement of our country. I hope it will contain useful articles contributed by experts who are engaged in this industry in India and outside for the improvement of our Steel Plants and for the establishment of new ones with better technique. It should also contain useful information for those who are interested in setting up medium and small-scale industries in urban and rural areas.

I wish your venture every success.

GOVERNOR OF UTTAR PRADESH

Raj Bhavan,
Shillong,
11th August, 1960

I send my best wishes and congratulations to the Editor, JOURNAL OF IRON & STEEL ENGINEERING, who is bringing out a technical Journal, devoted to "Iron and Steel Industry" from November, 1960.

GOVERNOR OF ASSAM

Kerala Governor's Camp,
Calicut,
10th August, 1960

A technical Journal devoted to Iron and Steel is highly essential and necessary and I wish the same every success.

GOVERNOR OF KERALA

ROYAL
SWEDISH EMBASSY

New Delhi,
9th August, 1960

.........Best wishes for the new publication, which will be of great interest also for this Embassy facilitating the task of keeping us informed of recent developments in this main sector of Indian economic life.

Otto Rathsman
CHARGE D' AFFAIRES A. I.

Raj Bhavan,
Bhubaneswar,
15th August, 1960

......Best wishes for the success in your undertaking to publish a half-yearly journal devoted to Iron and Steel Industry commencing from November, 1960.

GOVERNOR OF ORISSA

New Delhi, India,
22nd August, 1960

India's imaginative and immense efforts to develop the nations economy within the framework of democratic processes is one which the other nations of the world have watched with admiration.

These efforts have encompassed many fields of endeavour, but principally they have concentrated on the two most vital—agriculture and industry.

Industrialisation is dependent, of course, on the establishment of the basic industries - beginning with power, steel, and heavy machinery and then proceeding into a host of ancillary undertakings that mean ever-increasing employment and the ever-increasing availability of essential products.

Therefore, the advent of a technical journal such as "Iron and Steel Industry" which will provide essential information to those engaged in this particular aspect of India's industrialisation is certain to prove valuable.

I take this opportunity to wish those responsible for this new publication every possible success. The role of a responsible journal is one which augments the democratic function of a free press. I am sure that this role will be carried out wisely and well by "Iron and Steel Industry."

AMBASSADOR FOR UNITED STATES OF AMERICA

Ballabrooie,
Bangalore-1
12/16th August, 1960

It is gratifying to know that you propose to publish a Journal devoted to the Iron and Steel Industry which is undoubtedly one of the foremost basic industries of the country. The need and importance of such technical Journals dealing with production techniques, marketing trends and other problems of the industry are quite obvious. I, therefore, wish every success to the ensuing publication and would be glad to see the Inaugural Number of the "Iron and Steel Industry."

CHIEF MINISTER OF MYSORE

Bhopal,
6th October, 1960

For a long time in the past a doubt was entertained how far heavy industries would be suitable or would thrive in an agricultural country like India. These misgivings have since been dispelled so much so that the programme for the development of major industries now forms a very important part of the Third Five Year Plan.

The Iron and Steel Industry is the very foundation of this programme for industrial development. In the Second Plan, with the expansion of the plants in the private sector and with the setting up of new plants at Bhilai, Rourkela and Durgapur in the public sector, a great stride has been taken in the development of this industry in the country. But what has been done is not enough. The requirements of this essential material in the Third Plan call upon a very material increase in its output and accordingly further expansion of the industry is being planned.

With this rapid increase in its size the Iron and Steel Industry is bound to face new problems in its technology. Nothing could have been more opportune than the inception of a Journal which will handle these and disseminate latest information and developments in the technology of steel making. I am very glad that you have launched upon this very essential venture. I wish your Journal all success and hope that it will be of real service to this important industry.

B. A. Mandloi

MINISTER FOR REVENUE, LOCAL GOVT.
& COMMERCE AND INDUSTRY
MADHYA PRADESH

EDITORIAL

WE have great pleasure in presenting the inaugural issue of this technical Journal, "IRON AND STEEL ENGINEERING" and in all humility we would like to emphasize that this is the first of its kind to be published in the whole of India and probably the whole of Asia. The importance of Iron and Steel Industry in the building up of the national economy of any under-developed country like India, can hardly be exaggerated, and hence, we hope, the above Journal devoted to a careful and critical study of the various problems relating to this vital industry must fulfil a long-felt need in our country. The Journal will contain useful and valuable information on the progress of the industry in our country and it is our aim and object that the Journal should also disseminate information on various aspects like new techniques of production, production costs and marketing trends and the like, that have been successfully tackled in different countries that have gone far ahead of us in industrialisation, so that we may benefit by their experiences.

Mr. N. V. Gadgil, Governor of Punjab, in a message wishing the Journal success, has most aptly stated, "steel today is worth gold. Heavy industries are really the foundation of industrial progress and they cannot be built up without adequate and cheap supply of steel." But in India, until recently our production of steel was miserably low. Even upto 1955, at the end of the First Five-Year Plan, our annual production had been 1.26 million tons, while the corresponding figure for the U. S. A. was 125, U. S. S. R. 50, U. K. 20 and West Germany 20. It is important that the use of steel must rapidly expand if the country is to achieve its long-term economic goals. But even in the year 1959, steel consumption in India was barely 52% more than the 1929 figure whereas world production of steel had increased by 165% during the 30 year period.

That was why our Government launched the three giant steel projects in public sector, Bhilai in Madhya Pradesh, Rourkela in Orissa and Durgapur in West Bengal and thereby laid surely and strongly the foundation for the rapid industrialisation of the country. Till recently, as stated above our production had been very meagre, the limited sources of supply being, the Tata Iron and Steel, Jamshedpur, Indian Iron and Steel Co., Burnpur and the Mysore Iron and Steel Works Ltd., Bhadravathi. The three mighty projects launched by the Government of India under the Second Five-Year Plan are symbolic of the international goodwill between India and other countries and it is a tribute to the policy of *Positive* neutrality and non-involvement pursued by our Government wedded to the goal of pursuit of peace, that different countries irrespective of their economic ideologies and social systems are most generous in their assistance to India in her task of economic reconstruction.

Under the Second Five-Year Plan, which has got only six months more to run, the target is fixed as 6 million tons and it is feared that we may fall a little short of our target. Again, it is estimated that under the Third Five-Year Plan, the country's requirements would amount to about 10 million tons but it has now become an established fact that with the expanded capacity of the three steel plants in the public sector and even with the completion of the expansion programmes of the steel plants in the private sector, we may not be able to produce more than 8½ million tons annually. It is gratifying to note that the establishment of a fourth steel plant in the public sector at Bokaro (Bihar) has become a *fait accompli* and it is stated that the proposed plant will meet the requirements of the country mainly in terms

of sheets and strips. In this connexion, it is also interesting to note that the experiments conducted with the low-grade iron ore in Salem District in Madras State have proved quite successful and with the assistance of the East German experts, a new plant will soon come into being utilising the lignite in Neiveli for smelting the iron through the low shaft furnace method.

The most urgent and grave problem facing the Iron and Steel Industry in India is to improve the quality and quantity of coking coal and we can ill-afford to be complacent over this aspect Unless prompt and efficient measures are undertaken by Government in this direction, the problems of the Industry will become even more acute when the three steel plants in the public sector are geared to full production by the middle of next year.

With faith in the Almighty and confident of the goodwill and cooperation of all those engaged in the Iron and Steel Industry both in India as well as outside, we have ventured to start this publication. Any suggestion, nay, even criticism, to improve the Journal, we welcome in good spirit. We trust and hope that this technical Journal will find its way to increasing usefulness and popularity as time passes on, by virtue of its own worth coupled with the encouragement of all our well-meaning friends.

A MINE WITHOUT MINERS

The workings are brightly illuminated by electricity. At the face a machine is humming evenly. Now and then there is a sharp rolling blast. This means that the coal seam is crumbling. Broken up into small pieces the coal drops on a conveyor belt and smoothly travels along the underground gallery where it drops into waiting trucks.

It would seem that this is a most ordinary picture. But suddenly we note that there are no men in the gallery, the machine itself props the roof, it moves forward, continually biting into the coal face.

This picture can be observed in one of the mines of the Kuznetsk coal basin, in Siberia, where a coal mining combine, model A-3, is undergoing tests. It has been produced by the Coal Engineering Institute.

The A-3 combine is a machine equipped with a set of mechanisms which perform completely all the operations, or, as the miners say, the entire technological process of coal mining. This "clever" machine undercuts the coal, removes it from the face and props the mine's roof.

The machine is operated from a control panel, manned by only 3 workers, whereas a conventional combine requires a team of eight to ten men.

With the new machine the worker's job is reduced to that of just watching the apparatus, of starting and stopping the whole unit. And this work is done by remote control.

The tests are going ahead successfully. The new coal combine is showing good performance, turning out up to 1,200 tons of coal a day.

*

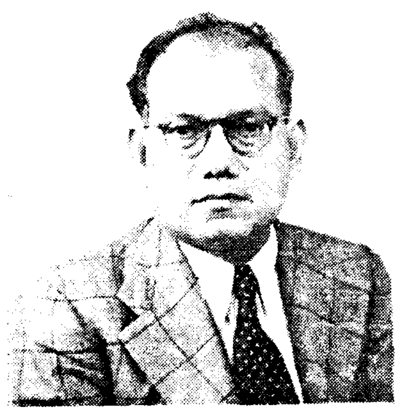
LIGNITE DEPOSITS DISCOVERED IN MOLDAVIA

Two deposits of high quality lignite have been discovered in the South of the Moldavian Republic.

A Tass correspondent was told that the more promising of the two deposits is expected to contain 100,000,000 tons. The average thickness of the coal seam lying at a depth of about 500 metres is three metres. The ash contents of the coal do not exceed 12 per cent.

Expert opinion is that the waterproof rock through which the coal seam runs makes it possible to use underground gasification.

RECENT TRENDS IN STEEL TECHNOLOGY



By

Dr. A. B. Chatterjea, M. Sc., B. Met., D. Phil (Sc.), A. I. M. (Lond.), A. M. I. E., M. I. I. M.,
Assistant Director,
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Jamshedpur-7

During his several visits to the United Kingdom and the Continent, the Author has exhaustively studied the recent developments in Iron and Steel-making techniques. In this paper these methods have been briefly described and their potentialities have been critically examined—Editor.

STEEL is the vital raw-material for the industrialisation of a country. Due to rapid expansion of industries, the world output of steel shows an upward trend. An examination of steel production trend shows that the world production of ingot steel fell by 19,000,000 tons or by 6.5 per cent between 1957 & 1958. This compares with an increase of 10,000,000 tons between 1956 and 1957, of 13,000,000 tons between 1955 & 1956, and 45,000,000 tons between 1954 and 1955. In India, the consumption of 12 million tons of steel is estimated by 1965-66 against the actual demand of 3 million tons in 1960. A statistical data compiled by the European Economic Commission (E. E. C.) indicate that the world production of ingot steel in 1965 would attain a figure of 529 as compared to 369 million tons in 1958 and 136 million tons in 1936. Table I shows the steel ingot production in 1939, 1957 and 1958 and probable outputs in 1959 and 1965. The United Nations Economic Commission for Europe has estimated that world steel production will be doubled in the next 15 years. Even if the production does not reach the speculated figure, it is apparent that there will be substantial increase in production :

Table I :— WORLD CRUDE STEEL PRODUCTION AND ITS TREND
(In thousands of tons)

Country	1939	1957	1958	Estimated 1959	Capacity (A) 1965
AFRICA :					
Algeria	...	15	15	15	20
S. Rhodesia	5	65	65	80	200
S. Africa	390	1,735	1,836	2,000	3,600
TOTAL :-	395	1,815	1,916	2,095	3,820
MIDDLE EAST :					
Egypt	...	80	100	150	300
Iran	...	...	...	...	200
Iraq	...	...	...	...	100
Israel	...	60	60	100	300
TOTAL :-		140	160	250	900
FAR EAST :					
China, Taiwan	...	60	60	60	100
China, Mainland	545	4 987	11,000	18,000	45,000
India	1,067	1,715	1,839	2,000	13,000
Japan	6,696	12,564	12,120	14,860	25,000
North Korea	101	365	450	500	1,000
Pakistan	...	15	15	20	300
Philippines	...	50	50	50	3,000
Others	...	...	...	50(b)	3,000(b)
TOTAL :-	8,409	19,756	25,534	35,540	85,000
OCENIA :					
Australia	1,191	2,904	2,616	3,200	5,000
TOTAL :-	1,191	2,904	2,616	3,200	5,000
LATIN AMERICA :					
Argentina	20	220	250	280	1,000
Brazil	114	1,560	1,600	1,800	3,400
Chile	...	389	385	400	700
Columbia	...	40	40	60	300
Cuba	...	...	...	...	100
Mexico	77	900	996	1,100	2,100
Peru	...	30	40	60	120
Uruguay	...	20	20	20	100
Venezuela	...	20	20	...	1,200
TOTAL :-	211	3,179	3,351	3,720	8,900
NORTH AMERICA :					
United States	47,898	102,253	77,244	133,904(d)	163,000
Canada	1,407	4,570	3,936	5,500	9,000
TOTAL :-	49,305	106,823	81,180	139,404	172,000
U. S. S. R.	17,600	51,000	54,868	58,900	91,000(c)
WESTERN EUROPE :					
ECSC Countries	36,054	59,779	57,945	71,073	86,800
United Kingdom	13,433	22,047	19,884(d)	24,900	31,000
Others :	2,943	8,726	8,701	10,760	16,800
Eastern Europe	6,522	16,255	17,388	19,290	27,750
TOTAL :-	58,952	106,807	103,868	126,023	162,350
World's TOTAL :-	136,063	292,424	273,493	369,132	529,000

A critical examination of the trend of production reveals that a rapid advance in technology has been the outstanding feature of the post war growth of iron and steel industry.

The principal trends in the technological development of the iron and steel industry during the last few years show four main characteristics such as improved preparation of raw materials for the smelting in the blast furnace, greater use of oxygen in various steel making processes, increasing use of semi-continuous rolling and finishing, and growing use of automatic devices to reduce the employment of manual labour with consequent economy in the cost of manufacture.

In the production of pig iron, major developments are installation of larger blast furnaces; incorporation of high top pressure; increase in the temperature of the blast with dehumidification or controlled moisture contents coupled with oxygen enrichment; higher productivity from a furnace and decrease in coke consumption per ton of pig iron primarily due to the prepared burden. In view of shortage of appropriate grade of raw materials, the alternative methods of iron production in the low shaft furnace and by the various direct reduction techniques have received much attention.

As is well-known, the production of steel from iron-ores found in nature depends on two distinct and separate operations. The iron ore is smelted with the addition of limestone as flux in a blast furnace with coke for the supply of heat and for the reduction of the iron-oxides and the resulting pig-iron contains too many impurities to find any extensive engineering application with the exception of making grey iron castings. In the second stage the pig-iron is converted into steel. While the smelting of iron in blast furnace essentially depends on the reduction of iron-oxide by carbon, the conversion of pig-iron into steel depends on the oxidation of impurities like carbon, silicon and phosphorus by oxidation. Although attempts are being made for the production of steel directly from the ore, the chemical nature of the two processes obviously constitutes chief obstacle. As several recent developments have revolutionised the steel-making, the object of this paper is to present a brief account of these techniques. Leaving aside the electric steel making processes which contribute an insignificant amount in the total production, the two major steel making processes are open-hearth processes and Bessemer converter processes besides the recently developed basic oxygen steel making processes. As originally developed, the oxidation of impurities in the open-hearth furnace process of steel-making depends on their interaction with combined oxygen derived from iron-oxide while in all pneumatic steel making processes the oxidizing reactions are due to injection of elemental oxygen either from air or from tonnage oxygen plant. The oxidation of carbon by iron-oxide requires supply of heat but with the injection of elemental oxygen heat is generated. The open-hearth processes will, therefore, consume fuels for the generation of heat. As an increase in the amount of molten iron will require higher amount of ore addition for oxidizing the impurities and thereby increase the amount of slag formed, a proper ratio between molten iron to steel scrap is maintained for economical open-hearth operation. Generally 50% scrap is added in the open-hearth processes and regular supply of this amount of scrap is necessary. As normally 25% scrap results in an integrated iron and steel plant, the balance has to be procured. In highly industrialized countries where most of the steel is absorbed in the production of consumer goods, 40% of the ingot weight of steel is available as scrap. Obviously the steel making processes should be capable of reclaiming this quantity. The Bessemer converter process although affords the cheapest means of eliminating the impurities, suffers from the disadvantage in its inability to absorb little or no scrap. Apart from these factors, the main consideration for the selection of a suitable process of steel making obviously depends on the composition of iron, particularly phosphorus contents of the hot-metal. As the entire amount of phosphorus present in blast furnace burden finds its way to pig-iron and as a maximum of 0·05% of it is acceptable in steel, reduction of phosphorus must occur during steel making processes. With less than 0·08% phosphorus in hot-metal acid Bessemer process is employed, upto 0·4% phosphorus can be treated in the L-D process without modification; in iron having 0·4 - 1·1% phosphorus "Kaldo" or "Rotor" process can be employed while those containing 1·1 to 2·2% phosphorus require refining the basic Bessemer (Thomas) process. It may be possible to employ the L-D process for high phosphorus irons after suitable modifications but details have to be worked out. The OLP and LD-AC processes can treat high phosphoric irons. Apart from the composition, the other relevant factors for the selection of a suitable steel-making process are the availability of low phosphorus iron-ore for employment in open-hearth furnace, scrap and fuel.

It is well known that steel made in Bessemer converter, whether acid or basic, differs from the open hearth variety in certain respects as it has higher yield and tensile strength with lower ductility. It is attributed to the presence of phosphorus and nitrogen, the latter adversely affects the ductility due to the strain-ageing characteristics. In basic converter the elimination of

phosphorus simultaneously results in higher nitrogen contents of the steel. It explains the difficulty of obtaining low nitrogen low phosphorus steel by blowing air in the converter. Due to the ageing characteristics of converter steels, they cannot be used for deep-drawing such as auto-car bodies. In Europe, the use of oxygen for steel making has been mainly applied to improve the quality of steel obtained by the basic Bessemer process. This is due to the fact that while only 5% of the steel production in England and U. S. A. is derived from basic converter, it accounts for 83 pct. in Belgium, 61 pct. in France and 44 pct. in W. Germany, or in other words converter steel amounts to 35% of the production in Europe. The steady increase in metallurgical uses of oxygen in steel making in Western Europe is aimed to improve the quality, to increase the amount of scrap addition and to increase production

OXYGEN IN BASIC OPEN-HEARTH FURNACE

For the combustion of fuel in the open hearth furnace, oxygen is supplied from air. The enormous amount of nitrogen in flue gas will carry away a substantial amount of sensible heat. An enrichment of the air with oxygen will not only reduce the waste gas volume and lower the heat carried away but will also enable to burn more fuel in a given time. It will accelerate the melting rate of the scrap and thereby increase the output. Oxygen enrichment is particularly beneficial when small flues and limited checker capacity of the regenerator of the furnace prevents higher firing rate by burning more fuel. In practice, the air is enriched to contain 25 - 30% oxygen till the scrap is melted. The flame temperature increases by 100-150°C. As the roof of the furnace attains higher temperature, chrome-magnesite bricks are used instead of silica refractory. Enrichment of combustion air by oxygen is widely adapted in the United States, Canada, Russia and the United Kingdom.[1-3]

It is known that rate of decarburization in open-hearth furnace falls with the lowering of carbon in the bath. Making low carbon steels containing about 0·06 - 0·07% carbon, therefore, requires a long refining time which adversely affects production and refractories as these are subjected to high temperature for a long period. Longer refining time requires high fuel consumption. Decarburization with elemental oxygen generates heat, greatly reduces the refining time and thereby increases the output. The use of oxygen lances through the backwalls and frontwalls have been tried from time to time, but splashing and formation of heavy fumes prevented regular and systematic practise. The author had the opportunity to study the decarburization of molten iron in the basic open hearth furnaces of the Abbey melting shop of The Steel Company of Wales. The water cooled oxygen gun[4] is inserted vertically through the roof of 200 tons furnace opposite to the hole through which finished steel is tapped, as shown in Fig. 1. The oxygen gun has a 4½ inch diameter, 12 in. long replaceable copper head welded to seamless steel tube The copper head is kept at an angle 4-6 inches above the layer of slag and oxygen is jetted through 1 inch orifice at the rate of 835 cu. ft./min. at a pressure of 200 - 210 lb/sq. inch when the bath contains 0·35 to 0·40%C and is continued till the bath contains 0·07% carbon.

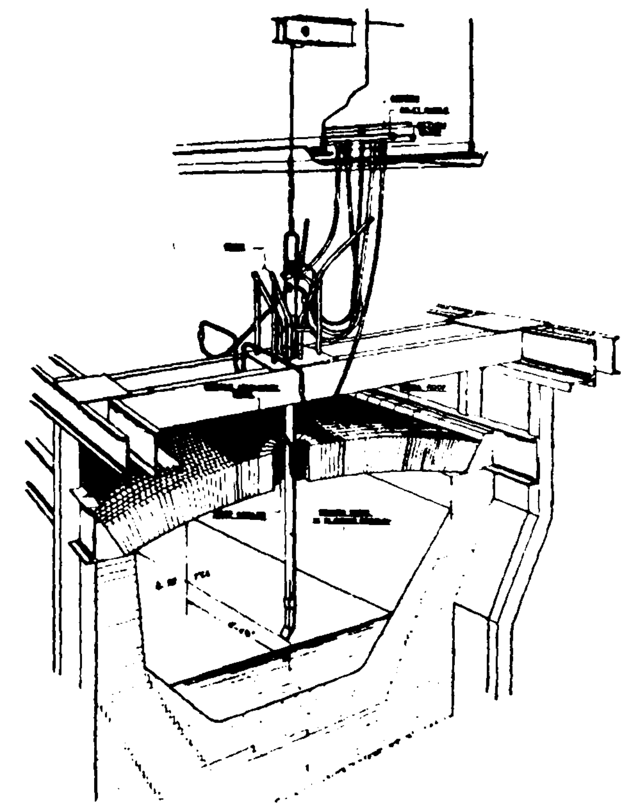

Fig. 1. Arrangement of Oxygen Jet at Abbey Works

Introduction of water-cooled copper lances through the roof for injection of oxygen for the direct oxidation of molten bath of iron in open hearth furnaces is widely used in the U.S.S.R.[5]

In the Margam melting shop of the Steel Company of Wales, oxygen-gun of somewhat similar construction is inserted in the furnace through a hole in the back wall. When the carbon content is 0·50% or less oxygen blowing is started at a pressure 150 lb/sq. inch and a rate of 30,000 cu. ft./hr. Injection of oxygen at higher carbon content of the bath creates a large flame, a foaming slag and excessive fume.[6]

The oxygen lance can also be introduced through the furnace door. At Redbourn Works of Richard, Thomas, and Baldwin Ltd., oxygen lancing is employed for decarburization from 0·22%C to 0·024%C in about 70 min. Using 12,000 cu. ft. of oxygen per 100 tons of steel.

At the Gary Steel Works of the United States Steel Corporation stationary furnaces with basic roofs are equipped with suitable burners for air enrichment with oxygen and two water cooled oxygen roof lances. These modifications have increased the productivity[7].

In the " Ajax " process the water cooled retractable oxygen lances enter the open-hearth furnace through the top of the ports at an angle of 30 degrees to the bath, for the oxidation of the impurities. Oxygen is also introduced into the burners for the combustion of coke-oven gas. Working primarily with hot-metal analysing 3% C, 1% P and 0·2 - 0·3% Si, the lancing is commenced after charging. Due to the foaming of the slag, the capacity of the furnace is reduced by one third and modifications to exclude infiltration of air and gas cleaning were incorporated. This modified process has increased the output of steel.[8]

In order to increase the production oxygen lancing is being adapted in five more 375 ton open-hearth furnaces at the Sparrows Point No. 4 shop of Bethlehem Steel Co.

The generation of heat by the use of oxygen incidentally helps to attain relatively high tapping temperature of 1590 - 1595°C. The reduction of refining time reduces the attack on refractories. Saving of fuel results from the shorter refining period and due to the generation of heat during decarburization by oxygen, when fuel firing is stopped. Fuel oil has generally replaced producer gas for heating of open hearth furnaces with consequent improvement in production and lower operational cost. Despite these improvements, which are likely to rejuvinate the open-hearth process, the poor heat transfer, carrying away of a large amount of heat with combustion gases and particularly slow speed of refining with consequent lower output constitute chief disadvantages of this process and its versatality is now questioned by the basic oxygen steel making processes.

As already mentioned the aforesaid processes of steel making are subdivided into two classes depending on whether phosphorus is removed during refining or not. It is not possible to remove phosphorus with an acid lining irrespective of the refining processes selected viz. open-hearth, pneumatic or electric. An acid lined vessel for refining is only applicable when the iron is low in phosphorus but if substantial amount of phosphorus is present in iron, a basic lined furnace is employed. While iron with wide compositional limits can be treated in basic open hearth process, the basic Bessemer or Thomas process can only be applied when the iron contains 1·7 - 2·1% phosphorus and 0·3 - 0·6% silicon.

In order to reduce irregularities of the iron analyses, pre-refining by blowing the metal with oxygen in the ladle has been practised. Although it reduces the metallurgical load during steel-making and increases the temperature of the hot-metal, the exothermal heat cannot be employed for melting scrap. At Durgapur plant of the Hindusthan Steel Ltd., desiliconization in the ladle followed by refining in open hearth is employed.

The difficulty of blowing high-silicon metal in the converter has been overcome by injection of low pressure oxygen in the ladle which not only reduces silicon, but favourably increases the temperature of the metal for converter operation. The reduction of final blowing time obviously helps to lower nitrogen content of the steel.

It is known that the refining of pig iron in open-hearth furnace takes about 10 hours while in Bessemer converter it is achieved in 15-20 minutes. But the difficulties associated with production of low nitrogen low phosphorus deep-drawing quality steel by basic Bessemer process have already been explained. Without going too much into the theoretical aspects of high nitrogen contents of basic Bassemer steels, it can be mentioned that the molten bath of iron absorbs nitrogen from the air blown during the dephosphorizing reaction. Obviously, therefore, attempts have been made to exclude nitrogen by steam or carbon-dioxide. The mixture of carbon-dioxide and oxygen, or steam and oxygen is made in desired proportion to generate the required heat in the vessel so as to absorb the desired amount of scrap. As the generation of large amount of pure carbon dioxide is difficult and costly, the oxygen-steam process is preferred. This process is practised at the Esperance-Longdoz Steels Works in Belgium[9], where high cost of fuel stands against the basic open hearth process and at Klockner Huttan Werke Hagen-Haspe[10], West Germany. Almost all Thomas plants in West Germany, France and Luxemburg have been converted into oxygen/steam process. It was originally wrongly considered that blowing with oxygen/steam mixture will produce a poor quality steel due to the absorption of hydrogen resulting from the dissociation of steam. The technical difficulty in the bottom blowing with oxygen/steam is the hydration of the dolomite lining of the vessel by the steam, which can be

avoided by super-heating oxygen/steam mixture to 380°C. The blowing time for a 26 ton converter is 7 - 8 minutes and tapping time about 25 minutes. 50 : 50 oxygen/steam mixture is used after decarburization about 5000 cu. ft. of waste gas are produced per ton of pig iron. The consumption of refractories is lightly higher than the normal converter practise. By this process (OV Process) the nitrogen content is usually below 0·002% and the steel is quite comparable to basic open-hearth steel of similar grade. As steam effectively reduces the fume, blowing with oxygen/steam mixture does not evolve brown fumes and does not require gas cleaning plant. The gas mainly contains carbon-monoxide and hydrogen, is practically free from sulphur. It has a calorific value of 280 Btu/cu. ft. and can be used in chemical industry. The process has been in use in the steel plant of M/s. Richard Thompson and Baldwins Ltd., England. This process will be adapted at the Steel Company of Wales in the United Kingdom.

In the other process, the nitrogen is replaced by carbon-dioxide. In oxygen/carbon-dioxide blowing, the usual mixture is also around 50/50. The blowing time for the same amount of iron to be refined, is almost the same and the nitrogen content of steel is 0·0026%. At La Sambra in Belgium both oxygen/steam and oxygen/carbon-dioxide blowing are employed.[11] The exhaust gas from the cowper-stoves of blast furnace containing 22% carbon-dioxide, 3% oxygen and 75% nitrogen is suitably treated to obtain carbon-dioxide of 99·6% purity. The consumption of carbon-dioxide is 27-34 normal cubic metre per ton of pig iron blown. Due to the dissociation of carbon-dioxide to carbon-monoxide and oxygen, the effective oxygen concentration in the second phase of blowing becomes quite high. As there can be no possibility of absorption of hydrogen by steel due to the absence of hydrogen in the blast, the process is particularly suitable for producing low nitrogen steel. Scrap consumption amounts to 53 Kg/ton of iron for the oxygen/carbon-dioxide and 16 Kg/ton of iron for the oxygen/steam process. The costs for these two processes are about the same but due to absence of steam, red fumes are generated in the oxygen/carbon-dioxide technique.

It has been recognised that absorption of nitrogen in the basic Bessemer process depends on the partial pressure of nitrogen, minimum contact of this gas with metal and the finishing temperature attained during the refining. The replacement of nitrogen by either steam or carbon-dioxide completely eliminates nitrogen partial pressure or its contact with metal and therefore produces a low nitrogen steel. Investigations at IRSID have shown that nitrogen can be maintained at 0·008% by controlling the temperature and introduction of iron-ore through the wind-box.[12] In the HPN process at Duisburg Hamborn, iron ore and in the LNP process at Corby, England mill scale are used to lower the final temperature thereby resulting in low nitrogen in steel. In the Mannesmann Rohrenwerke West Germany the MA. side blown converter is employed to reduce the duration of contact of nitrogen with molten iron to reduce nitrogen absorption. It must be emphasized here that these methods have not been widely adapted, and have met with limited success.

OXYGEN STEEL-MAKING PROCESSES

The modern process of blowing molten iron with almost pure oxygen from the top has revolutionized the conventional steel making practice. In Austria, the important considerations like non-availability of enough scrap for open hearth operation, and the composition of the iron which is not suitable for blowing by either acid or basic Bessemer process, contributed towards the development of L-D (Linz-Donawitz) Process.[13-16] A great advantage of the process lies in its simplicity. The converter has no separate bottom, no wind box and no blast pipe which reduces the possibilities of break-downs.

As the oxidation of metalloids by oxygen generate a large amount of heat, the process at least theoretically, is capable of refining any grade of iron. Certain modifications however, are necessary for blowing high phosphorus iron. Amongst the three new oxygen steel-making processes developed recently, viz., the L-D, the Kaldo and the Rotor, the L-D is the oldest and has been widely adapted. In the absence of high phosphorus iron ore which yields high phosphorus iron suitable for blowing by the basic Bessemer process 18 L-D converters will be installed in Japan by 1962 producing 4,720,000 metric tons of ingot steel thereby accounting for one fourth of Japan's total ingot steel capacity In the United States, the iron ores furnish iron with 0·3% phosphorus thus making it suitable for the L-D process. Several L-D converters are in operation in the United States of America and in the Continent. Messrs. Richard, Thomas and Baldwins Ltd., of the United Kingdom have adapted the L-D converters at Ebbw Vale, the process is the first of its kind in the United Kingdom.

Briefly speaking the L-D Process consisting of blowing oxygen downwards on to the bath of molten metal is a revolutionary development. The L-D vessel (Fig. 2) is shaped like a Bessemer converter can either be concentric (Donawitz) or eccentric (Linz). Due to oxygen impingement Fe 0 is formed at the "reaction zone" and temperatures between 2000 - 2500°C are attained when C, Si and Mn are rapidly oxidized. A slag containing high lime is formed at a very early stage of the blow and phosphorus can be eliminated before carbon. Due to the difference in the specific gravity of liquid steel (7.1 gm/cm^3) to that of liquid pig iron (6.5 gm/cm^3), a flow of steel downwards and iron upwards occurs. The evolution of carbon monoxide which cannot come up due to the pressure of oxygen, causes agitation and promotes transfer of un-reacted iron to the reaction zone. It is, therefore, obvious that a relation should exist between the diameter and depth of the vessel and the height of the jet above the bath to permit metallurgical reactions and transfer of metal inside the vessel. The refining takes 20 mts. in a 30 ton vessel, the tap to tap time being about 30-35 mts.

A water cooled copper tipped retractable nozzle is used for the oxygen supply at a pressure of 100 - 150 psi. The height of the nozzle above the bath is kept at 6-7" but it depends on the converter design. The consumption of oxgen is about 2000 cu. ft. ton of steel, the efficiency amounting to 95%.

It has been reported that pig iron of variable composition can be used and about 20% scrap, which depends mainly on the silicon contents of hot metal can be charged. The L-D steel contains very little phosphorus, sulphur, nitrogen, and oxygen and its quality is similar to the open-hearth steel. As the residual manganese is higher than in the open hearth process the addition of ferro-manganese is much less, thus saving the cost. The data [17-18] of L-D plants have been furnished and it has been mentioned that the steel is always of excellent quality. Lining methods and materials were same as those of Thomas converter. Refractory wear generally occurs at the bath surface line and depends on the size of the nozzle. The lining is 20-24 in. thick at the sides and 26 in. thick at the bottom. The refractory consumption of 20 lbs ton of steel though higher than Bessemer practice, is lower than open-hearth operation. As there is no bottom to be replaced, production time is not lost for replacement. This accounts for higher production than basic Bessemer Process for identical vessels. It is now known that Rourkela Steel Plant of the Hindusthan Steel Ltd., will produce 0·75 million tons of ingot steel by the L-D Process. It may not be out of place to briefly examine the possibilities of L-D Process in India. Indian pig-iron for steel-making generally contains 3·5 - 4·5% C, 1·0-1·4% Si, 0·5% Mn, 0·5-0·08% S and 0·3 - 0·35% P. It will therefore be seen that such iron contains higher silicon, sulphur and phosphorus and lower manganese. Sulphur can be reduced by the desulphurization of blast furnace metal by the ladle additions of soda-ash

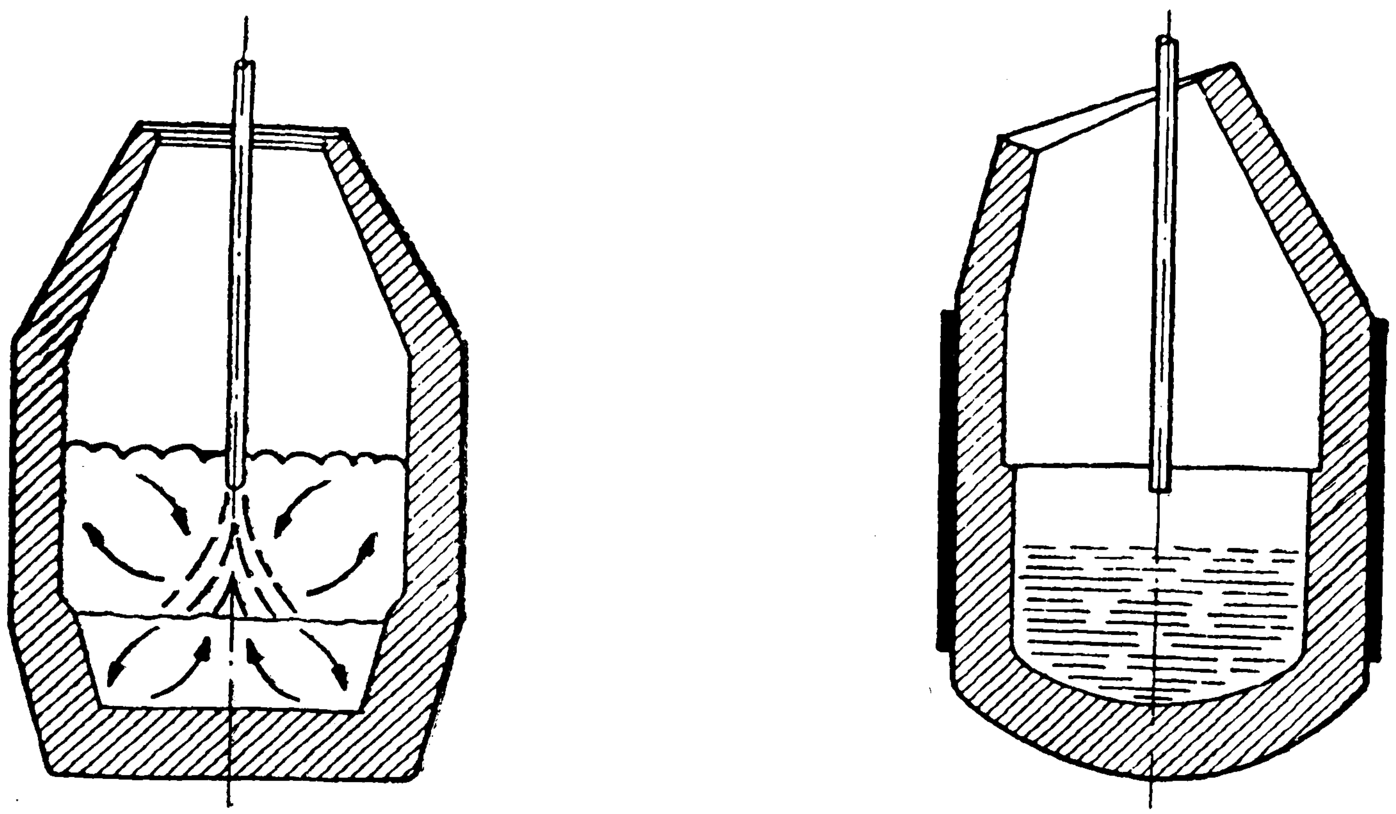

Fig. 2. L-D Converters at Linz and Donawitz

and lime. High silicon will increase the wear of converter linings and prior desiliconization in the ladle will perhaps be necessary which will reduce the amount of scrap addition. Alternatively pig-iron containing lower amounts of silicon has to be produced in the blast furnace. Removal of higher amount of phosphorus will require greater additions of lime and or lime-stone thereby producing larger volume of slag. Whether the increased volume of slag will create operational difficulties or not can only be observed during trials, possibly double slagging will have to be adopted if the silicon in the metal is high. Large slag volume will cause comparatively low lining life thereby increasing the operational cost. The desired amount of manganese in steel can be obtained by the additions of ferro-manganese with due adjustments for its higher (0 5 - 0·6%) phosphorus contents.

Bath temperature in L—D process is adjusted by the addition of scrap which can be figured out from the silicon content of hot-metal. Making allowance for heat losses, 20 - 25% scrap is added for cooling the vessel, regular supply of which is normally available in an integrated steel plant. Iron ore can be added as a 'coolant' upto extent of 7% of the ingot weight. One ton of iron ore can replace 3·5 tons of scrap. Iron reduced from the ore adds to the yield of metal. In countries like India producing little scrap, this factor is advantageous. The yield of ingot is 85 - 90% of the metallic charge the losses are due to oxidation of metalloids (4 - 5%), loss of iron in slag (1-2%) loss of dust consisting mainly of FeO (1-1·5%). The fume contains 93% Fe_2O_3, MnO, CaO and SiO_2 the particle size varying from 0·5 - 1u. About 25 lb of dust per ton of steel is produced.. Disposal of fume and dust constitute a difficult problem but suitable methods have been devised. A 25-30 ton vessel yields 55 tons of steel/hr. LD process, therefore, combines the advantages of production rate of the Bessemer converter processes and the quality of the production is not inferior to open-hearth steel. The L-D process has received wide application as large number of converters are already working and inclusive of those under construction the total will be a high figure [19]. While the tonnage of individual vessel ranges from 10 - 160 tons and the capacity of a plant varies from 20,000 to 1,300,000 tons, the size of a converter has not reached its limiting value. It is reported that still larger vessels of 300 tons are under consideration. A large number of modifications now enable treatment of high phosphorus iron [20].

In countries like Belgium, Luxemburg and Eastern France, the iron contains about 2% phosphorus which have led to the investigations on various other oxygen-injection processes.

THE "ROTOR" PROCESS

With the aim of treating pig-iron with low, intermediate or high phosphorus contents, a steelmaking process by oxygen injection in a rotating furnace, known as the "rotor" has been developed in the Works of Guttehoffnungshutte at Oberhausen, West Germany [21]. The author had the opportunity to observe the "rotor" furnace in 1956 and 1959 and examine its potentialities. At present two "Rotor" of 120 tons and 60 tons are in operation at Huttenwerke, Oberhausen, A. G. (HOAG). The liquid pig iron is placed in horizontally mounted revolving cylindrical furnace about 50 ft. long with 12 ft. diameter (Fig. 3). It revolves on its axis once in about two minutes The molten pig-iron occupies one-sixth

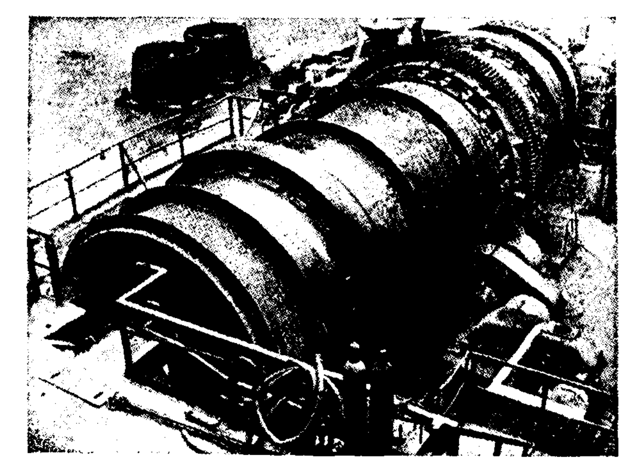

Fig. 3. Assembly of Rotor Furnace

the volume of the furnace, the bath is wide and shallow with a large area of exposed surface as in open-hearth furnace. Oxygen is fed through a water cooled retractable lance inserted through one of the ends the other end of the "rotor" is connected to the gas cleaning arrangement (Figs. 4 & 5). It has been mentioned that the primary oxygen for the oxidation of 95-99% purity is blown at a pressure of 6 atmospheres and its consumption amounts to 15 - 20 Nm^3 and that of secondary oxygen of 73% purity fed at a preassure of 3 atmospheres for the combustion of CO to CO_2 above the bath amounts to 60—65 Nm^3 per ton of basic bessemer pig-iron. The combustion of CO (generated by the decarburising reaction) to CO_2 inside the furnace results in better heat-economy and therefore large amount of scrap and iron ore can be added. At the same time it does not damage the refractory lining because the rotation of the furnace immediately plunges the heated refractory lining under the molten metal. Silica sand and powdered lime are added to get slag of desired composition to absorb sulphur and phosphorus Oxide. The requirement of pig-iron amounts to 1000 Kg/ton of finished

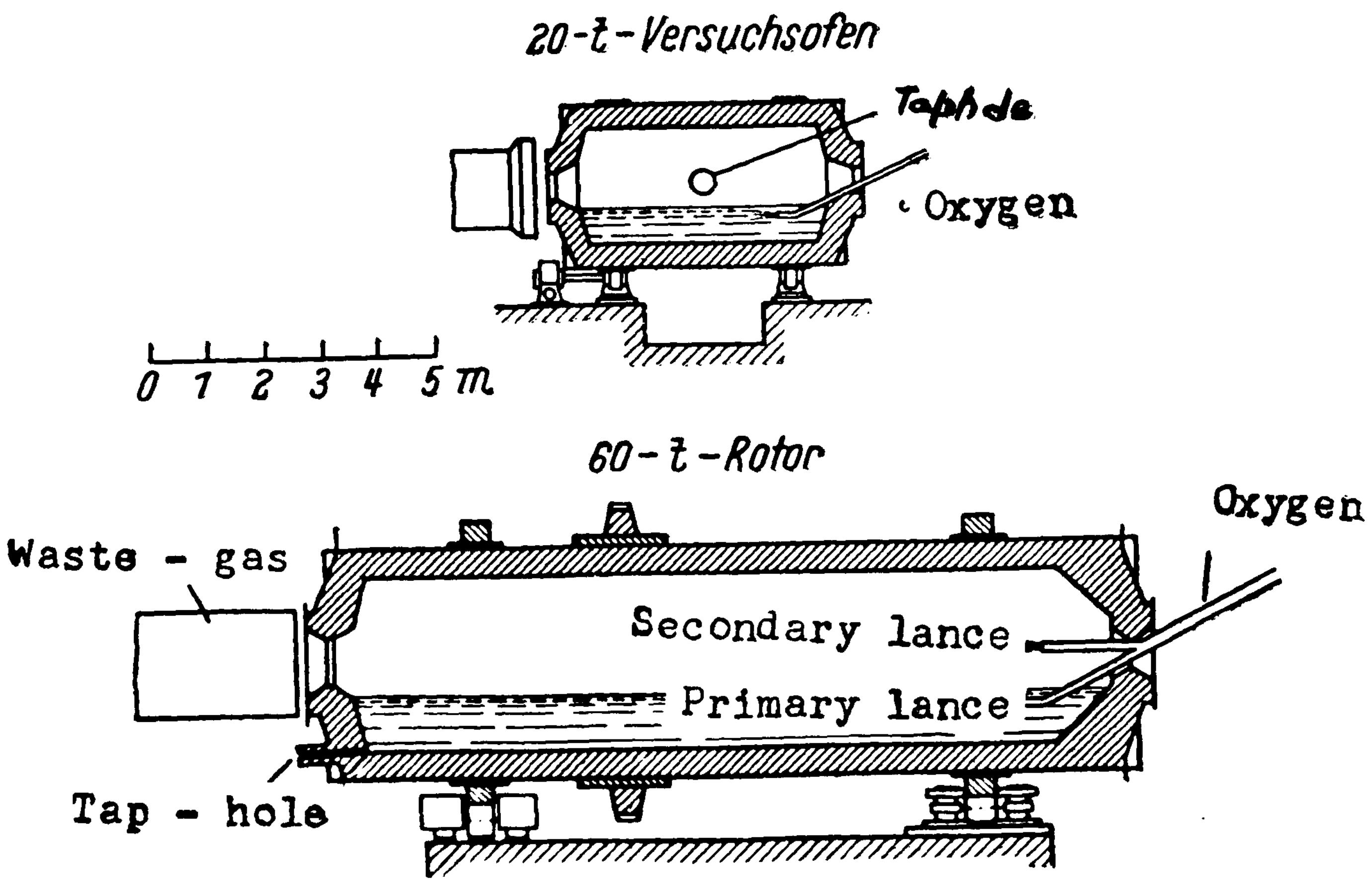

Fig. 4. Schematic Diagram of Rotor Fnrnace

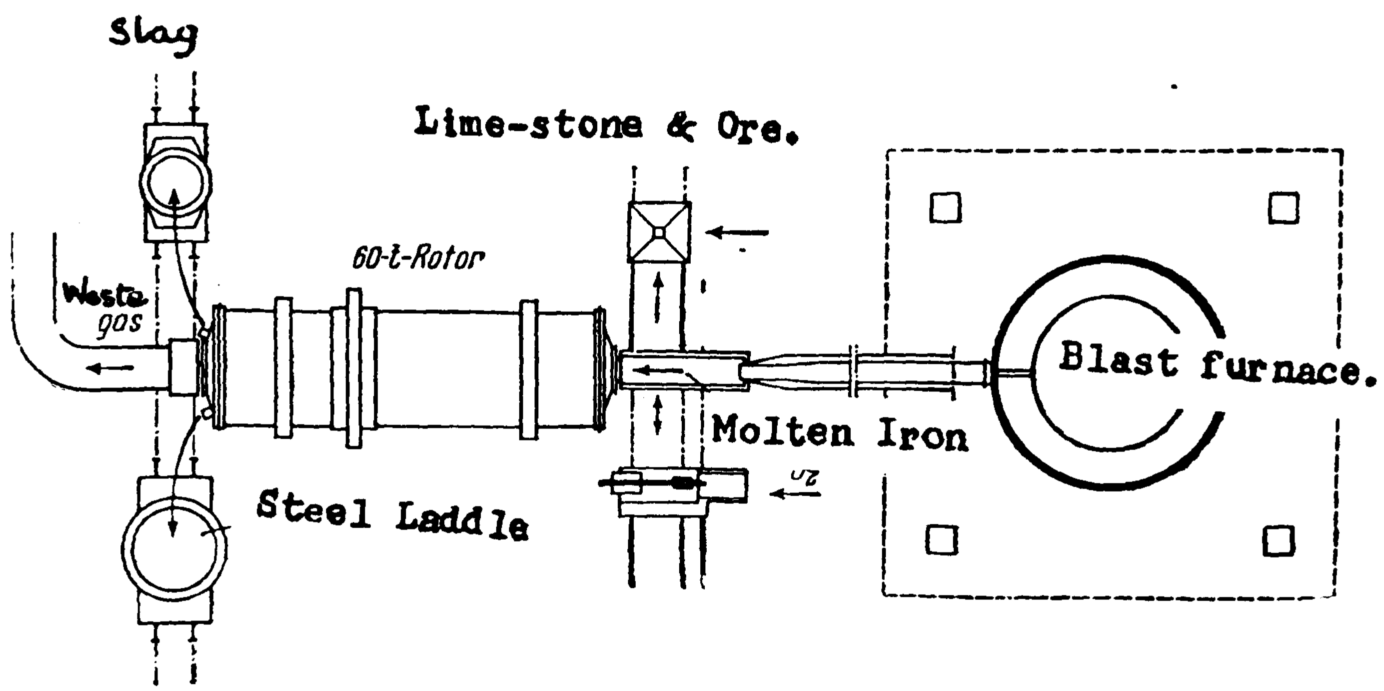

Fig. 5. Arrangement of Rotor Furnace at Gutte Hofnung shuttee, Oberhausen

steel. The blowing time 50-60 min. for 60 tons of steel. With single slag practice the metal is suitable for finishing by the "duplex" process, while by double slagging, finished steel can be produced. In "Rotor" process almost all P is eliminated by the time 50% decarburization has taken place. It is claimed that desulphurization is more effective. The consumption of dolomite lining is 30-40 Kg/ton of steel. It has been mentioned that the steel contains 0·003-0·005% nitrogen and its quality was comparable to open-hearth steel. During a personal discussion, Dr. Spetzler[22] claimed that the chief advantages were (i) oxygen of lower purity can be employed (ii) comparatively simple means of dust elimination due to its larger particle size.

It is reported that the cost of erection was 60% of the open-hearth plant of equivalent capacity while the cost of conversion of pig iron to steel was 40% of it. Two 100 ton Rotors are installed at the Vanderbijil Park Works in South Africa which can be removed from the roller and put in vertical position to facilitate relining. As the blowing from one end is likely to affect the refractory lining towards the other end, the "Rotor" converter at Ilsden Hutte at Peines, West Germany has been mounted on a turn table to facilitate blowing from either end. The process is being adapted by the Richard, Thomas and Baldwins Ltd. at their Redbourn Works for pre-refining The vessel can be tilted to facilitate pouring. As this firm is installing both L-D and Rotor converters, the comparative results will be of interest.

'KALDO' PROCESS

A new rotory oxygen steelmaking process, developed by Prof. Kalling and his colleagues is known as "Kaldo" is in commercial operation (The name Kaldo is derived from the names of inventor Kalling and the place Domnarvet) since May 1956 in Stora Koppenberg, Domnarvet steel plant Sweden [23-24]. The shape of the vessel is that of conventional converter inclined at an angle of 15-20 degrees to the horizontal (Fig. 6). The oxygen is introduced through the central opening. The 30 ton vessel lined with tar and dolomite is rotated at 30 rpm. during the steel making reactions which exposes fresh surface to the reaction zone and facilitates interaction between the slag and metal thereby accelerating the removal of phosphorus (12-14%). Iron ore is added for the purpose of cooling The blowing time 35-40 minutes and the consumption of oxygen of 97-98% purity amounts 2250 cu. ft. / ton of steel. Despite the lower purity of oxygen, the steel is claimed to contain 0·002% nitrogen. In the process substantial desulphurization occurs and low phosphorus steel can be made regardless of phosphorus in hot-metal. Addition of 40% scrap is possible and the yield of steel is 92% of the pig-iron or 99% of pig-iron and the iron-ore additions. The consumption of dolomite is 45 lb/ton of steel. It has been claimed that the process has the advantages of good heat economy as CO is burnt to CO_2 inside the furnace, flexibility of the operation by changing the number of revolution and the direction of the oxygen impingement, carbon can be held at any desired level without effecting the elimination of phosphorus, sulphur can be brought down, low nitrogen in steel despite low purity of oxygen and probably gas cleaning plant would not be necessary. The construction cost is comparable to the regular Bessemer converter.

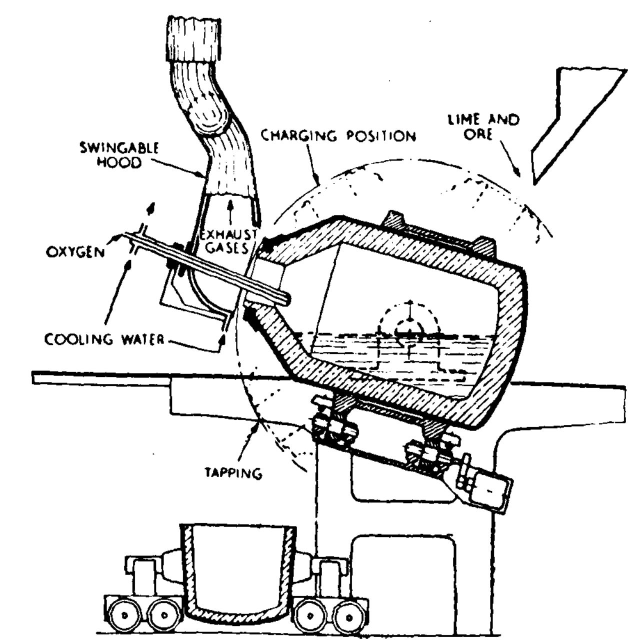

Fig. 6. Assembly of 'Kaldo' Furnace

Two 110 tons Kaldo converters are installed in new steel plant at Oxelosund in Sweden and two 110 tons Kaldo converters are in operation for a plant (Sollac) in France. The Consett Iron and Steel Co. Ltd, England will instal two 110 tons 'Kaldo' converters. It may be mentioned here that in these rotating furnace oxygen injection processes, pig iron of any phosphorus content can be refined. The reasons for the rotation of "Rotor" and "Kaldo" vessels are to spread refractory wears uniformly and to accelerate the chemical reactions. It has been claimed that adequate process control affords the production of various carbon and alloy steels; the heat generated inside the vessel enables adjustment of scrap to hot metal ratio over a wide range and the yield is high The particle size of dust is 3 -20/u. The nitrogen pick-up is low despite the oxygen purity of 95%.

THE BUFFER-SLAG PROCESS

Although the buffer slag process[25] essentially consists of top blowing with oxygen, it does not come in direct contact with molten pig iron due to the layer of slag which acts as a carrier of oxygen. The oxidation of impurities is effected through the highly oxidized slag, oxygen potential of which is kept high due to its absorption. The process is suitable for conversion of pig iron of variable analysis, but has not been largely adapted.

THE PHOENIX—LANCE PROCESS

It has already been mentioned that absorption of nitrogen occurs at the final stages of blowing with air during the dephosphorization reaction. Consequently the possibility of combining bottom blowing with air for decarburization followed by top-blowing with oxygen for dephosphorization has received attention. The method retains the advantages of the cheapest method of decarburization by blowing air and elimination of the disadvantages of nitrogen pick up by carrying out the dephosphorization by blowing with oxygen in the complete absence of air. In the first stage, iron containing high phosphorus is blown in a basic Bessemer converter to reduce the carbon content between 0·4 and 0·1 per cent. In the second stage the converter is tilted on its side to prevent the entrance of molten metal to the tuyers. A water-cooled oxygen lance is then introduced through the top and blowing with technically pure oxygen is continued. A molten slag containing high lime is formed and gradually phosphorus oxide passes on to the slag with slight decarburization of the bath. Finally the vessel is again put in up-right position and blowing with oxygen or oxygen enriched air is continued to lower the phosphorus to acceptable limits of 0·020 to 0·040 per cent. The carbon now comes down to 0·02 to 0·10 per cent. The nitrogen values of "PL" steel ranges between 0·003 to 0·005 per cent. Substantial elimination of sulphur occurs resulting in a steel containing very little undesirable constituents. The slag can be used as a fertilizer.

The total blowing time is about 15 min., which is little longer than the conventional basic Bessemer process. Oxygen consumption is approximately 70m^3/ton (2500 cu. ft./ton) of which 50% is derived from the atmospheric oxygen.

This technique known as the "PL" process has been developed and practised in the Ruhrort plant of the Phoenix-Rhienrohr A. G., Duisburg, West Germany, where several 50 ton converters have been installed in a new basic Bessemer steel melting shop[26].

OXYGEN-LIME-POWDER INJECTION (O. L. P.) PROCESS

It has been mentioned that the L-D process cannot normally treat high phosphorus irons. Consequently many attempts have been made to modify the process to make it adaptable to such irons. In West Germany experiments have been conducted by "double-blowing" in which air is blown through the bottom of the converter as in classical Bessemer process, with simultaneous blowing of oxygen from the top. The agitation of the bath due to the blowing from the bottom accelerates dephosphorization [27]. In Austria fluxing agents like fluorspar or bauxite have been employed to treat pig irons containing 1·2 or lower amounts of of phosphorus. A French Steel Company, la Societe des Forges et Acieries Ole Pompey has extended the limit of phosphorus to 1·8 per cent by the addition of mill scale

(IRSID) in France has developed another industrial technique known as O-L-P Process [28-29] for the treatment of irons of any phosphorus content and iron containing 2% of it can be converted into good quality steel. (Fig. 7.) In this process varying contents of finely divided lime powder (86% C a O) is entrained in the stream of oxygen (99. 5%) for refining iron of variable phosphorus contents. The technique eliminates the use of fluorspar and no foaming occurs due to high silicon in molten iron.

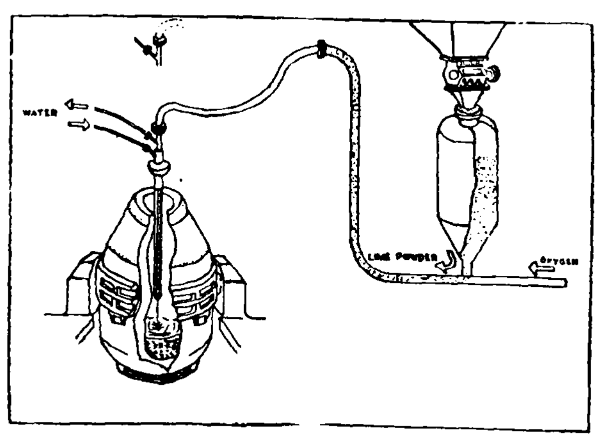

Fig. 7. Schematic Arrangement of IRSID. O-L-P. Process

The water cooled retractable oxygen lance is placed at a distance of about 3 ft. above the bath level and oxygen is injected at a pressure of 210 psi. The suspended lime powder about 1 m.m. in size is simultaneously injected with any desired flow rate on the surface of the molten iron. The simultaneous injection of oxygen and formation of high lime slag greatly favour the dephosphorization.

The 30 ton vessel is cooled by the addition of either scrap or high grade iron ore with 55-57% iron.

On the completion of dephosphorizing reaction, the foamy slag is removed. Simultaneously with the removal of phosphorus, the slag is able to effect considerable desulphurization. After which scrap and ore are added and the blowing is continued for the removal of carbon and silicon to the desired limits. As the final slag is rich in iron, it is retained in the vessel. In this process pig-irons containing 0·017 to 1·8% phosphorus and any silicon have been converted into low carbon low nitrogen steels (0·001—0·002%). The consumption of oxygen and lime are 2,200 cu.ft. and 310 lb. per ton of iron and about 600 lbs. scrap can be added.

THE LD—AC PROCESS DEVELOPED BY ARBED

Metz[30] has described the top blowing with oxygen in the presence of powdered lime, which was called OCP (Oxygen-CaO in powder) Process.

At ARBED—Dudelange oxygen injection with lime powder was employed in a new steel making process christened as ": D-AC" where LD refer to the collaboration with the LD of Austria, A stands for ARBED and C for CNRM (Centre Natioral de Rocherches Metallurgiques, Liege, Belgium). Investigations[31] were done in a 25 ton vessel. The elimination of phosphorus before substantial decarburization is possible as in other oxygen steel making processes. Pig-iron containing 1·7 to 2·0% phosphorus and 0·1 to 0·6% silicon is converted into good grade steel in 16 to 20 minutes blowing time. The process can consume 450 lbs. of scrap per ton of steel. The oxygen consumption of 1900-2050 cu. ft./ton of iron is low. It requires 186 lbs. lime per ton of steel. Nitrogen in steel depends on the purity of oxygen and with 96·5% purity, the steel contains 0·0044% nitrogen, which can be brought down to 0·003% with 99·5% oxygen. The consumption of dolomite refractory lining is not higher than the conventional Basic Bessemer process.

Several 110 ton furnaces are planned for operation at the Duisburg Hamborn Works of August Thiessen Huette for treating high phosphorus iron by the LD - AC Process. A 66 ton LD - AC converter will be operated at Hutton Work Salz getting AG - A44 ton vessel is installed at Mannsmann Huttenwerke

OXYGEN IN SIDE-BLOWN CONVERTER

As the analysis of iron in the States was somewhat different to that employed elsewhere for the oxygen steel making, investigations were conducted to produce high carbon low phosphorus steels, low in nitrogen contents from pig irons containing upto 1·0% P by a pneumatic process without the application of external heat[32]. Investigations were initially conducted in 750lb. side blown basic lined converter. Molten pig iron analysing C - 4·0%, Mn - 1·5%, Si - 1·0% and P - 0·24 - 0·27% was charged with limestone (6% of hot metal weight), iron-ore sinter (6% of hot metal weight) and scraps (25lb.). The metal was lanced with 1/4" dia, lance tube with pure oxygen. The foamy slag was removed by the opening of the side. The lancing was then continued after the addition of lime and fluorspar. The elimination of C and P progressed simultaneously and after 20 minutes of blowing phosphorus was lowered to acceptable limits while the bath still had about 1·25% C. The rapidity of phosphorus removal was attributed to the removal of highly oxidizing slag formed initially. Substantial sulphur is eliminated and nitrogen contents in steel varied from traces to 0·003%. On the successful attainment of the objective, the process was tried in commercial scale to produce 125 tons of steel/heat by modification of a 175 ton basic open-hearth furnace. Oxygen of 95% purity was introduced by three lances at the slag metal interface and at a blowing rate of 1980 cu. ft./min. no external fuel was necessary. The rate of oxygen blowing was half of that employed in top blowing. The pattern of elimination of carbon and phosphorus was similiar to that in 750 lbs. heat.

For bottom blowing, oxygen at high pressure has been injected through specially designed injectors which are not cooled by water. Desiliconization can be effected and carbon can be kept at the desired amount.[33]

CONCLUSION

The world production of steel is steadily increasing. In order to increase the output and lower the cost of production improved techniques are adapted. These generally depend on extensive usage of oxygen, either for accelerating the combustion of fuels or for direct oxidation of metalloids. The necessity of producing low nitrogen deep-drawing quality steel from pig-iron of intermediate and high phosphorus contents in the continent, for which basic Bessemer process was practised, has been responsible for the rapid development of several basic oxygen steel making processes. With the commercial adaptation of the these modern and revolutionery techniques, the steel making has entered into a new era and these processes have come to stay. For increasing the steel-making capacity, the oxygen steel making processes deserve consideration.

Without going deeply into economics of these recent steel making processes, it appears that the capital investment for basic oxygen steel making converter plants is less than that of an open-hearth plant of comparable capacity and the conversion cost is also lower. It has been mentioned that capital cost of L-D steel plant is 60% of the open-hearth shop of identical output. The quality of the steel coupled with attractive economics, both for the cost of the steel plant and the steel making practice, have focussed considerable interest and may receive wider application.

Selection of an appropriate process of steel making presents a difficult problem. Apart from the composition of molten iron, the availability of fuel-oil, good grade iron-ore, the utilization of the scrap produced not only in the steel works itself, but also arising from the associated engineering industries and the production cost deserve careful consideration.

Although the ability to produce steels of various grades from hot metal of varying analyses will maintain the position of open-hearth steel making particularly after modifications like all basic roof, employment of oxygen for combustion and oxidation, the lower cost of installation and maintenance with higher output will focus serious attention for the selection of an appropriate oxygen steel making process.

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STEEL PRODUCTS FOR GENERAL ENGINEERING PURPOSES

The Indian Standards Institution has prepared the following Indian Standard Specifications for Steel Products for General Engineering purposes:

(a) Mild Steel Plate, Sheet and Strip for General Engineering Purposes [Doc: SMDC 6(253)],

(b) Mild Steel Flats for General Engineering Purposes [Doc: SMDC 6(254)] and

(c) Mild Steel Bars — Round and Square for General Engineering Purposes [Doc: SMDC 6(255)].

The sizes and other properties to be included in these standards will be in metric units. These sizes have been arrived at after taking into consideration the sizes of steel products at present used in the general engineering industry. A list of sizes for these products has been given as a guide in the ISI Handbook for Structural Engineers—1: Structural Steel Sections. A general guidance with regard to the selection of these sizes had also been given in IS: 1138-1958 Sizes of Metal Strip, Sheet, Bars (Round and Square), Flats and Plate (for Structural & General Engineering Purposes). But, it has now become necessary to standardize the sizes for various steel products.

After these standards are published, it is intended to withdraw IS: 1138-1958.

The draft standards will be circulated by the middle of October 1960 to interested producers, consumers and technologists for eleciting technical comments. These draft standards will be open for comments for a period of three months from the date of circulation.

*

SHIPS OF IRON ORE

A contract has been entered into between the great Eastern Steamship Company of Bombay and nine major Japanese Steel mills, under which, ships belonging to the Great Eastern Company will lift one lakh tons of iron ore of the one and a half millions tons being purchased by Japan this year under a long-range agreement with the Indian Government.

The contract was signed by Mr. K. M. Sheth, Manager of the Great Eastern with the Fuji Steel Company acting on behalf of nine steel mills. As three months have already elapsed since April, Mr. Sheth said his firm had volutarily agreed to deduct 5000 tons from the agreement, so that between July and March next Great Eastern vessels will lift in all the 85,000 tons of ore. There will be an average sailing of one ship monthly during these nine months.

Productivity Through Industrial Maintenance

By Shri L. N. Misra
Chief Mechanical Engineer, Bhilai Steel Project

INDIA is on the threshold of industrialisation. Machines form the most important wheels of Industry and modern industrial production operation is largely dependent on the continuous performance of electrical and mechanical machines. Therefore, well managed operations demand much attention to developing practices which keep efficient and economic production operations from breaking down as a result of equipment failure. This work, called maintenance, is yet an undeveloped technique in India.

National Productivity Council of India, with the help of International Co-operative Administration of U. S. A. has been sending out teams of Indians abroad to learn methods of increasing productivity prevalent in those countries. Rightly, therefore, the N. P. C. sent a team of maintenance Engineers to study the prevalent maintenance practices in Germany, England and America. The team left India in the middle of May, 1960, spent in all seven weeks in Germany, England and U. S. A. visiting various factories and having discussions with maintenance men, engineers, technicians and managers. The team has just returned. I am glad I was associated with the team as its member.

Generally speaking, men who buy equipment, including I and you when we buy a car, decide to spend money on the machine and its driving personnel. We don't even care to see that whether there is good workshop or maintenance facilities are available. More often it is forgotten that when a machine has to be run properly, it has to be maintained so that it does not break down. What actually happens is this : In spite of clear instructions that for the first 500 miles the car should not be run beyond a certain speed, the engine and gear oil should be changed at such and such mileage, none of these instructions are carried out. In fact, the driver, and sometimes the owner, in an effort to try the capacity of the car, runs it or at least spurts it at its full power, the oil is not changed and tuning is not done in time, with the result the parts get affected even before running in and its adjustments. Starting with bad operations combined with lack of maintenance, so much of damage is done in the beginning itself that more often an equipment cannot be brought back to the original condition any more.

Almost the same happens to the wheels of industry. When a plant is started, the first effort is to get it going some-how and in the condition of 'some-how', maintenance, which is at times considered only an expensive evil, is generally forgotten. New operators only add to the damages.

A car could, however, be for a joy-ride for somebody for whom time is not important or it could be for someone whose every second is precious. It is here that the technique of maintenance and type of maintenance differs. Rightly, therefore, maintenance is combined art and science of keeping machinery running. If an equipment is for a man for whom it only means a joy-ride, it does not matter if it gets struck on the road. He should be satisfied with repairs to the equipment when it breaks down, irrespective of the time taken, because probably this type of maintenance is the cheapest, no storing of spare parts, no planned shut-down, no inspection. Whenever a breakdown does occur, it is set right at convenient time. This kind of maintenance is called breakdown maintenance.

On industry side, probably the very first type of maintenance was capital replacement. An equipment—let us say a farmer's implement – was used till it broke-down and completely finished its life, and then was changed. The nearest solution to this was to have a standby equipment. When one broke, the one lying idle was used. At some places this method is common still. As industry grew and bigger size of plant and machines locked up more and more of capital, huge standby plants became uneconomical. Probably at this stage breakdown maintenance caught in and equipments were set right when they actually broke down.

Modern industry, however, has become more complex. Most of the continuously operating Plants, more so Iron and Steel, which use large number of heavy machines that are generally of major size and cumbersome, involving large capital investment and continuous processes, every minute of down-time of any single equipment not only renders this equipment out of operation but affects operation of the rest of the plant. Here such break-down maintenance is inadequate and once it is accepted that an industry is of a type which cannot afford unwarranted breakdown, steps have to be taken to adopt methods which ensure continuous operations of the plant. And this leads to new maintenance procedures, like 'Scheduled maintenance', 'Planned Maintenance', 'Preventive Maintenance' and now 'Productive Maintenance'.

"Scheduled maintenance" is best suited to service plants such as small boiler houses and compressed air stations where the plant does not run continuously or is subject to being idle due to change of load, product or completion of orders. Maintenance of such of the major items of the plant as may require attention are scheduled to fit in with production programme. The plant may be inspected during nights or week-ends when it is not in operation; and scheduling maintenance helps to utilise efficiently the down periods of the plant for maintenance work.

"Planned Maintenance" is employed with great advantage in plants operating continuously at high rates of output. As a preliminary step, schedule maintenance for all major items, serves as a basis for planning the details of actual volume of work, enabling tentative estimates to be made for labour and material required. Records of actual performance form basis for estimates in making a forecast more appropriate. Planned Maintenance, to that extent, helps planned allocation of material and equipment, aims at better utilisation of material and labour, besides ensuring reliable and constant production. Naturally it also calls for highly skilled supervision to obtain full benefits of the scheme. This method not followed scrupulously, however, is likely to lead to increase in paper work which then becomes worse. With proper follow-up, planned maintenance reduces both maintenance and production costs and frequencies of breakdown.

With growing use of more automatic machines in continuously operating plants, even "scheduled" and "planned maintenance" is not sufficient. For this, the American industries have developed properly scheduled and planned schemes to prevent instances of breakdowns and reducing quantity of maintenance calling it 'preventive maintenance' system. The preventive maintenance system is directed not merely towards planned maintenance but towards upkeep, replacement, and modification rather than a repair. The Maintenance Engineer inspects machines or pieces of equipment and schedules in great detail in respect of maintenance, replacement and modification as may be necessary in its life time. The intervals at which such work should be undertaken and also the time it will take are all studied to obtain better performance and improved methods. All and complete records are kept to help long range planning. Most plans are thus prepared and work done so as to carry out at regular intervals an overall plant maintenance programme to fit with planned production schedules. This ensures continuity and regularity of maintenance of plants.

More important within 'preventive maintenance' is, however, the idea of doing maintenance for 'preventing maintenance'. I will clarify. Very often suppliers of equipments and their designers in an effort to sell their machines and methods and to be able to compete with competitors, are apt to forget the maintenance aspect of the machines. Frequent inspection of certain parts may need lot of bolts to be opened; an over-head bearing may be causing too much worry on work. This may be an achievement from design point of view, but is a very great disadvantage from maintenance print of new. Under preventive maintenance will fall the procedures which may spotout places requiring more frequent maintenance, and methods introduced, if necessary, by even changing the design of the equipment to reduce such quantity of maintenance. Preventive maintenance, therefore, is really reducing quantity of maintenance and even designing out maintenance. Bearings of motors lubricated for a life time, permanent lifting tackles in places where maintenance is done very often, rightly fall within this.

Naturally reduction in the number of men on the job is one of the constant practices, because it has been realised that putting more men on the job itself causes complication. With more men employed on a machine, the idea that the other man will take care of the work takes greater root and is unhealthy. Simultaneously, inspection records and job study combine to find methods for mechanical gadgets and machines to work under a man's control and reduce his physical work. One of the great differences among supervision of work in this country and the West is that unfortunately a supervisor here is most of the time busy in seeing that men do their work. In the West, a man fixed for certain job has to do it during duty hours, working all the time on the job or has to clear. He will be appointed only if he can deliver the goods. Work of supervision is to make constant improvement in machines, equipment and more important improvement in working conditions, so that machinery does the work under man's control. This is the one important feature missing in our supervision here. In India, the common man has still not developed independent industrial habits and needs more and more guidance, check and follow up. Supervisor also carries his own weaknesses. This one fundamental has to change and each one has to take care of his part of the job. With that done alone can preventive maintenance or even planned maintenance be successful. The workman does the work planned, supervisor gives him plans, tools and spares and simultaneously, by job study and comparison of records constantly, reduces quantity of maintenance.

In India, it looks 'preventive maintenance' is referred to, only vaguely. Most of the industries only follow break-down, 'Schedule' or planned maintenance. We, in Bhilai, are lucky that we are following 'scheduled' and 'planned' maintenance and preparing ground for 'preventive maintenance'.

Preventive maintenance can, however, be carried too far by enthusiastic maintenance engineers and this may be over-done. Therefore, to divert maximum effort, time and money on that part of machine and equipment which holds up production maximum, 'productive maintenance' has come in the field. Preventive maintenance takes time to show up the results, but productive maintenance is immediately effective as is getting more common in America also.

To be able to do right plant maintenance, workshop facilities are very important. Mechanical handling equipment and mechanised transport are the first necessities to the maintenance man if the maintenance work is to be done with accuracy and speed.

The more advanced countries, where industrialisation is already at a certain stage, have rightly given a proper place to 'maintenance'. In the beginning, however, all pass through a stage of indifference to maintenance. The British Institute of Management indicated that only 15 years back, scheduled or planned maintenance was not thought a factor deserving consideration in British industry. The production somehow was the only criterion. As production increased in other countries and competition set in, England also had to find its own methods to increase productivity. Now regular inspection, proper records and constant study of job methods are employed and constant improvements are being made to keep the wheels of industry - running better and economically.

India is possibly passing through the state of infancy where production and not productivity is aimed at. In general, Indian industries feel the same as Britain felt 15 years back. In its report dated November 15, 1956, Ramsey Miller Co., consultants on steel plant maintenance to the Goverment of India, indicated that 'repairs and maintenance' are already a problem in the existing steel plants in India in the private sector and if the Government steel plants do not plan in advance, repairs and maintenance may soon become a problem in the public sector too. Time alone will show whether we have learnt by this timely suggestion. As young construction engineer, I was told by my officer, who had spent years in America, that on any job, services should be erected first. This should include pipe lines, electricity accesses and approaches and workshop facilities. This not noly helps operation to come up fast when started, it reduces cost in construction. You go to any industry under construction. The operating units get ready but the services are not touched Repair facilities which should have been completed first are not finished even though main machines are in operation. Repair facilities have been given second priority. What is the result? For the first few months no trouble. Simultaneously construction going on along with operation leaves operation surroundings dusty and machines deteriorate fast. Then resources of spares do not remain sufficient to meet the challenge of the industry to keep its wheel running. Like the new car, the damage done may not be repairable in the life time of the equipment and in any case the life of the plant is affected.

These are some of the general points. Some other relevant points that came to light during the course of study tour are as follows:—

PERSONNEL

In Halskesiemens Karlsrhu, it was stated that some time back for every 6 men on operation they had 1/2 man for maintenance Operation has been mechanised with more machines in position. The position now is that for every one man in operation there are 2 men in maintenance. The men required for maintenance as mechanisation takes shape only increase. You remember the case of the lady who wanted to mechanise her kitchen as she was tired of the whims of one cook. After mechanisation, soon to her horror, she found she now had to deal with two men-a mechanic and an electrician.

Another thing that came to light in the West was that men working on the production lines need not be technical men and can be trained from people who have no technical education. They have to develop only the ability to do some repetitive work. Maintenance men, however, have to be from trained persons, have to develop skill, have to do new types of work independently every day, and are, therefore, paid higher than production-line men. In the Hoest Chemical plant, we were advised that an unskilled man can become an operation man on the production line but never a maintenance man.

The tendency today to train everybody on the job when starting new plants may go too far. It is more likely that trained boys will pick up job faster and develop the ability and confidence to run a job quicker but in the beginning it is very essential that at least a few experienced men must be available to lead the work, to start and commission it. Once the plant is commissioned and has run for sometime, the newly trained personnel would have developed the confidence and would do better therefrom.

On the question of incentives to labour, now that incentive schemes have been working for some time, there seem to be varying views. More people are now in favour of fixed hourly wages rather than incentive schemes. Incentive tends to reduce quality and since generally incentive schemes are difficult for the common man to understand, workman is suspicious and gets dissatisfied. By a fixed hourly-wage, workman knows precisely what he is to get for a whole day, gets it and is satisfied. Hourly wage can, however, be effective in those places where the workman works a whole day efficiently in the work he is employed for. This efficiency should have come up to certain level so that he does not have to be chased for his part of the work. In such places where men have still to be chased for doing their legitimate jobs, for a while it may help putting incentive schemes limited only to places where work can directly be measured. This also should be on temporary phase. When workmen have achieved the standard and they realise that working for the prescribed duty hours is a part of their job, straight way higher hourly wage is the best method to keep workers' minds satisfied. America and the West achieved productivity by incentive bonus. They have reached a stage where they can start giving it up. We are still in infancy and to make our men production-minded, incentive can be profitably introduced in places where work can be measured.

MATERIAL

On the question of spares, it will not be exaggeration, if I say, that we were laughed at our situation when we asked for how many months, spare parts are stocked with them. Their simple answer was that spares are available on phone 24 hours of the day. Still in places where spare parts do become a problem on machines bought from other countries, worn out parts are built, and building worn out parts is already a good technique. It is felt, however, that built up worn-out parts are uncertain in their behaviour. Therefore, unless emergency really exists such parts are not used very much. It was also stated that very often spares are not stored properly and when required they are mostly not usable and they have only to be scrapped at a later stage. Therefore, unless costly and efficient storing services are at hand, spare parts should not be stored. This recommendation, however, does not apply to Indian conditions at present.

Firms supplying machines generally give recommended life of the machines and their spares for a certain time. Such recommendations are based on general conditions rather than particular conditions existing in a certain plant. A cold dry place may need one kind of preventive maintenance and spares, but a humid and hot place may need entirely different spares and maintenance. If the place is dusty it may have more maintenance requirement. This itself puts us at a comparative disadvantage. The manufacturers may have in view, factories which have no dust problem, and where the temperature is not high. Therefore, recommended life and period of changes should be studied in every factory and each factory should develop a basis for its own use.

It has been found that every equipment has some kind of troubles in the beginning for a year or two and this can be called infancy stage. Then 2 to 25 years is normal working life of most of the machines. If at the end of working life, the machine is not thoroughly repaired due to old age it may start showing failures and give troubles. If at proper time, the machine is thoroughly overhauled and renovated, the life can be made long.

In Daimler Benz it was pointed out that labour in Germany is costlier than material and parts, and there is no difficulty in obtaining parts in time. Parts are, therefore, changed in time or even before time to save down-time and costly labour.

BOTTLE-NECKS OF MAINTENANCE

In breaking down 'maintenance work' in smaller basic units, it is seen that 30 per cent of the men are all the time busy opening bolts and nuts for inspection only. It is here that job methods and job study can eliminate extra maintenance.

It is also found that 48 per cent of the breakdowns in industry are associated with lubrication. Thus lubrication alone, if taken care of, can save half the unwarranted down-time. Therefore, tendency should be not to leave lubrication to unskilled men any more, but put suitable skilled workers on the job.

Problem of transport of hand tools is no less costly. Maintenance men going around from place to place need tools. Lot of time is wasted in men running about from store to work-site for tools only. Men should be trained to have most of the tools in their pockets provided in their pants, otherwise tools shold be carried in special carrier.

Loss of tools is yet another problem. The American factories have a very nice way of controlling this. There, the man brings his own trade tools and owns them. When a fitter is employed, he is employed with his own tool box. Loss of tools is unknown because every fitter recognises his tool anywhere. Also as the mechanic gets known by the type of tools he keeps, every one tries to keep his tools better than others. One of the mechanics repairing a small lathe indicated to me that his tool box cost him about 500 dollars and he was proud to own it. We, on the other hand, just have no habits of keeping tools. Right from the technical institute, people selecting a trade should take pleasure to keep their own trade tools. This will give them pride of profession and will make them more suitable in their own jobs.

Communication is another bottle-neck. For efficient maintenance, the maintenance man must have the fastest means of communication. Mechanised transport, telephones, radio communication have all come up. In one plant the maintenance men all carried small transistor sets in their pockets and communicated through the Head Office wherever they were. We look forward to the day when we could have these facilities for our maintenance men.

COST

In the more industrialised countries, maintenance cost has been controlled in various ways by industries and they consider maintenance important. Some, for whom down-time is not an important factor still consider maintenance as an auxiliary function. Others, who run heavy equipment and down-time of equipment affects their operation and other equipments, have introduced better maintenance methods. Some of them allow any cost to be incurred on maintenance. One company went to the extent of saying that they did not have any control over maintenance cost because maintenance must be done in the greater interest and whatever was necessary in that direction was done. Only when the cost of maintenance amounts to more than 10,000 dollars, it is brought to the notice of the General Manager. It will be a happy day in India when immediate expense on maintenance is not made the criterion and long view of things is taken. In any case, those who have budget control have found out a method of correct index of maintenance. They consider cost of insurance, plus cost of maintenance, plus cost of down-time compared to total operating cost, as a very good yard-stick to know whether or not maintenance is doing fine.

The relative position of the maintenance man in an organisation is that the facilities manager is at par with the production manager. Facilities manager generally helps maintenance work in the plant and is directly answerable to the General Manager whose decisions are more important than Financial Directors.

As India is getting more and more industrialised, we will also sooner or later have to reach our goal. I am only glad to say we are heading towards it faster and very much faster than many others did.

VAST IRON ORE DEPOSITS DISCOVERED IN SIBERIA

The iron ore reserves of Gornaya Shoriya, Ampalyg and the mountainous regions of Altai (Western Siberia) and Hakassiya (South-East Siberia) have lately been estimated at 2,500,000,000 tons. This is enough for a 50 years long operation of Siberia's giant iron and steel works, forming part of the Soviet Unions third iron and steel producing centre being established in the Eastern regions.

The Gornaya Shoriya basin, whose ore workings will soon become the largest of their kind in Siberia, has been found one of the greatest promise. Geologists have discovered new ore deposits in this basin which has been supplying ore to the Kuznetsk Iron and Steel Mills for close on 30 years.

Shoriya's ores are of high quality. That of the Tashtagol deposit, for instance, is good for unbenificated steel and pig iron smelting. Besides, it contains some components needed for alloy steel production.

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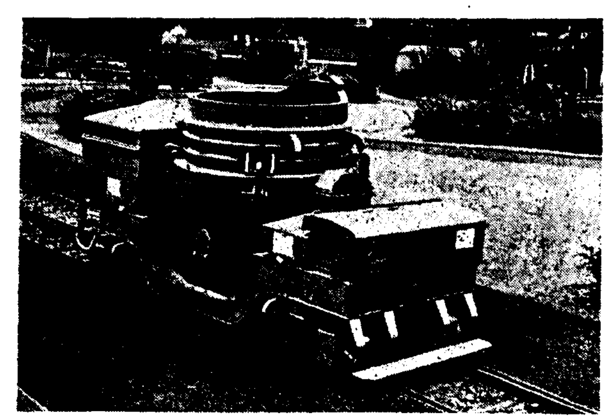
TWO STEEL PLANTS FOR PAKISTAN

Pakistan will have two steel plants in the second-five-year plan which will be launched in July 1961. The plan prepared by the Planning Commission, was endorsed by the Economic Council held under the chairmanship of President Ayub Khan. There will be one steel plant in each wing of Pakistan.

Rolling Stock for Improved Production Efficiency in Iron and Steel Works

By An Engineering Correspondent

ONE of the most important considerations when choosing the location of an iron or steel plant is the provision of facilities for transport of the two chief materials, ore and coal. Supply routes should be kept as short as possible, and the best use should be made of any existing facilities. For this reason, the first plants were usually located in the vicinity of storage depots for coal and ore. Only in more recent years has the practice emerged of establishing new plants on the sea coast following the increased processing of overseas ore and coal. Provision of facilities permitting a smooth flow of materials right up to the finished product is just as important inside the actual steel plant. So as not to congest the transportation routes unnecessarily, the movement of dead material should be kept down to a minimum. Consequently, transportation is one of the most compelling problems for which the steelworks and rolling mill engineer has to provide a suitable answer. Materials of the most varied types, in the most varied quantities, have to be conveyed, stored, loaded and unloaded, each one requiring special treatment according to its nature and intended use. This has led to the introduction of several special types of vehicles, the most important of which are summarized on these pages.



Converter charging car with electric ladle tilting gear

Inside the plant molten iron is transported in ladles mounted on transfer cars. The ladles are either of the standard pot design, or, if they are to be used for charging pig machines, of a special design equipped with trunnions and horn-shaped brackets to facilitate controlled pouring. Modern endeavours to introduce utmost economy into the entire production programme require that all losses be limited to the minimum or preferably eliminated entirely. Among the advances that have been recorded in the course of such endeavours is the development of hot-metal mixer cars which hold upto 250 tons of molten pig iron in a torpedo-shape vessel with a comparatively small filling hole. They are of great value in helping to avoid loss of heat.

Slag pot transfer cars with tilting gear and automatic pot locking mechanism for disposal of open hearth slag

Pig iron is usually transferred from the producer to the user in the cold solid form. This means that it must first be cast in pigs, whereby the heat of the molten iron is lost and new heat is required to melt it again. Apart from this drawback, the transfer of solid iron calls for extensive handling equipment and considerable labour expenditure.

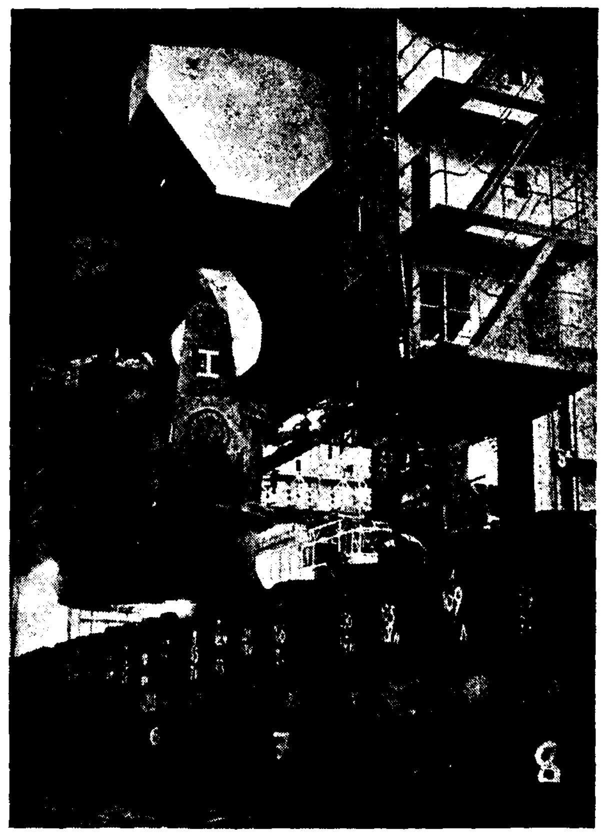
During the search for other, more suitable solutions to the problem it appeared reasonable to transport molten pig iron in special trains from one plant to another over large distances on the public railroad system. In Germany efforts to obtain the necessary permission from the Federal Railways have finally been successful. Before permission could be granted, however, it was necessary to develop ladle cars and ladles capable of satisfying the exacting requirements of the Federal Railways safety codes. BAMAG has designed such a molten iron transfer ladle which fully conforms to the official regulations and also meets all steelworks requirements.

For disposal of molten slag from blast furnaces and steel plants BAMAG builds special cars with a tilting pot that is emptied at the dump by either a crane or a tipping mechanism built into the car. In modern open-hearth steel plants the slag is emptied into a specially designed self-propelled slag-disposal car which travel under the furnace an l is controlled from the charging floor. The loaded slag pots are lifted off the car by a crane in the pouring shop and placed on cars equipped with tilting gear which run to the slag dump. A locking feature on the trunnion ring automatically secures the pot when it is tipped so as to prevent it falling out. When returned to the upright position, the pot is released so that it can be lifted out by a crane without any further effort. This new design merits special interest, since it eliminates the need for dangerous work on or near to the hot, slag-filled pots. The car's tipping mechanism is actuated electrically, either directly by a drive motor mounted on the car or indirectly by a separate drive unit that couples up to the car by a plug-in shaft. In both cases manual drive can be employed if necessary.

Slag transfer cars with automatic pot locking

Converter charging cars form a special category in the production of steelworks rolling stock They are employed to carry the molten pig iron from the mixer to the coverter floor and charge it into the vessels. Emptying of the iron from the ladle into the converter is usually only possible if the ladle is moved toward the vessel, cross-wise to the direction of travel, during the charging operation. In other words the ladle has to be displaced to one side when it is tilted. This means that the car must have an additional shifting mechanism that moves the entire tilting gear across to one side. Such drives are electrically operated. Self-propelled cars have a separate electric running gear drive.

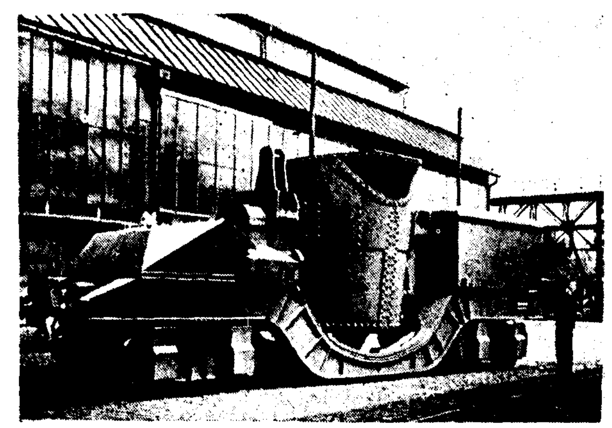
Skull and nose sloppings removed from converters can be collected directly in special lump-slag disposal wagons which travel straight to the slag dump. These wagons have a tipping hopper and are of extra-heavy construction. Thus, the removed skull and lump-slag can be disposed of immediately instead of being allowed to accumulate between the coverter stands where it has to be picked up, loaded on to trucks and then carried away in an extra operation at certain intervels.



Ingot mild cars of 135 tons carrying capacity in the stripper shop and 250 tons steel casting ladles of welded design

The bottoms of Bessemer converters have a limited service life and need replacing after a certain number of blows. There is however no lifting gear under the vessel to help in the removal of worn bottoms and the fitting of new. BAMAG builds for this purpose bottom-hoist cars which have a jack (usually electro-hydraulic) to lift the new bottom into position in the converter. During this operation, considerable pressure loads are placed on the car's wheels and axle bearings. Hydraulic support cylinders are therefore provided under the chassis to absorb these forces and to add to the car's stability. The plungers are fitted with support heads and automatically extend downwards when the oil pressure increases, bracing the car on the heads of the track rails. As the oil pressure drops, the plungers are forced back into their original position by return springs, allowing the car to be withdrawn.

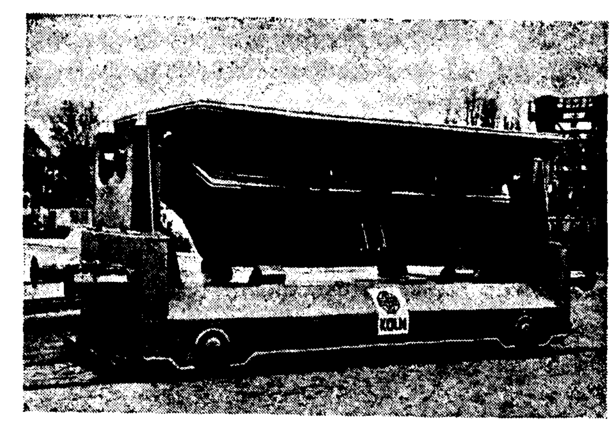
Converter shop cranes are one item of equipment that is taxed to the absolute limit in modern steelworks practice. A profitable reduction in the burden of work placed on the cranes can be achieved through using self-propelled ladle cars to transfer the blown steel and teem it into the ingot molds. BAMAG has devised steel disposal cars of straight-forward design equipped with an electro-hydraulic ladle lifting mechanism and an electric running gear drive. They are mostly remote controlled from the converter charging floor. The car lifts the ladle towards the descending nose of the converter and follows the movement of the nose until the entire charge of blown steel has been emptied into the ladle. By means of a functionally designed bearing arrangement of the ladle lifting gear, the ladle is lowered in an arc that conforms to the path of the coverter nose; in other words it advances automatically as it is lowered. The full ladle is carried by the car across the converter shop to the pouring area, where it is picked up by the ladle crane. Electric power is normally supplied by drag cables, which is made possible by the relatively short distances that have to be covered.



Converter charging car with ladle to hold 32 tons of pig iron. Equipped with electrically powered ladle tilting and shifting mechanism. Controlled from coupled electric locomotive. (Clutch system Scharfenberg)

If the plant layout is such that the blown steel has to be transferred by cars operating on a track that runs parallel to the line of converters, another type of car is required which has the ladle lifting mechanism mounted on a swivelling upper carriage. As with the standard-type steel disposal cars, the ladle lifting mechanism can be operated either electro-hydraulically or fully electrically by a rack and pinion gear.

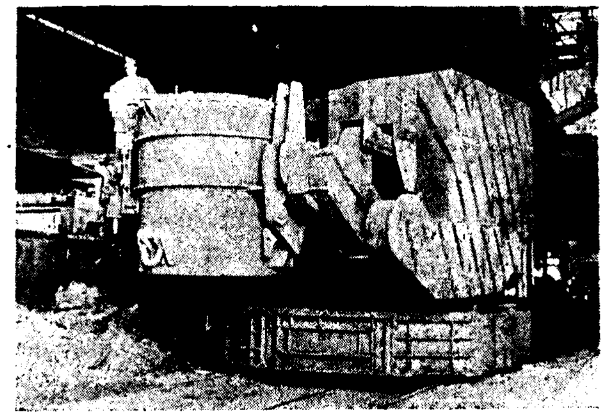
These steel disposal cars are sometimes equipped with a ladle tipping mechanism to permit their use for teeming the steel into ingot molds; they are then known as steel casting cars. The additional tipping mechanism is necessary to enable residual slag to be poured off, the ladle to be cleaned, and a new well block and stopper to be fitted. A special automatic locking feature is provided to make possible rapid and simple changing of the ladles. It enables a ladle fitted in the trunnion ring to be tilted without any further securing. Through the design of the tipping mechanism and the arrangement of the gears for transmitting the tilting movement to the trunnion ring, the ladle is forced to remain vertical at every height although the movement is arched. Moreover, it is possible for the gears to be totally enclosed. Steel casting cars are built by BAMAG for ladles of 60 tons and higher capacity. Power is usually carried by busbars installed under floor level and sometimes, but only rarely, by overhead cables. If neither system of power distribution can be employed, a diesel electric drive is used. In order to achieve a high level of operational dependability, in keeping with the aim of providing for a smooth run of steel production, BAMAG has developed a heavy, clearly and simply laid out construction that meets all requirements. All important parts of the cars are easily accessible and can be replaced if necessary with the help of a crane after removing the motor or cab housing at the corresponding point. The steel casting cars can be used to pour the molten steel into ingot molds either standing in pits or mounted on cars. In special cases they can be supplied for pouring both into pits and on cars, although this requires an extra-high ladle lift.



Lump-slag disposal wagon with tilting hopper for the carrying and dumping of converter skull and nose sloppings

BAMAG makes ingot mold cars in a complete range of load carrying capacities. Like the steel disposal and steel casting cars described above, they are of welded construction. In modern plant lay-outs that have the pouring shop and stripper shop located parallel to one another, so that the ingot mold cars operate in a straight and direct line between the two, the cars are driven by a permanently installed electric drag chain system. The system is remote controlled and is equipped to handle one or two cars at each stand with a capacity equivalent to a full charge. If the tracks on which the mold cars operate run down the length of the shop, the cars are shunted by a locomotive between pouring shop and stripper. In this case the cars are built for greater capacities and are mounted on bogies Automatic couplers are used to permit simpler and above all safer assembling of complete drags of cars.

When hot ingots need to be transferred over long distances they are carried in insulated box wagons closed at the top by a hood-like cover. These hot ingot transfer wagons provide the maximum safeguards against cooling down of the ingots beyond the desirable or permissible level. For short-distance transportation they are built in a non-insulated design permitting of quicker loading and unloading. Along short routes outside the reach of the crane hot ingots can be carried on small remote controlled electric-drive buggies. Travel can for instance be controlled by the operator of the soaking pit charger, who unloads the ingots from the buggies as they come from the stripper and lowers them into the soaking pit.



BAMAG 30 tons steel casting car

Within the restricted framework of this general text it is naturally not possible to present a detailed review of the complex transportation problems facing the iron and steelworks engineer and the equipment available to help him in finding the most satisfactory solution. It will however be seen that BAMAG's diversified programme of rolling stock construction covers practically every aspect of this vital part of successful metallurgical plant operation.

NEW LIMESTONE MINE TO BE COMMISSIONED AT BHILAI

The new limestone mine of the Bhilai Steel Works at Nandini will be formally commissioned on October 7. Governor of Madhya Pradesh H. V. Pataskar will perform the ceremony.

The Nandini mine has been provided with up-to-date equipment including several drills, large shovels and dump cars. A well-equipped crushing and screening plant has been put up about a mile away from the mine for reducing limestone boulders to required size before being despatched to the Bhilai Steel Works.

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BHILAI PIG IRON FOR LONDON MARKET

The first consignment of 2,000 tons of Bhilai pig iron which has left Visakhapatnam is on its way to the London market, it is learnt. It is for the first time that the Hindustan pig iron from Bhilai will be in the market of the United Kingdom. It is learnt that orders for the export of 8,500 tons of pig iron to London have been received by the Bhilai Steel Project authorities. More than 40,000 tons of Bhilai pig iron have already been exported to Pakistan and Japan.

COAL FOR POWER STATIONS DIRECT FROM THE MINE

Power stations automatically fed with pulverised coal direct from an automatic mine are the subject of a design project by a group of Moscow scientists.

Coal will be hewn and pulverised to a very fine dust by machines controlled from the surface. Transportation of the dust from the coal face to the furnaces, in quantities decided by the load, will be by compressed air tube conveyors.

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BILLET MILL AT DURGAPUR

Preliminary hot rolling trials in the Billet Mill at the Durgapur Steel Works were carried out according to a report from ISCON. It is capable of producing a range of billets from two inches to five inches square, slabs and shaped sleeper bars. These products will be used as stock for the merchat mill and the sleeper plant of the steel mill or will be available as billets to the re-rolling and forging industries.

Iron and Steel Production in the German Democratic Republic

By A Special Correspondent

WHEN the German Democratic Republic was founded ten years ago, there existed but one works producing pig iron, the "Maxhuette" at Unterwellenborn that had been completely deteriorated during the war. Metallurgical production in the eastern part of Germany in 1946 came up to merely 19 percent of 1936. Formerly the Ruhr District had been the metallurgical basis of Germany. In the G. D. R., apart from the "Maxhuette" — the steel works at Riesa, Groeditz, Brandenburg, there were smaller works at Thale, Ilsenburg, Burg and Auerhammer. After the war all these works were, in consequence of the fights, considerably damaged or they were dismantled, more or less, for preparations. For the construction of economy and the development of the country the creation of a metallurgical basis was indispensable. The government of the G. D. R. therefore made the solution of this task the main target of the first Five-Year Plan from 1950 to 1955. At the end of 1949 pig iron production came up to 250,000 tons per annum. For the G. D. R., a country with a highly developed engine construction industry and other industries the expansion of steel and pig iron production is indispensable. In the "Maxhuette" four blast furnaces were set going. The construction of the steel combine Stalinstadt was started in 1951. After less than ten months the first furnace was blown-in. Meanwhile six furnaces are in operation. The Seven-Year Plan provides for a further enlargement of the works. At Calbe on the Saale, the construction of the iron works west was started in 1951, and four years after ten pit furnaces were in operation. It was the first works of this kind in the world that was adapted to the use of acid home ores poor in iron and of lignite high-temperature coke. So far the G. D. R. is the only country that succeeded in lignite carbonization and in using lignite coke for metallurgical purposes. Within the next years the technical prerequisites will be created to work all ferrous residues of industry, besides the home ores poor in iron. A group of scientists of the G. D. R. has found out by experiments how to utilise flue-dust, dross and other industrial residues as raw materials for iron production. The ore and fluxes are pelletized before charging the furnace, thereby furnace operation is improved and accelerated and thus more and cheaper pig iron can be produced. Mixing and charging of furnaces is performed automatically. The first plants for this procedure are already in operation. Further, a new pit furnace is being constructed, which in contrast to the so far quadrangular furnaces, will be round and of higher capacity. The former pit furnaces for the smelting of iron ore are furnaces of 10 metres in height in which lignite hard coke can be used for fuel. The new round furnace is meant to provide experience for the construction of larger pit furnaces. These performances are due to the pioneer work of scientists and workers of the G. D. R., highly acknowledged by international circles of specialists. Parallel to the creation of the pig iron basis, the construction of steel mills took place. In Riesa, the steel works I, damaged during the war, was reconstructed, and in addition to it, a new modern steel works with three Siemens-Martin furnaces was erected. In 1950, the construction of the nationally-owned steel and rolling mill "Brandenburg" began that has eleven modern 140-ton Siemens-Martin furnaces at its disposal. The steel and rolling mill "Wilhelm Florin" at Henningsdorf has four 8-ton and a number of 40-ton Martin furnaces, and further 10 to 18-ton electric furnaces and one electric furnace for the slag mixing process. Further, the steel mill "Groeditz" was reconstructed and enlarged, and in Doehlen a refined steel works was built. The smaller works were also modernised and enlarged. The balance of these efforts is demonstrated impressively by the following figures reflecting the development of metallurgical production.

PRODUCTION OF STEEL AND PIG IRON IN THE G. D. R.

(in 1,000 tons)

	1936	1950	1955	1956	1957	1958
pig iron	202	337	1,517	1,574	1,662,9	1,774,9
Steel	1,199	999	2,507	2,740	2,894,5	3,043.0

Metallurgy has been set the task to increase the output of rolled sections of our own production and imports from 4. 5 million tons in 1960 to 6·3 million tons in 1965. In this connection the expansion of the production of refined and top quality steel, of special alloys as well as products of the second stage of manufacture is of particular importance. Thereby, the prerequisites for the extensive tasks of the metal-working industry are created which, above all, is to produce first-rate products, simultaneously when efforts are made to reduce metal consumption.

In the field of iron industry, the main share of investments within the next years will he concentrated on the expansion of raw steel and rolled sections production Simultaneously, the capacity for the refining and enriching of rolled sections is enlarged. In the Siemens-Martin steel mills, efforts are made to reduce the high charge of solid pig iron (at present over 550 kilogrammes per ton of steel). If the fixed charge of pig iron is reduced to a maximum quantity of 35 percent, the production of steel can be increased to 10 per cent. In the "Maxhuette", the use of oxygen-enriched air in all converters was advanced, resulting in an increase of Thomas steel production. By reducing the percentage of nitrogen to below 0·008 per cent a far-reaching assimilation to the serviceableness of Siemens-Martin steel is achieved. Oxygen metallurgy shall find wider application in the electric steel mills, to attain an increase in production apart from saving of electricity and recovery of important alloying constituents. Electric steel mills, not having oxygen plant at their disposal, for the time being use oxygen bottle batteries that have stood the test in the "Maxhuette" and in the refined steel mill Freital.

In accordance with the available chrome magnesite and forsterite stones further Siemens-Martin furnaces will be fully basic-lined, thereby with a temporary utilisation factor of at least 90 per cent, the smelting performance of these furnaces can be improved by 5 to 10 per cent. The far-reaching utilisation of smelting performance of basic-lined Siemens-Martin furnaces implies a sufficiently high heat supply and increased charging speed. The construction of the furnace has to comply with this basic lining. Closely connected is the application of automatic measuring and control plant, securing a correct heat and smelting performance as well as furnace operation which improves the quality of metallurgical products. As the temporary utilisation factor of the smelting aggregates, apart from the kind of lining of furnace maintenance and of heat transfer, mainly depends on the method and efficiency of repairs, great importance is attached to furnace-repair.

By means of radio-active isotopes investigations were performed on the closure of masonry in the bottom part—the hottest one—of the furnace, in the hearth and the revolving bar screen in order to state where the places of greatest wear of masonry are, and how fast the wearing process takes place. Valuable conclusions were drawn by these investigations for the maintenance and repair of furnaces as well as the smelting process.

Main feature of steel production in the G. D. R. consists in the production programmes being more varied than elsewhere in steel works. This is due to the various requirements of engine construction, electro-technology, chemical industry and building industry having many dimensions. The planned development of national economy has resulted in the full utilisation of all steel mills. The demand for steel, growing year by year, makes us enlarge the available steel capacities over the present performance by new constructions. The economical smelting process has to be particularly observed.

Except for the "Maxhuette", the steel mills of the G. D. R. have no blast furnaces, and. in view of the raw material situation, are working on the principle of pig-iron scrap smelting in Siemens-Martin or electric furnaces without the possibility of transferring the required pig iron from the blast furnace over the mixer into the steel smelting furnace in a fluid state, as it is generally the case in mixed metallurgical works. The charge of fluid pig iron, however, means from the very beginning an increase of performance in the steel mills by 15 to 25 per cent.

With regard to the limited space of the works as well as the situation as to raw material, the construction of blast furnaces in the G. D. R. is inexpedient. Therefore, pre-smelting aggregates shall be introduced that require less space than blast furnaces and are operated on the basis of petroleum, inferior pit-coal coke mixed with lignite coke. This process is now being tested in the steel mills.

Over and above this, the attention is being given to a further process of steel making. This process is already applied in the "Maxhuette" and in smaller foundries. In comparison with the Siemens-Martin process the converter process, owing to strong mechanical mixing, permits of keeping the necessary heat quantities by chemical reactions within a comparatively short space of time without additional conveyance of outside heat. This process is of greatest economic significance in so far as the expenses for the erection of a convert plant amount only to one-third of the expenses for a Siemens-Martin plant of equal capacity. The disadvantage is that the pre-material can only be charged fluidly in the converter and may only bear a certain percentage of some accompanying elements like silicium, sulphur and phosphorus. In the end, the oxygen contained in the air by the turbulent motion of fluid can result in cracking of brittleness later on at lower temperature and its strain on the manufactured steel. The converter steel that is smelted on the usual process is therefore applicable as structural steel, but only conditionally useful as constructional steel. Therefore, new processes were developed. The use of oxygen-enriched air or the application of an oxygen-steam mixture in the converter process enable to obtain new qualities of steel with a very low percentage of phosphorus and nitrogen as well as high cold working property that up to now were only left to the Siemens-Martin furnaces. Apart from that it is possible, by the mixing of converter and electric steel with the slag-alloy processes in the kettle, to increase the production of steel of first-rate quality.

In the nationally-owned steel and rolling mill "Wilhelm Florin" at Henningsdorf a converter plant was constructed with the available cupola smelting furnace that produces free cutting steel for high cutting speeds which is cheaper than the free cutting steel produced in Siemens-Martin furnaces and possesses more favourable properties. The converters were placed in a manner that a new oxygen evaporation plant can be set working soon in order to test the oxygen blast process plant for the production of blast steel on a small scale. After the conclusion of tests, the free cutting steel needed in the G. D. R. shall be additionally produced and simultaneously, the oxygen blast process shall be introduced on a larger scale. At the moment it is being tested as to how far the application of hot blast cupola smelting furnaces in connection with the blowing-up process is more economical contrasted with another process of steel production, and which qualities can be achieved by the connection of converter and electric furnaces. These experiences will be of consequence to the planned extension of the steel combine of Stalinstadt where within the next years converters will be erected that are to work together with electric furnaces. The converter steel production at Henningsdorf brings an annual retrenchment of 8 million marks foreign currency. Therefore it is to be increased by 36,000 tons per annum in order to cover the demand for free cutting steel out of our own production by 1965.

The development of metallurgical production takes place in close co-operation with the metallurgists of the Soviet Union and other socialist countries. The development of metallurgy in the G. D. R. to the present level is a remarkable performance of workers and intellectuals. By joint efforts, they developed this industry literally from nothing and today they are providing metallurgical products of high quality and have mastered complicated technological process. There is no doubt that our metallurgy will also accomplish the high targets of the Seven-Year Plan.

CHEMICAL ANALYSIS OF IRON AND STEEL

The Indian Standards Institution has recently published IS: 228-1959 Methods of Chemical Analysis of Pig Iron, Cast Iron and Plain Carbon and Law-Alloy Steels which is a revision of the same standard published in 1952. Although iron and steel industry is well established in this country, the various laboratories are following different methods of chemical analysis for iron and steel. As the results reported are not always in agreement, a necessity was felt for prescribing standard methods. Consequently, this standard was published earlier as a tentative standard. As a result of experience gained during the working of this standard, it has been decided to issue it as a firm standard after expanding its scope, apart from general improvements, to cover analysis of some more elements which may, sometimes, be required for commercial transactions.

This standard covers procedures for the chemical analysis of pig iron, cast iron and plain carbon and low-alloy steels.

For the purpose of this standard, low-alloy steels are intended to include steels containing chromium not more than 1.0 percent, nickel not more than 5.0 percent, copper not more than 0.50 percent, titanium not more than 0.25 percent, molybdenum not more than 0.30 percent, and vanadium not more than 0.10 percent.

The methods of analysis prescribed in this standard have been prepared with a view that they shall be useful as reference methods in case of dispute and suitable alternate methods have also been given for determination of some elements. Due consideration has been given, in the preparation of this standard, to the facilities available in the country for such analysis.

The Position of Iron and Steel Industry in Yugoslavia

By An Engineering Correspondent

WITH the development of the Iron and Steel Industry in Yugoslavia a sound basis for the successful expansion of all the industrial activities, building trades, land, river and marine transport and for an intensive mechanization in agriculture has been established. The index of increase in the scope of production of the iron and steel industry in 1958 as compared with 1939 (index = 100) amounted to 536 while the index of the increase in the physical scope of aggregate industrial production during the same period increased to 345. The increased production of the iron and steel industry enabled a considerable increase in the volume of production of those industrial branches which consume steel in large quantities as semi-finished products in the production of capital investment equipment or consumer goods. Thus, for instance, during the period under review, the electrical industry production increased by almost 31 times and the production of the engineering and metal processing industry by about 5.9 times. The production of shipbuilding and building industries likewise recorded an increase.

The production of iron and steel industry in 1958 as compared with 1939 and 1954 amounted to (according to the "Index" of the Federal Statistical Office):

(in 1000 tons)

Product	Production			Index	
	1939	1954	1958	1954 39	58/39
Iron Ore	667	1,111	1,997	167	3000
Pig Iron	101	356	748	350	740
Crude Steel	235	616	1,119	260	475
Rolled Steel	151	411	766	272	505
Drawn Steel	2.5	19.2	37.1	770	1,490
Forged Steel	0.4	8.0	18.3	2,000	4,550

The per capita production of crude steel in 1939 amounted to about 15 kilos and in 1958 to about 61 kilos and the consumption (apparent = production + imports − exports) to about 69 kilos. Despite the high post war increase in the production of iron and steel industry, it is impossible to fully meet the steel consumption either quantitatively or in range, of the country which is under-going an intensive economic development. The output of finished steel products was sufficient to meet only about 75 percent of last year's demand. The balance was met by imports chiefly including all flat profiles (tin plates, sheets, strips rolled wire and other special profiles, for which there are not corresponding rolling mill capacities or other processing plants. On the other hand it was possible to export 14 to 15 per cent of the finished steel products of our own production including the products (Semi-finished manufacturers, iron profiles, reinforcements bars, tubes) which were not absorbed by the local market.

The trend towards a steady, comparatively high, increase in the gross national product and particularly the continual increase in industrial production seems to indicate that in the future one should still reckon on a continual steady increase in steel consumption, particularly if one considers that there are all the requisite conditions for a further successful development of steel consumption in the engineering industry, electrical industry, shipbuilding industry, transport and building both for the production of consumer goods (in connection with the steady per capita national income) and for the needs of investment development. In this conjunction it should be borne in mind that the actual steel consumption in the country is at present much greater than the apparent consumption, as the imports of finished products of the metal processing industry considerably exceed the exports from domestic production.

When during the ensuing years all the capacities of the still incompletely built plants are fully utilized, domestic production will amount to about 1·0 million tons of finished steel products, and the share of sheet products will amount—conditioned by the pattern of the present equipment of the plants—to only about 26 to 27 per cent. However, the reorientation in the structure of metal processing industry production in favour of an increased production of consumer goods, and the steadily growing application of modern methods in the production and technology of the engineering industry (the introduction of steadily growing production of welded structures, etc.) will result in a steady growth of the share of all kinds of sheets and strips in the total steel consumption. The share of these assortments in the country's total steel consumption now amounts to approximately 40 per cent.

Although in the future a part of the steel products will be replaced by aluminium and plastics, there will still be a deficit in the country's supply with steel products from her own production, particularly in sheets and strips. Accordingly, a continued increase in imports of steel products is to be expected.

However, during the post war period, in Yugoslavia considerable new deposits of iron ore, were discovered particularly in Macedonia and these will facilitate a further increase in the production of pig iron and steel over a period of years to come. If we add to this the fact that the country has huge reserves of still untapped cheap water power and low value coal such as lignite then one can readily understand the decision adopted by the competent authorities in Yugoslavia to increase during the next 12 to 14 years the output of the iron and steel industry to a figure of about 3·1 million tons of crude steel per annum. Such an increase will be achieved by the use of modern technical and technological achievements in all the stages of metal and iron ore processing into finished steel products.

The planned increase of production capacities is to be achieved by the development of a new steel plant in Macedonia, a considerable increase of the capacities in the existing steel mills of Zenica, and the reconstruction and modernization of the plant in other smaller steel mills existing in the country. In further developments special care will be taken to see that such capacities are erected which will ensure optimum economical production and to properly distribute the production programme among the various mills. Thus the Yugoslav steel mills will be producing the special kinds and ranges of products for whose production they are most suited.

Increased steel production will be made easier by the fact that in the country there are available sufficient quantities of the essential raw materials for the production of all the auxiliaries such as all kinds of refractories, ferro-alloys, limestone, etc.

REFRACTORIES FOR STEEL PLANTS

The following three Indian Standards Specifications prepared recently by ISI prescribe the requirements for various refractories materials used in steel plants:

(1) IS:1523-1960 Bottom Pouring Refractories for Steel Plants.

(2) IS:1524-1960 Refractory Sleeves for Steel Plants.

(3) IS:1525-1960 Ladle Refractories for Steel Plants.

These standards belong to a series of Indian Standards being prepared by ISI in order to meet efficiently the requirements of the industry in the country.

Refractories required by steel plants constitute the bulk of production of the refractory industry. The requirements of refractories for steel plants have greatly increased with the establishment of three more steel plants in the public sector and with possible further expansion during the Third Five-Year-Plan period. The quality refractory to be used in different units of the steel industry varies depending upon the performance requirements. With a good quality refractory for a particular location, there would be no need for frequent replacement, thus contributing to increase production of steel and cutting down cost of maintenance.

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METHODS OF SAMPLING IRON ORE

The Indian Standards Institution has published draft standard methods of sampling iron ore for determination of ore sizes, moisture and chemical composition. The draft standard details the procedure for sampling of iron ore from stockpiles, loaded rail wagons, conveyor belts etc.

"Ajax" Oxygen Process gives more Steel from Open Hearth Furnace

By A Special Correspondent

During a recent four-week period, the AJAX furnace produced a record 19,263 tons of steel, making over 5,000 tons per week in three of the four weeks. This is believed to be the highest output ever attained by an open hearth furnace in England.

IMPORTANT modifications to a 350-ton tilting open hearth furnace at the Scunthorpe works of Appleby-Frodingham Steel Company, a branch of The United Steel Companies, Limited, have led to a substantial increase in steel output compared with normal furnaces for approximately the same cost per ingot ton of steel. This has been achieved by the use of oxygen in the specially-adapted furnace.

Experiments in the oxygen lancing of open hearth furnaces have been carried out at Appleby-Frodingham since 1950 and have led to some exceptionally high rates of production. The higher outputs were partly offset, however, by such factors as severe roof wear and repeated blocking of the furnace chequers by dust. It became apparent that very considerable changes in furnace design and structure would be necessary in order to develop an efficient oxygen process and that this could only be proved by full-scale trials. The demand for ingots to supply the company's rolling mills dictated a stringent time schedule for the reconstruction, and it was in fact accomplished in 27 days. Trials began on the modified furnace-which was given the code name of *AJAX* to distinguish it from conventional furnaces-in February of this year, and over 100,000 tons of steel have since been produced by the process.

DETAILS OF RECONSTRUCTION

At the chimney end of the furnace, the first problem to consider was that of gas cleaning in order to deal with the increased amount of suspended matter carried out by the waste gases while using oxygen and to avoid excessive atmospheric pollution. On grounds of economy in capital cost and the very low air infiltration expected, it was decided to instal a dust removal plant with a capacity much below that for an open hearth furnace of comparable production potential. Available evidence indicated the bag filter type as the one most suitable for this experimental furnace.

In order to minimise the volume of gas to be cleaned, the whole structure of ports, uptakes, slag pockets, regenerators and flues in the reconstructed portion of the furnace was completely encased in steel up to the junction of the main stack flue in the valve arch. Flexible packing joints are provided at every junction and at every inspection or cleaning hole.

The *Ajax* furnace regenerators are much smaller than those on a conventional furnace so that they can be blown easily and quickly with compressed air lances at frequent intervals. The height of the chequer filling is similar, but the maximum gas flow rate more nearly resembles that of a blast furnace stove than an open hearth regenerator. The small cross-sectional area of the regenerator has an additional advantage when using oxygenated air to assist combustion in that no added oxygen is lost through the structural brickwork.

The area of the offtake from the furnace hearth was also considerably reduced for four main reasons: (1) To lift the furnace end bank as high as possible in order to through the port at an angle of 27 degrees. The lance is fixed to a movable, motor-driven carriage and withdrawn at each reversal of gas and air; it can be changed in 35 minutes.

Coke oven gas burners are inserted in each corner of the tilting portion of the hearth instead of through the port ends; this helps both to avoid any enlargement of the port and the addition of more trailing flexes. Oxygen can be used to assist combustion when required and is fed into the burners through two holes just below each gas inlet. For rapid melting, this placing is not very efficient but is quite adequate for holding the bath temperature at the end of refining, when burning in dolomite or heating up scrap.

The thermal input of the furnace is low by design and, without oxygen, it would produce steel at probably no more than 10 to 12 tons per hour compared with 25 to 35 tons per hour when on oxygen.

Comprehensive controls and instrumentation are provided, all valves being centrally operated by electric pushbuttons to achieve the rapid manipulation which is essential to the successful operation of the process. The controls enable oxygen to be used in three ways: through the water-cooled lances, through the coke oven gas burners or through the regenerators as an addition to the air. The latter is possible because of the freedom from infiltration.

Experience gained during several months of continuous operation of the *Ajax* furnace has proved the value of the process in raising steel output without incurring heavy capital expenditure and at no greater ingot cost. But there are still many problems to be solved. Losses of iron in the slag, for example, are higher than in the normal Appleby-Frodingham practice It still remains to be discovered how these losses can be reduced without slowing down the process: the furnace taps every 7 to 8 hours compared with the normal practice of 14 to 16 hours and to retard it would only increase costs without a comparable saving in iron. An improvement in roof life is also sought, although the extra costs here are balanced by savings in 'below stage' refractories. Finally, there is further work to be done on the life of the oxygen lance and the best gas velocity when lancing. The *Ajax* furnace is now the largest steel producing unit at Appleby-Frodingham and, in view of the rapid progress already made with its development, it seems unlikely that any of these problems will be found to be incapable of solution.

NEW INSTRUMENT FOR GEOLOGISTS

With heavy loads on their shoulders, geologists have to travel through marshes, sands and deep snow in search of minerals. Much is being done to lighten their work. Today they have at their disposal helicopters, planes and all kinds of instruments. Not long ago they received another "clever" instrument, called magnetometer. I. Karasyov, chief designer of the insrument, described it thus:

"Up till now, in order to determine the magnetic field of an ore deposit, geologists had to conduct the levelling of the terrain, use the theodolite and make all kinds of calculations. This work was done by a whole geological party.

"The instrument which we have recently offered for mass production will enable the geologists to do without unwieldy instruments. It ensures speed and accuracy in determining the various parameters of the magnetic field. It has a self-orienting device. On a special scale it shows the direction of the occurrence of ores along the vertical and horizontal. It weighs only about 6 kilograms."

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A CRANE 156 METRES HIGH

Trainloads of parts of a huge concrete-layer crane for the Bratsk hydro-power station are leaving these days the S. M. Kirov Transporting and Hoisting Equipment Plant. It is the third unique machine which will take part in the construction of the hydro-power station. Two similar cranes are already operating at the site.

The crane has no equals in efficiency and other technical indices. It is 156 metres high and weighs 430 tons. Its bucket holds 22 tons of concrete. Cars with concrete are delivered to it along four railway tracks laid between its supports. The crane is operated with the help of television, radio and telephone.

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SOVIET SPECIALISTS HONOURED FOR WORK IN BHILAI

The Presidium of the Supreme Soviet of the USSR has awarded orders and medals to 257 Soviet specialists for their work in building the Bhilai Iron and Steel Plant which is under construction in India under the economic cooperation agreement between India and the Soviet Union.

The Order of Lenin has been awarded to 12 persons, the Order of the Red Banner of Labour to 38, the Order "Badge of Honour" to 53, and the Medal "For Valiant Labour" to 154 persons.

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BHILAI PRODUCES ONE LAKH TONS OF STEEL BILLETS

Workers completed production of the first one lakh tons of steel billets in Bhilai on 19-5-60.

Production of billets at Bhilai commenced on 24th December, 1959 when the billet mill of the Steel Works was inaugurated by Union Minister for Steel, Mines and Fuel, Sardar Swaran Singh.

Upto now 88,000 tons of steel billets have been despatched from Bhilai to re-rolling mills in the country.

Physio Chemical Properties of Some Heat-Resisting Alloys

By
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Introduction

THE field of application of heat-resisting alloys is wide and constantly expanding. The tests which are carried out in the ordinary way at normal temperature are of less significance or of no value in indicating the behaviour of a steel either at sub-zero or at elevated temperatures. Modern developments in the high temperature field demand materials of high working efficiency and of exacting nature in regard to strength and freedom from any but the smallest dimensional changes under the strict working conditions. Due to 'Creep' the normal mechanical properties of steels as used for design purposes at ordinary temperatures cannot be similarly applied at elevated temperature conditions of service.

At temperatures above about 350°C, steel behaves in a viscous rather thanelastic manner and yields continuously to applied stresses Under such conditions, the elastic limit, yield point and the maximum stress do not remain as well defined properties but depend on the applied stress and rates of loading ; as such these properties cannot be used for any such design purposes where sustained loads have to be borne. In such cases, creep strength of the material viz. the stress to produce a certain rate of deformation at a certain temperature is taken into consideration for any design purposes. Since scaling does not occur to a very serious extent at temperatures up to 550/600°C, steels for use at temperatures up to the above temperature range should be of high creep strength and immune from any tendency to embritlement after prolonged heating at elevated temperatures. For steels to be used at temperatures above 650°C, resistance to scaling becomes more important. At such elevated temperatures, high creep strength is not maintained and heat-resisting properties become more important which necessitates use of high alloyed steels including austenitic heat-resisting steels. As high temperature engineering is still in the stage of development, the field of usefulness of high heat-resisting steels is constantly expanding.

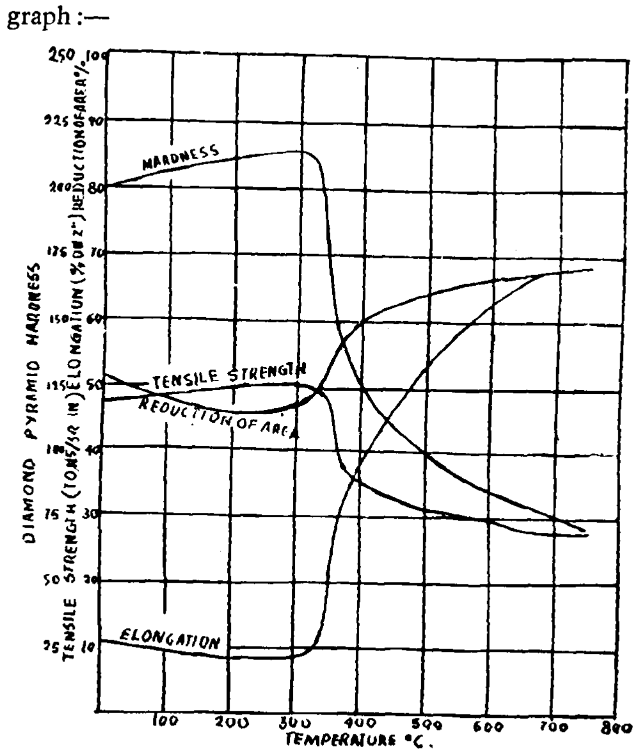
In this technical note, a review has been made of some of the commercially available heat-resisting alloys which have been classified according to the maximum service temperature for which they are suitable, including their physical and mechanical properties, creep properties, scaling resistance and typical applications. Development of high creep strength alloys is progressing constantly and covering a wide field of applications still many more are yet to be developed to cover the remaining uncovered portion of this field.

(ALLOYS FOR USE UP TO 500/550° C)

Several non-ferrous alloys as well as a few low alloy-ferritic, heat-resisting steels could be grouped together for use at the above temperature range. In the non-ferrous group the 5 / 7% and 10% Aluminium Bronzes ; the Monel alloys - Monel metal, Monel K, Monel H and Monel S and in the ferrous group, certain carbon-molybdenum and chromium-molybdenum steels have been found to be quite suitable for industrial applications in high temperature steam boiler, Power and Chemical Plant etc.

(5/7% ALUMINIUM BRONZES)

The 5/7.5% aluminium bronzes consist of a homogeneous alpha phase and suitable both for hot and cold working. They also possess good ductility and capable of being worked into tubes, sheets, strips and wires for use as condenser tubes, pump-parts, fans and impellers exposed to corrosive action. The single phase aluminium bronzes cannot be heat-treated but could be cold-worked to improve both the room-temperature and elevated-temperature strength as these alloys are not completely softened after cold work until at least a temperature of 650°c is obtained as could be seen from the following graph :—



Annealing of an Alloy containing 93 per cent Copper and 7 per cent Aluminium

MECHANICAL PROPERTIES 7% ALUMINIUM BRONZES

(Cu 93.25% Al. 6.7%)

Temperature °C.	Tensile strength Tons/Sqr. inch.	Elongation %	Condition of Specimen
15	20	70	Sand cast
15	46	10	30% cold drawn
15	28.8	71	Hot rolled
300	20.9	25	,, ,,
400	17.9	16	,, ,,
450	13.3	10	,, ,,
500	10 9	14	,, ,,

CREEP PROPERTIES 7·5 ALUMINIUM BRONZE

(Cu 92·5% Al. 7·5%)

Temperature	Stress Tons/Sq. inch for creep strain of 1·0% in 10,000 Hours.
295	4·46
450	1·34

Non-scaling properties of aluminium bronzes is very significant of all the copper-base alloys on account of their resistance to oxidation even up to 900 C. These alloys are also resistant to attack by flue gases containing sulphur-dioxide, hydrogen-sulphide or other acid vapours at elevated temperatures.

10% ALUMINIUM BRONZES

The 10% aluminium bronzes are produced in the form of castings, forgings, bars, rods etc. conforming to various standard specifications. These alloys can be cold-worked only to a limited extent but readily hot-worked by rolling, extruding, forging, stamping etc. and also formed by sand and die-castings and mostly used where resistance is required against the corrosive action of sea-air, sea-water steam etc. as bearings, pump parts, fans, impellers steam valve seats, cylinder heads etc. Most of the products are used in the forged, normalised or cast condition ; for engineering applications at higher temperatures, heat-treated materials are however used. This heat-treatment is mostly a stabilizing treatment which increases the creep-strength at the cost of room-temperature ductility. The mechanical properties obtained from a 10% Aluminium Bronze at elevated temperatures after giving a suitable stabilizing treatment are as quoted below. Scaling properties of 10% Aluminium bronzes are almost the same as those of the 5/7% Aluminium Bronzes.

MECHANICAL PROPERTIES

Aluminium Bronze containing 9.5% Al. normalised at 800°C, re-heated to 500 C for 60/70 hours followed by slow cooling.

Temperature 0°C.	Max. stress Tons/Sq. inch.	Elongated%	Reduction of area	Izod Ft./Lbs.
20	30/40	15/30	10/30	12/30
400	15/22	25/65	25/65	—
500	8/11	—	—	—

For better creep-strength properties at elevated temperatures, the complex alloys containing Nickel, Iron, Manganese have been found to be superior to normal bianary aluminium bronzes. An aluminium bronze having 9.5% Al. and 3.5% Iron stabilised as per heat-treatment quoted above has been found to exhibit the following creep properties.

Temperature	Stress Tons/Sq. inch. for creep strain of 1% in 10,000 hours.
250	11.0
400	2.5

THE MONEL ALLOYS

The monel alloys are the proprietary alloys of M/s. Henry Wiggin & Co. Ltd., Birmingham conforming to various standard specifications. The nominal chemical composition of these alloys are as quoted below :—

MONEL ALLOYS—MAKERS HENRY WIGGIN

Trade Name	Chemical composition (Average)
Monel L	Ni 67.0%, Cu 30% + Fe 1.4% + Mn 1.0%
Monel H	Ni 67.0%, Cu 30% + Si 2.75/3.0%
Monel K	Ni 66.0%, Cu 29% + Al. 2.75% + Fe 0.90% + Mn 0.40% + C. 15% + Si .25%
Monel S	Ni 67.0%, Cu 29% + Si 3.75/4.00%

Monel metal is used for marine propellers, shafts, valve seats and spindles in steam up to 420°C, sheath for immersion heaters, springs operating in corrosive conditions up to 400°C. Monel metal cannot be heat treated but cold-work hardened.

MECHANICAL PROPERTIES AT ROOM TEMPERATURE

Property	Hot rolled	Cold drawn	Sand cast
Maximum stress			
Tons/sq. inch.	34 - 38	40 - 45	23 - 33
Proof stress 15%			
Tons/sq. inch.	15 - 18	35 - 40	11 - 15
Elongation %	35	15 - 20	16 - 40

MECHANICAL PROPERTIES AT ELEVATED TEMPERATURE OF HOT ROLLED MONEL

Temperature 0°C	Maximum stress Tons/sq. inch.	Limit of proportionately Tons/sq. inch.
200	33	13
300	34	12
400	32	10
500	28	6
600	20	—
700	14	—

Creep properties as measured in stress tons/sq. inch for 0·10% creep strength in 1000 hours at 425°C and 450°C are 8·9 and 7·8 respectively.

Monel 'K' is used for similar purposes as Monel metal. It could be hardened either by cold-work, heat-treatment or both. Normally the alloy is tempered at 500/600°C for a few hours followed by slow cooling and softened by heating to 750/800°C followed by quenching in water or oil. Mechanical properties at elevated temperature are higher than these of Monel metal. At about 600°C, the maximum stress and 0·2% yield stress are about the same 38 tons/sq. inch with 2% elongation. Creep properties are also higher. At 425° and 475°C, stresses in tons per sq. inch to produce a strain of 0·10% in 1000 hours are about 21·0 and 11·5 respectively.

Both Monel 'H' and Monel 'S' are of special casting grades and used in bearings, valve bodies etc. Monel alloys have good resistance to corrosion both at ordinary and elevated temperatures and could be used without progressive scaling upto 500°C but these alloys are corroded by chlorine, sulphur-dioxide, ammonia etc. in the presence of water or condensed water-vapour.

LOW ALLOY FERRITIC HEAT-RESISTING STEELS

Steels for use up to a temperature of 550°C are primarily of high creep strength quality since heat-scaling at the above temperature range does not occur to any serious extent. A few low alloy steels like carbon-molybdenum, chromium-molybdenum, molybdenum-vanadium types have been found to possess better heat-resisting properties at the above temperature range. In this connection Hadfield's "Era 131", "Era 131 B", "Heela 153" and "ERA 147", Samuel Fox "Esshete D 4C", "Fsshete CML", "Durehete", Jessop's 'H-40', 'H 27' as well as Firth Vickers 'Moly-vand' steels have been found to be quite useful for applications as heat-resisting material to work in the above temperature range.

Carbon-molybdenum steels are usually of low carbon content and therefore could be easily worked into tubes, plates etc. for applications as superheater-tubes, boiler drums, valve bodies, turbine castings etc. It has been found that of all the elements, molybdenum greatly increases the creep strength of a steel up to a maximum temperature of 550°C. Chromium-molybdenum steels are characterised by a high tensile strength at normal temperatures and therefore used where higher cold-strength is necessary such as for autoclave bodies, steam and flange bolts etc. The presence of chromium does not increase the hot-strength of these steels but increases the cold-strength after proper heat-treatment and when present in proportionate amount, greatly enhances the resistance of the steel to the attack of sulphur compound, hydrogen fissuration and similar other reagents, molybdenum-vanadium steels are characterised for high creep properties.

Chemical composition, mechanical properties and typical uses of some of the above proprietary steels are indicated in the tables. Mechanical properties of some of the above heat-resisting steels at high temperature (400°–500°C) are also described below :—

Mechanical properties at high temperature

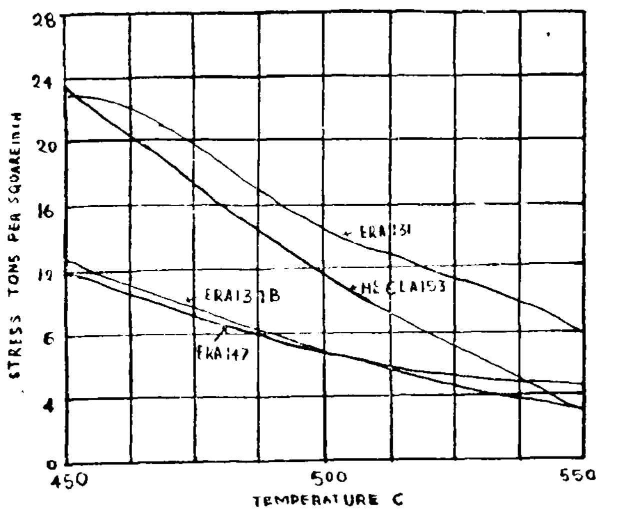
RATE OF LOADING 10 SECONDS PER TON QUICK FULL TEST

Heat-treatment	ERA 131B Annealed			ERA 131 Normalised			HECLA 153 Oil quenched & Tempered			ERA 147 Air cooled & Tempered		
Temp. 0°C.	400	450	500	400	450	500	400	450	500	400	450	500
P. L. Tons/sq. inch.	8·0	6·8	5·1	10	8 5	7·7	32·5	30·3	29·5	9	8·2	7·0
M. S. Tons/sq. inch.	28	23·5	20·0	40·1	35·5	33·5	55·0	50·0	44·0	30	27	25·2
E%	43	41·5	38·4	28	26·0	23	22·7	25·0	27·0	27	28·4	32·5
R of A%	76	75·4	74·0	67	65·4	66	62·3	71·5	77·0	60	63·0	67.2

TABLE

LOW ALLOY HEAT-RESISTING STEELS TEMPERATURE RANGE 400°C — 600°C

Trade Name	Manufacturer	Composition of Type	Heat treatment	Mechanical properties at Room Temp. U. T. S. Tons/sq. inch	Proof stress 0·10% Tons/sq. inch	Elongation %	R of A %	Coelticient of Expenses	Uses
1	2	3	4	5				6	7
Esshete D-4C	Samual Fox	0·10% C 0·50% Mo	Normalised 900°C/950°C	27/33	14 (Min)	30 (Min)	60 (Min)	20°/500°C 14·7 x 10^{-6}	Super-heater tubes, pipe lines up to 510°C
Heecla 153	Hadfields Ltd.	0·40% C 1·00% Cr 0·40% Mo 0·80%	Oil-quenched 840°/860°C Tempered 500°/700°C	65/75	55 (Min)	16 (Min)	40 (Min)	20°/450°C 14·0 x 10^{-6}	Steam pipe, Flange bolts, valve bodies, spindles etc.
H-40	W. Jessop & Sons	0·20% C 0·50% Mo 0·50% W 3·00% Cr 0·70% V	Air Cooled 1060°C Tempered 670°C	55·0 (Min)	40/45	20 (Min)	60 (Min)	20°/600°C 13·6 x 10^{-6}	Non-austenitic High creep resisting steels, gas turbine rotor discs.
Era 147	Hadfields Ltd.	5·00% Cr 0·50% Mo	Annealed	35·8 (Min)	16·0 (Min)	35·5 (Min)	65 (Min)	20°/500° C 12·8 x 10^{-6}	High pressure chemical Plant Resists oxidation and sulphur scaling to 600°C.
M-V	Firth Vickers	0·18% C 0·16% Cr 0·27% V 0·50% Mo	Normalised 950°C	47·0 (Min)	37·0 (Min)	27·0 (Min)	66 (Min)	20°/600° C 14·0 x 10^{-6}	Turbine discs.



CREEP STRENGTH
(The value is based on a rate of creep of 0.% per 1000 hours (10.6) after subjection to load for a period of 1000 hours)

Heat resisting alloys for general engineering purposes include alloys for use up to 700°/750° C, steels for uses up to 800°/850° C, 900°/950° C, 950°/1000° C, 1050°/1100° C, 1100°/1150° C and steels alloys and metals up to 1200° C. High temperature engineering is fast developing and many more new metals, alloys and steels will be added to the list in future with still better creep-strength and heat-resisting properties.

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LARGE METALLURGICAL WORKS COMMISSIONED IN USSR

The construction has been completed of a large metallurgical works which will manufacture light alloy articles. Equipped with first class machinery, this works, named after Lenin, opens up new prospects for the use of light alloys in the Soviet economy.

The construction was effected at a high technical level with the large-scale application of industrial building methods. This resulted in a high effectiveness of capital investments.

For a number of articles the works has already attained designed capacities.

The leading engineering works of the Soviet Union, scientific research and designing organizations have made their contribution to the building of the Lenin Metallurgical Works. For million cubic metres of earth were removed on the job, over 300,000 cubic metres of concrete and reinforced concrete structures were poured or assembled, 100,000 to technological equipment were manufactured and installed.

In spite of the high chimneys towering over the production blocks no smoke is seen, for the works uses local gas as fuel. Automated rolling mills are installed in the shops. Everything is mechanized. All the complex machine-tools, instruments and automatic devices are Soviet-made.

A housing estate with a total living floor area of 70,000 square metres has been built for the workers. Schools, kindergartens, creches, a palace of culture, a gymnasium and a stadium seating 20,000 have been opened.

A meeting of the building workers was held to mark the commissioning of the Lenin Works. An ovation met the message of greetings from the Central Committee of the Communist Party of the Soviet Union and the Council of Ministers of the USSR which was read out by Dmitry Polyansky, Chairman of the Council of Ministers of the Russian Federation and member of the Presidium of the Central Committee of the Communist Party of the Soviet Union.

Specialists at the works believe that the designed capacity can be surpassed before long.

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RECORD OUTPUT FROM OPEN-HEARTH FURNACES

Last year 237.5 thousand tons of steel from each 185-ton furnace were produced by operators of an open-hearth block of the Zaporozhstal Works in the Ukraine.

This is not only an all-time high in the USSR, a TASS correspondent was told by the plant manager Lev Yupko, Hero of Socialist Labour, but also a world record. It is tens of thousands tons above the output of 185-ton open-hearth furnaces in West European countries and 60 to 65 thousand tons above the output of similar furnaces in the United States.

Outstanding Castings at Engineering Materials Exhibition

By An Engineering Correspondent

A collection of more than 50 outstanding castings which were selected from firms throughout Britain by the British Steel Founders' Association, Sheffield, were the main features at the Engineering Materials and Design Exhibition held in London, from February 22 - 26, 1960.

The British steel foundry industry were hopeful that this collection will sh w that there are considerable facilities in the U. K. for the economic production of components of all types for a wide variety of industrial purposes.

OVERALL ECONOMIES

The examples which were on display, either by actual casting or photographs, ranged from golf clubs to the hydraulic cylinder for a 105,000 ton tanker. They helped to show how steel castings have actually replaced components previously fabricated or forged; how they have enabled a saving in direct cost or weight and how overall economies have resulted with its longer life and reduced maintenance.

At the same time, they showed how designers used steel castings to introduce strength where wanted or lightness where desirable as well as allowing redesigning to take place to give full effect to the greater freedom afforded by steel castings. The various displays also spotlighted how the problems of thermal and mechanical shock, wear or distortion have been successfully countered in this process.

Many steel foundries have been developed in various areas in Britain to supply the specific needs of individual industries but continued research has greatly extended material specifications and ways in which materials can be used.

MANY ADVANTAGES

Today, steel castings play a vital part in industry and modern foundry techniques are such that, apart from cases where complexity rules that only the casting process can be employed, the most economic means of producing many components is by casting in steel.

Even where there is no immediate cost advantage the strength and rigidity of cast steel, and the freedom afforded in design to distribute weight and lightness where needed, mean that the overall cost of steel castings can be lower than that of competitive materials by virtue of longer life and lower maintenance costs.

The various individual exhibits showed the wide range of modern foundry techniques, and the advantages that can be gained by consultation with steel foundry engineers at the earliest possible stage. Direct cost saving is most clearly shown by the diffuser vanes for atomic energy application, by the coal cutter gearbox, by the winch gear ring and gearbox top cover for mechanical handling, by the idler hub centre for earth moving equipment where steel castings have replaced fabrications with direct cost savings of from 12 to 60 per cent. Similar direct cost advantages are illustrated at the exhibition by bung bush for breweries, an axle box for railway goods wagons, a splicer bar for hot drawing of gas cylinders, golf club heads, fly wheels for automobile diesel engines, a bearing saddle and eccentric straps for large marine diesel engines.

WIDE RANGE OF APPLICATIONS

The bearing saddle casting also affords an example of a technique now becoming even more widely appreciated by designers. Nowhere have more marked advances been made in recent years than in the extension of the range of steels which can be welded. This has widened the application of sound engineering principles in the design of components and assemblies and is resulting in the increased use of steel casting—often in conjunction with fabricated or forged parts.

Savings resulting from reduced machining times are represented by a slip for oil-drilling equipment, a reactor guide pan and lantern for atomic energy use, an anvil for a large steam hammer and by a terminal header and nozzle segments. These latter two also illustrate the technique of producing small components by precision casting, a method which can give worthwhile economies where repetition work with alloy steels is involved.

Longer component life, in many cases enhanced by reduced maintenance costs and greater working efficiency, is shown in a coil lifter for steelworks, an excavator bucket for earth moving, an automatic coupler and draftgear for mine cars and brake beam for railway goods wagons.

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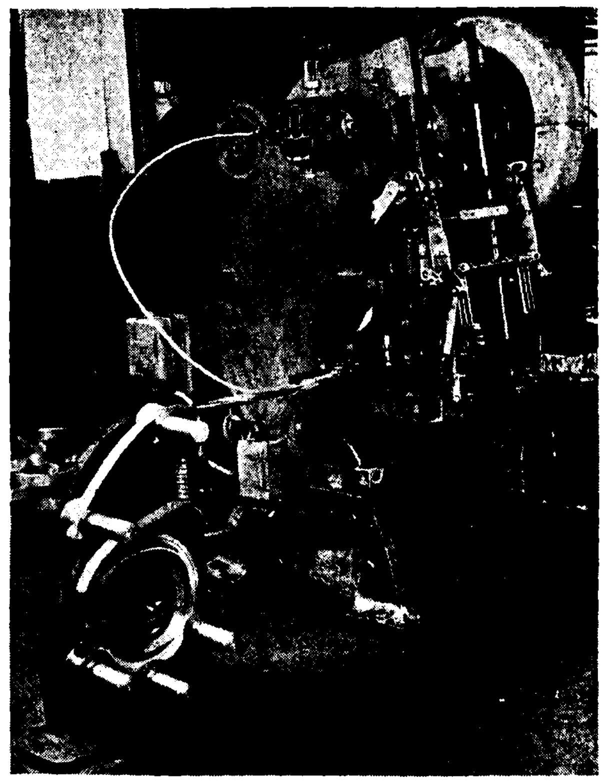
Automatic Press Feeding Device in Steel Rolling Mills

By An Engineering Correspondent

NOW that supplies of steel strip in coil form are more readily available in India, it is interesting to consider the various methods of feeding such material into power presses.



One such device which is already in use in considerable quantities in England is the 3" Swift-Feeder. This equipment is capable of feeding strip material up to a maximum thickness of ⅛" providing the strip is in good condition and is not drawn from the coil with any "bow" in it; in other words, when operating on this maximum thickness it is desirable for the strip to be passed through power operated straightening rolls.

The maximum width of strip which can be fed is unrestricted due to the open-sided gripper design of the feeding slide, the determining factor really being the weight of the material which the device is required to pull from the coil cradle. If coils in excess of 70 lbs. weight are to be fed it is necessary to use a power assisted coil holder.

The actual maximum pitch progression which the Swift-Feeder is capable of giving is 3½" and providing the material thickness is consistent, extreme accuracy of pitch can be maintained. In practice it is found that with material which varies only two or three thousandths of an inch in thickness it can be fed to a pitch accuracy of + or - ·002" without any difficulty. The feeding slide of the unit is provided with a means of releasing the gripping pressure so that strip can be fed to a stop but in most cases it is found desirable slightly to overfeed and with piloted press tools allow the pilots finally to locate the materials in the tool; it should be noted that whereas the strip cannot be pushed back into the coil, it can be drawn forward by the pilots of a press tool providing the material itself is sufficiently robust. This facility is made possible by the patented gripping mechanism which employs a roller and inclined wedge piece as the gripping medium.

The vast majority of applications upon which the Swift-Feeder is used are in connection with strip material varying from ·002" to ·050" and it is within this range in which the Swift-Feeder excels over conventional press feeding devices. In passing it can be mentioned that apart from feeding steel and non-ferrous strip, the Swift-Feeder is capable of handling paper, cardboard, P. V. C. and plastic materials.

The equipment has been designed with extreme simplicity of setting in mind, the material to be fed being used as a gauge for strip thickness adjustment and the pitch progression at which it is required to operate being readily adjustable by inserting an Allen key in the pump housing which is mounted on the crankshaft end of the press in use.

This latter adjustment for pitch progression can be increased or decreasd by the rotation of the Allen key in the pump unit, a clockwise adjustment of one full turn giving a pitch increment of ·1" and an anticlockwise turn of the key giving a corresponding decrease in pitch.

The mechanism itself is of extremely compact design and all mechanical parts are immersed in a reservoir of oil thus virtually eliminating any wear on these parts. The feeding stroke is obtained by the conversion of the rotary motion of the press crankshaft into an hydraulic impulse which is conducted down a copper connecting tube from the pump unit to the slide; the return stroke of the slide unit is effected by a Bowden cable running within this tube.

The manufacturers of the Swift-Feeder, Messrs. Birmingham Tool & Gauge Company Limited of Handsworth, advise that their agents for the Swift-Feeder in India are Messrs. Madan Engineering Tool Products' Delhi.

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The direct replacement of other materials, to overcome failures by greater strength or superior properties, is displayed in the drive gear housing for mechanical handling trucks, the mould holding and closing device for plastics, injection machines, and the piston for a marine diesel engine.

Apart from the main theme of the display, graphs and charts demonstrate the centralised research activities of the British Steel Castings Research Association, and a number of recent international contracts completed by British steel foundries.

Photographs of steel castings, including the 185 ton crosshead beam, the largest steel casting produced in Britain for delivery to a United States forging press, are also on show.

RADIO-CONTROLLED BRIDGE CRANE

A 100-ton bridge crane in the thermite shop of the Ishora Plant is operated by a miniature radio transmitter carried by a worker on his belt. The operator's place in the cab of the crane is taken by are ceiver and a block of executive mechanisms.

Developed by scientists in collaboration with the engineers of the plant, the device makes it possible to deliver loads with greater precision. Besides, the crane-operator no longer has to stay in the atmosphere of the upper part of the building, heated by the operation of the furnaces.

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DETERMINATION OF ARSENIC IN IRON AND STEEL

The Indian Standards Institution has recently published IS:1546-1960 Method for Determination of Arsenic in Iron and Steel. The method consists of conversion of arsenic, which in iron and steel exists mainly as iron arsenide (FeAs 2), to arsenic acid ($H_3 AsO_4$) by dissolving in a mixture of sulphuric acid and nitric acid. Arsenic acid is reduced quantitatively in acid medium by sodium hypophosphite to metallic arsenic and the metal is then oxidized by a measured excess of standard iodine solution to pentavalent arsenic. The excess iodine is back titrated with standard arsenious oxide solution.

The necessity of prescribing a standard method for determining arsenic in iron and steel has been felt because various indigenous laboratories have been using different methods and results reported by them are not always in agreement. The prescribed method has various advantages. Iron, lead, chromium, vanadium, manganese, cobalt and aluminium are less electro-negative than hydrogen and, therefore, do not interfere. It gives a precipitate plainly visible on filter. The method is applicable for the determination of arsenic in either state of oxidation.

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FOUR OPEN-HEARTH FURNACES ALREADY BUILT THIS YEAR

The big open-hearth furnace at the Cherepovetsk Steel Works (in the North-West of the Russian Federation) where one of the biggest Soviet steel smelting shops has been set up, was lit on 10—9—60.

Thus, four open-hearth furnaces have been commissioned at various steel works in the country since the beginning of 1960. Before the end of the year, six more steel smelting units will be built—at the Magnitogorsk complex (in the Urals), the Krivoi Rog Steel Works (in the Ukraine) and other enterprises.

All processes at the new outfits are fully mechanised and automated.

The aggregate annual capacity of all 10 steel smelting furnaces will be several millions of tons.

Iron and Steel Industry in France

OWING to the abundance of its iron ore deposits, France was naturally induced to pay special attention to the iron and steel industry. In spite of the loss of one-tenth of its labour force and the collapse of its economy during the two world wars, which were only separated by an interval of twenty-five years, France after reconstruction and renewal of its obsolete plant, is now in possession of the most up-to-date iron and steel industry on the European Continent.

As early as 1948, output of French works was more than 16% higher than in 1938 and amounted to 7,236,000 tons (1). It rose to over 9,000,000 tons per annum between 1949 and 1951: from 1952 to 1954 it exceeded 10,000,000 tons.

In 1955, production rose to 12,592,000 tons and reached the record figure of 13,394,000 tons in 1956 (215% of the 1938 tonnage). This means that if no account be taken of the war years and the 1945-1947 period when fuel shortage and reconstruction slowed down production, the latter more than doubled in nine years, thanks to capital investments amounting to $ 1,465,000,000.

In 1956, of the 13, 394, 000 tons of raw steel produced, 60% was basic Bessemer steel, 32% open-hearth steel, 8% electric steel and a very small percentage crucible or small converter steel.

About 4% of this production is accounted for by special structural carbon steel, and 5.3% by special alloy structural steel, carbon and alloy tool steel, high speed, stainless, heat resisting steels, steels for rollbearings, cutlery, files, magnets, electrical resistances, etc.

During the last few years, French works alone have exported increasingly large quantities of all kinds of steel to European countries, French Overseas Territories and other parts of the world, in particular semi-products, joists, bars for concrete, other commercial rolled products, steel wire, strip, black sheets and plates of various kinds and thicknesses, railway track equipment, sheets and plates for eletrical structures, galvanised sheets and plates, tin-plate, etc. In 1956 these exports amounted to 2,790,000 tons, of which about 2,200,000 tons were basic Bessemer steel products. They do not include steel exported in the form of tubes, wiredrawn products, forgings, or steel incorporated in permanent structures, railway fixtures and rolling stock, building, machines, automobiles, etc. supplied to foreign countries.

The large proportion of basic Bessemer steel will be noticed, i.e. 60% of production, 79% of exports. This steel, also known as Thomas steel, produced in France from the phosphorous ores of the Lorraine and Normandy deposits, remained for many years unknown in several other countries because it was almost exclusively produced in France, Germany, Belgium and Luxembourg. It was only a few years before the first world war that Great Britain began to produce basic Bessemer steel at Corby.

Thomas steel, which is in general use in the abovementioned producing countries, has now entered the world market.

The qualities of Thomas steel are shown, in particular, by its use for rail manufacture; the French railways, the best and fastest in the world, have been entirely equipped with Thomas steel rails since the beginning of the century, and Thomas rails are now used on all continents, in particular in the Middle East, South America, the Union of South Africa, India, Pakistan, South-Eastern Asia and Australia.

Benefiting by the excellent properties of the steel available, French steel construction and mechanical engineering industries have developed on parallel lines with the iron and steel industry. The above fact will be amply illustrated by the following records set up by the industry.

1. The Aiguille du Midi telpher (France), in the Mont Blanc range; altitude: 12971 feet, span: 9514 feet. High tensile steel carrier cable; ratio of breaking load to diameter of cable: 20,224.
2. Hangar at Paris-Orly airport; 710 feet span without intermediate support; overhang of trusses: 125 feet.
3. BB 9004 electric locomotive; speed: 205 miles-h., on Thomas steel rails.
4. Electrification of the Thionville-Valenciennes line, on which run the heaviest trains in Europe under the lightest catenary wire in the world.
5. The most up-to-date marshalling yard (Villeneuve-St-Georges, near Paris); daily output, 4,750 trucks.
6. Penstock for the Pragneres hydroelectric power station, composed of super-compressed self-hooped pipes; capacity: 207,000 HP.

(1) All tonnages are expressed in tons of 1000 kg.

India Self-Sufficient in Steel Pipe-Fittings

By Sitaram

FROM the very ancient times steel pipe fittings, such as Bends, Sockets, Nipples, Flanges, Tees, Elbows, Reducers etc. have been in various uses with:

(a) high pressure steel tubes suitable for water, gas, air, oil, steam etc.

(b) boiler & scaffolding tubes which are generally consumed in the manufacture of steel furnitures, cycles, vehicles etc.

(c) conduit pipes which are used for carrying electric wire for protection purposes.

But unfortunately bulk of the country's requirement had to be imported for want of her own developed industry thereby costing valuable foreign exchange to a great extent.

Now with the development of other engineering industries, like nuts & bolts, pipes & tubes, drums & buckets, cycles, wire products, razors & blades, tools, fans, structurals etc., the steel pipe fittings industry has also luckily received our Government's favourable attention promptly and has ultimately grown to a satis-

THE AUTHOR

factory level. Not to speak of shortage, even the present capacity of this industry in India is much more than country's requirement of steel pipe fittings from "½ to 6" size. This industry has already saved foreign exchange worth crores of rupees by supplying its products to various power and other development projects like Bhakra-Nangal, Damodar Valley as well as water supply and sanitation schemes. As the first 5 Year Plan did not make satisfactory progress with regard to water supply and sanitation on account of shortage of materials, more emphasis has been laid in the 2nd 5-Year Plan. The 2nd 5-Year Plan makes a tentative provision of Rs. 530000000/- for urban water supply and sanitation schemes (most of the schemes are under implementation or completion). The capacity of this industry being spare is expected to be fully utilized during the 3rd 5-Year Plan provided no more units are sponsored by the Development Wing. India is, therefore, not only self-sufficient to-day so far as her requirement of steel pipe fittings is concerned but also she is in a position to export for which, unfortunately, there is very little scope due to cut-throat competition with Japan, U. K. and other countries, though constant efforts are being made enthusiastically by the manufacturers with all possible help from Govt. of India to find suitable international markets. On a rough estimate based on detailed survey there are 135 small and medium scale units and 4 large scale undertakings (out of which 122 are located in West Bengal alone) producing steel pipe fittings in the vicinity of 20,000 tons per annum, which is much more than what country needs.

Messrs. Jindal (India) Private Ltd., Howrah, a leading manufacturers of Bends, Sockets and Nipples in India with modern automatic plant and machinery, are alone producing about 2300 tons or 2300000 pieces a year and their production can be enhanced easily with the increase in number of working hours. They have still higher plans to make more fittings and create new methods for quality control and standardization provided the present competition, which is unprecedented and very keen, permits. Besides, there are also a number of factories in India producing malleable pipe fittings which, being used generally in water supply and sanitation, are replacing the use of steel pipe fittings steadily. On the other hand India's total requirement, including demands from railways, development and power projects, refineries, oil mills, water works, heavy and medium industries which are the main consumers of this commodity, is estimated at 15,000 tons per annum. Moreover, production can be doubled by these enterprises in case demand grows. Hence production of steel pipe fittings by the indigenous manufacturers being much more than the demand of the country, there is no need for further expansion of the present units or for sponsoring any more new units in this field. Further it is appealed to the Govt. that:

1. The production figure of all unlicensed units should be registered with the Development Wing of the Ministry of Commerce and Industry and account should be taken of the existing capacity when further expansion is proposed.

2. Complete ban should be imposed on imports and suitable steps should be taken for the promotion of standardization.

3. Govt. Deptts. should always give careful consideration to the quality of the products and should not insist on merely price factor while finalising orders. All Govt. purchases should be made only from those units who have got all testing facilities in their works to avoid imitation and in order that the entire industry may be made to strictly adhere to standards and quality.

However, it should be mentioned here that quality of steel pipe fittings manufactured in India is suffering to a great extent. Therefore, greater attention also needs to be paid to the quality of products. There are organisational defects and inadequacy of technical competence in certain layers of the industry. The larger and better organised units of the industry are, fortunately, fully conscious of their responsibilities and are rapidly re-equipping and modernizing their production facilities with a view to ensuring the highest standard of quality by carrying out various tests of their manufactures. Some of the most important tests indispensable to ensure quality are :—

(i) *Dimensions :* Outside and inside diameters, length, thickness, angle, radius, centre to face etc.

(ii) *Threads :* Number of threads per inch, length of threads, depth of threads, pitch of threads as per B. S. 21.

(iii) *Galvanizing :* The test should be carried out according to B. S. Specification No. 729 so that no adherent red deposit of metallic copper is observed after four dips, each dip of one minute in duration.

(iv) *Hydraulic Pressure :* To be tested to an internal hydraulic pressure of 700 lbs./sq. inch without showing any sign of leakage.

(*Continued on page 51*)

Japanese Steel for Los Angeles

THE arrival of a big shipment of Japanese steel products at the Port of Los Angeles recently spotlighted the continuing rise in Southern California population and its resultant construction boom, according to Kermit R. Sadler, port traffic manager.

The shipment of 1,500 tons of steel wire, bars and plate from Kobe was brought to Los Angeles by Nitto Line's NICHIWA MARU.

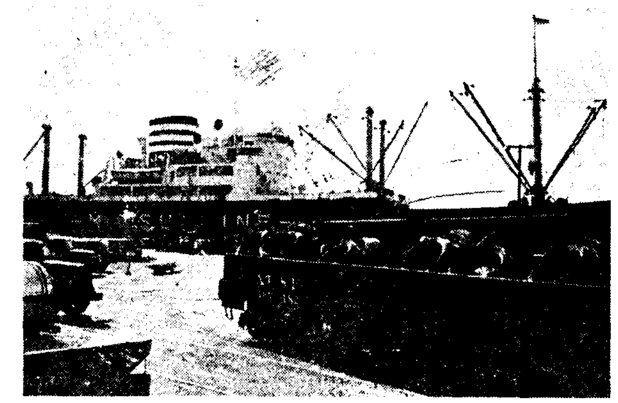
"All of it was consigned to members of the construction industry in Los Angeles area," Sadler explained. "And remember, this cargo is part of a steady flow of similar products from overseas steel-producing countries which cross our wharves."

Sadler envisions no change in the trend in the foreseeable future, basing his optimism on recently released statistics.

"The population of the southern half of California showed a net gain between the April 1, 1960 census, and January 1, 1960, estimates, of approximately 3,356,000 — or an average of 1,000 a day," Sadler noted. "That was 70 percent of the increase shown by the entire state."

A rise of this magnitude, Sadler pointed out, it is bound to boost the building of homes.

"Last year," he asid, "in the 14 counties that



Here is clear evidence of the varied types of Japanese steel products brought to Los Angeles Harbour by Mitsui Line's M/V SHOSEI MARU

make up Southern California, home building permits valued at $2,840,450,000 were issued. This huge figure compares with $2,322,578,000 in 1958 permits."

The number of dwelling units covered by these permits: 159,728 in 1959; 136,577 in 1958.

A more graphic view of the long-range home-building boom in this area appeared in a recent issue of a national news magazine which reported that Los Angeles alone has built enough houses during the last 11 years to house the entire current population of Paris.

(*Continued from page 50*)

(v) *Mechanical Expansion :* The fittings with threads inside such as sockets etc. are to be screwed on to a test plug held between the jaws of a vice to the extent of extreme hand tightness. The same are then to be rotated further five complete turns beyond hand tightness by means of a pipe wrench of an adequate length. The fittings should withstand the test satisfactorily without showing any sign of crack.

(vi) *Workmanship :* The fitting should be cleanly finished and all screw threads should be clean and well cut. All fittings should be varnished externally and their threads should be coated with rust preventing compound.

(vii) *Packing :* Materials should be packed in double gunny bags of very sound condition. Water-proof papers should also be used inside the bags whenever and wherever necessary. The threads of all bends should be effectively covered with protecting rings made from cardboard. For export, fittings should be packed in wooden containers with water-proof paper and other suitable packing materials for protection against all injuries.

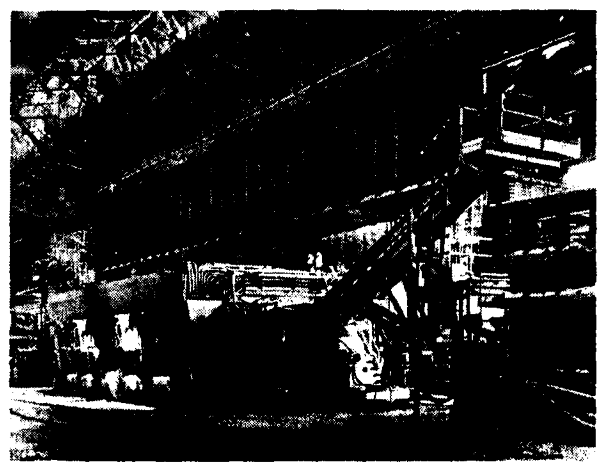
However, it may be hoped that Govt. will stress the need of protecting the existing units of this industry by restricting to further increase in the number of undertakings so that quality may be maintained which, under the stress of keen competition (generally more consideration is given to price factor than quality factor in India) and under the temptation of easy profits, might be tended to deteriorate.

Second 'Ajax' Furnace Conversion at Appleby-Frodingham

By An Engineering Correspondent

THE second open hearth furnace at Appleby-Frodingham Steel Company, Scunthorpe, to be converted to the *Ajax* oxygen process made a record output of 4,254 ingot tons during its first operating week, beginning its first charge on the morning of Sunday, June 7. This was 912 tons more than its previous best for a full week. It is also a record for the Company's Appleby melting shop.

Lit by Lt-Cdr. G. W. Wells, Managing Director (production) of The United Steel Companies Limited, and Director and General Manager of Appleby-Frodingham, the furnace retains its original hearth with an area of 526 sq. ft. and is tapping an average of 180 tons per tap from charges consisting of 100 per cent phosphoric pig iron produced entirely from home ores.



The second open hearth furnace to be converted to the AJAX oxygen process. It was lit for the first time after conversion.

Combined output of the newly-converted furnace and the original *Ajax* furnace, on which trials began in February, 1958, is expected to be about 9,000 tons per week with an average fuel consumption of under ten therms per ton. The lowest consumption figure achieved for a weeks production on the earlier furnace was 7.10 therms per ton; the highest weekly output was 5,717 tons.

Actual output from both furnaces last week totalled 9,406 tons.

Modification of an open hearth furnace to the *Ajax* process developed at Appleby-Frodingham enables a material increase in ingot production to be attained at a capital cost which is only a fraction of that necessary to instal any of the other oxygen steelmaking processes.

The changeover can be made in four to eight weeks, the actual time depending largely on the mechanical handling facilities available for the conversion in the melting shop. The first *Ajax* furnace took 26 days from "gas out" to "gas in"; the second required eight weeks, because it is in the middle of a busy shop and also because it was found that some of the concrete foundation work under the furnace rockers needed replacing.

COAL MINE WITH A CAPACITY OF 3,000 TONS A DAY

A new mine with a designed daily capacity of 3,000 tons of coal, has been commissioned at the Karaganda coal basin (Central Kazakhstan). Its underground faces stretch over more than 10 kilometres. Thick seams have been prepared for the use of highly efficient cutter-loaders. All production operations are directed from a control desk.

All stopping and preparatory work will be fully mechanized. The technology of surface work will be fully automated. Up-to-date instruments will watch the movement of a many-ton vessel carrying coal to the bunkers.

The coal from the new mine will be supplied to the coking ovens of the steel mills near Karaganda.

Ten more big mines are being built in the Karaganda coal basin. Three of them will be commissioned before the end of the year.

STEEL MAKING AT BHILAI

STEEL is the very foundation for the industrial development of a country. That is why, the steel industry in India received top priority in the Second Five Year Plan (1956-60).

The total target for the country in the Second Five Year Plan was six million tons of steel ingots or 4·5 million tons of finished steel products, against the then existing production of less than two million tons of steel ingots or 1·14 million tons of finished products. This was sought to be achieved by setting up three steel plants of one million ton capacity each at Bhilai, Rourkela and Durgapur, and by the expansion of the existing plants.

STEEL — AN ALLOY

Steel, in its simplest form, is essentially an alloy of pure iron with less than two per cent of carbon. Most of the steels, however, contain considerably less than one per cent carbon.

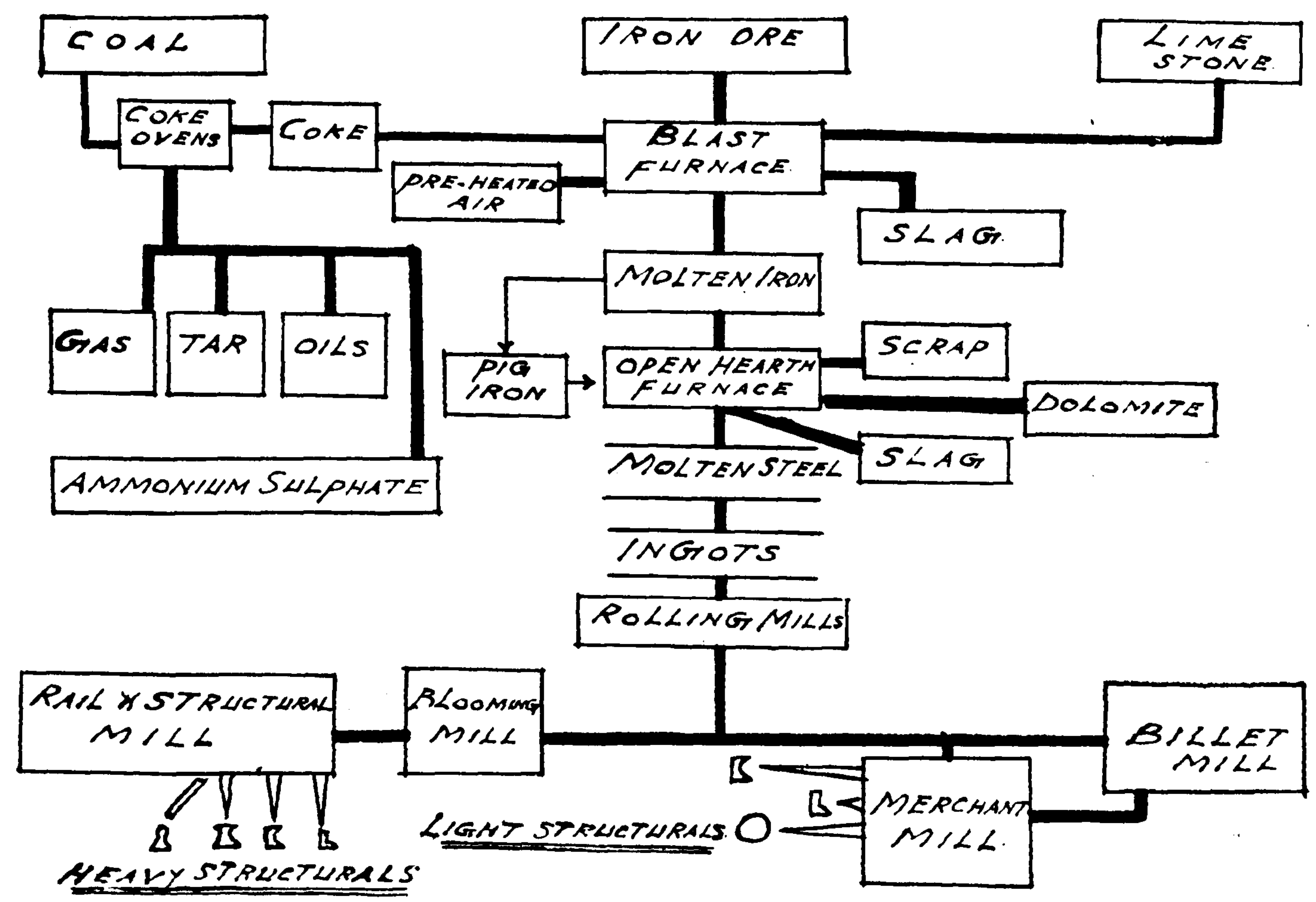
Iron is found in the mines in combination with oxygen as iron oxide, mixed with varying percentages of earthly materials.

In order to separate iron, the iron ore along with coke and limestone are charged into the blast furnace. Hot air is blown into the furnace. The heated air burns the coke to generate heat.

Hot carbon of the coke and the carbon-bearing gases generated by its burning, combine with the oxygen of the iron ore to form gases, leaving the iron in metallic form. The iron, in molten state, collects in the hearth at the bottom of the blast furnace.

In this process, iron also absorbs some of the carbon

FLOW CHART OF BHILAI STEEL PLANT

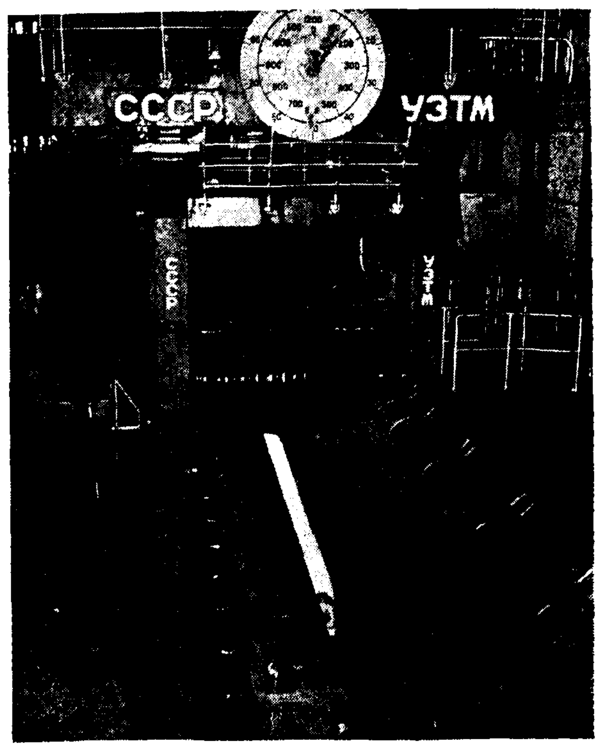


from the coke used as a fuel and other impurities like silicon etc. The product so formed is pig iron which may contain over four percent carbon, one percent silicon, manganese and other elements.

The limestone combines with the earthly materials of the ore to form molten slag that floats on top of the pool of molten iron, and is separated.

To make steel from pig iron, some of the carbon must be removed. The excess carbon is removed by the various steel-making processes, principally the Bessemer Converter, the Open Hearth and the L. D. Converter.

The resulting final product, steel in liquid form is poured into moulds to form ingots, which are later taken out of the moulds and sent to the rolling mills where they are reheated and rolled into various shapes.



Blooming Mill of Bhilai

The Bhilai Steel Works are at present planned to produce annually one million tons of ingot steel, which will be rolled into 770,000 tons of various commercial products like rails and railway sleepers, heavy structural sections, rounds and flats, and billets for rerolling mills.

In addition, the Steel Works will also produce 300,000 tons of pig iron for foundries and for export.

The entire construction at Bhilai is expected to be completed by March 1961.

The design of the plant provides for expansion from one million ton capacity to 2.1 to 2.5 million tons. The expansion programme is expected to be undertaken under the Third Five Year Plan.

The Bhilai Project is estimated to cost Rs. 131 crores, including the cost of machinery and equipment valued at about Rs. 63 crores being supplied by the Soviet Government on credit. The total foreign exchange involved amount to Rs. 80 crores. In addition, development of ore mines and quarries, fees for consultants and Soviet experts, water supply arrangements, township and certain other works outside the perimeter of the Steel Works are estimated to cost Rs. 47.65 crores, of which Rs. 14.65 crores will be in foreign exchange.

COKE PLANT

The starting point in a steel plant is the coke preparation plant and the coke oven batteries where in coal is converted into coke by heating it in air-tight chambers — called ovens. Coke so produced is required in the blast furnaces not only to generate the necessary heat for melting the iron ore but also the gases needed for chemical reactions in the production of pig iron.

Coke Plant of Bhilai Steel Works

The Bhilai Steel Works will have three batteries, each having 65 ovens, which will together produce 1,145,000 tons of coke annually. Two of these batteries are now in operation and each of them is producing about 1,000 tons of coke daily. The third battery has also been completed and is expected to be commissioned shortly.

About two million tons of coal will be required annually by the Bhilai Steel Works for production of coke. The coal required for the production of coke is a special quality coal known as metallurgical coking coal.

For making coke, the coal is mechanically unloaded from wagons, crushed, different qualities properly blended and re-crushed, and then charged into the ovens of the batteries.

The coke preparation plant, therefore, comprises of wagon tipplers, preliminary crushing plant, coal conveyor gallery, coal storage yard and gantry cranes, blending silos (mixing bins), final crushing plant and the coal bins, quenching towers, coke wharves, screening stations, etc.

WAGON TIPPLERS

In the Bhilai Steel Works, coal is received from Jharia and Kargali (450 miles) and Korba (135 miles). Wagons are unloaded mechanically by tippling devices at the rate of 600 tons per hour by open wagons and 300 tons per hour by closed wagons. There are also arrangements for manual unloading when tipplers are out of commission.

After unloading from the wagons, coal is carried by conveyor belts into the preliminary crushing plant, where it is crushed to 40 mm. size by 120 ton/hour roller crushers two in number. It is then transported into the coal, storage yard through conveyors, or sent direct to the coke oven batteries for use.

The coal conveyor gallery is 476 metres long. Coal yard at Bhilai has storage capacity for 1,00,000 tons, sufficient for 20 days' requirements, to allow for irregularity of supplies.

GANTRY CRANE

The gantry crane in the coal storage yard is the biggest of its kind and weighs 1,103 tons. It moves on 476 metre-track on two rail lines 76.2 metres apart. The height of the crane is 25 metres. The grab of the crane can handle 12 cu.m. of coal at a time. The Bhilai Steel Works will have two such cranes. One is already in operation while the second is being erected.

From the crushing plant (or the coal storage yard), coal moves to the blending silos. There are 10 blending silos for coal. Different varieties of coal, washed and unwashed, are stored in different silos and discharged simultaneously onto another conveyor belt in specific proportions.

From silos, coal moves to the final crushing plant where the crusher reduces the coal to 3 mm. size, and is then conveyed to the coal bin. The 150 ton/hour capacity crusher is driven by 400 k.w. 6.6 k.v. motors.

The coal bin serves as a ready storage for coal, crushed and blended to specification. It is on a 47 metres high R. C. C. framed structure and feeds crushed coal into a hoppered mobile car which charges the same into the ovens of the battery from above.

COKE OVENS

A coke oven is a chamber made of silica bricks 45 feet long, 14 feet high and 15 to 17 inches wide, with capacity to hold 16 tons of coal. 65 such ovens aligned with heating chambers alternately placed, constitute a battery. Three such batteries are planned for Bhilai. The length of a block of battery is 252 feet, its height 31 feet and width 46 feet. Each oven has two holes on the top for charging coal in it and another two for escape of the gases from heated coal to the big gas pipe lines.

The cost of a coke oven battery is estimated at Rs. one crore and its life is calculated to be 20 to 25 years, though in practice, it may work longer.

The ovens are externally heated by a mixture of coke oven and blast furnace gases.

The temperature of heating walls of the ovens is about 1,200°C. After about 17 hours heating, the coal temperature goes up to about 950/1,000°C. Since heating of coal in a coke oven takes place as in a closed retort without any access to air, the chemical reaction is called carbonisation of coal, as different from combustion when air is supplied and coal burns with release of much heat. During the heating, all the volatile matter of coal escapes through the exit gas pipes and the residue left in the oven is called coke. Coke is then pushed out by pusher-machines, collected in an open car, quenched in an enclosed water shower which forms coke into lumps, unloaded on coke wharves, crushed, screened and sent to the blast furnace by a set of conveyor belts.

Only coke of 25-100 mm. size is charged in the blast furnace, the smaller sizes being sieved and sent for use in other auxiliary shops.

BYE-PRODUCTS

About 57,600 cu. m. of gas are evolved in the coke battery every hour, which give a number of valuable bye-products. At Bhilai, the three batteries together will give annually 60,000 tons of bye-products including 44,500 tons of tar, 16,300 tons of ammonium sulphate, 100 tons phenoletes, 9,000 tons of light oil and 1,600 tons of crude benzol.

Tar is produced on primary condensation of the gases.

Ammonium sulphate is produced by bubbling the tar free gases through a dilute solution of sulphuric acid.

Napthalene is recovered from the gas by cooling in a final cooler with cold spraying of water.

After recovery of various bye-products and cleaning, coke oven gas is utilized as a fuel for major part in the coke oven themselves, in the blast furnace, power generation station, steel-smelting shops and rolling mills.

Work at the coke oven batteries in the Bhilai Steel Works was started in November 1956. The first battery was commissioned on the 2nd February, 1959, and the second on the 22nd December 1959.

Excavations for site levelling and foundation of each battery at Bhilai involved 9,63,000 cu.m. refractory masonry used in each battery totalled 13,400 tons. Some 546 different shapes of bricks were used in each battery—8,200 tons of silica bricks, 5,050 tons of fire clay bricks and 150 tons of diatomaceous bricks.

The 100 metres (326 ft.) high R. C. C. chimneys of the coke oven batteries are the tallest structures in Asia, Qutab Minar of Delhi being 238 feet. The diameter of these chimneys at the bottom is 8.2 metres (25 ft.) and that at the top 4.42 metres.

To protect against rain etc. a shed 77 m. x 20 m. x 17 m. was constructed over the battery. Such a shed weighing 400 tons, constructed over battery No. 2 was moved on rails to the site of battery No. 3 with the help of two five-ton winches. This was a unique feat in structural erection performed at Bhilai.

BLAST FURNACE

The second stage in the steel plant is production of pig iron from iron ore.

The blast furnace plant includes blast furnaces, pig casting machines, blast heating stoves, gas cleaning plant, ladle repair shops, and sintering plant.

There will be three blast furnaces at Bhilai. Two of these are now in operation, each one producing about 1,000 tons of pig iron daily. The foundation for the furnace were laid in June 1957. The first furnace was commissioned on the 4th February 1959 and the 2nd on the 26th December 1959. The third blast furnace is also now nearing completion.

The blast furnace has a useful volume of 1,033 cubic metres. Its hearth diameter is 7·2 metres. Its full height is 28·75 metres.

To produce one ton of pig iron, the raw materials required are: 1·5 - 1·7 tons of iron ore, 0·9 - 1·1 tons of coke, 0·4 - 0·6 ton of limestone and 3·5 - 4·0 tons of air blast.

Iron ore, limestone and coke are hoisted by electric power upto the top of the blast furnace by skip cars travelling over an inclined bridge and then dropped into the furnace, in the required proportions and sequence. Each blast furnace has three stoves by its side. Air is led into the stoves for being heated up before it is blown into the blast furnace. The stoves can deliver hot blast at a temperature range of 800-900°C. The furnace has separate holes for letting out the molten iron and the impurities which come out in the form of slag.

Maintenance of normal working conditions enable molten iron to be tapped every four hours. Removal of slag is also effected every 2-3 hours regularly. Molten iron is collected into ladle cars and taken to open hearth furnaces for being converted into steel. Molten iron

Blast Furnace Plant at Bhilai

may also be taken to the pig casting machines for being cast into pigs which are sold to foundries.

The slag is taken in special lable cars and dumped outside the Works area. Later, slag may be used for the production of slag cement.

The gases coming out of the blast furnace are led into a special gas cleaning plant where all suspended impurities are removed. The gases are then used as fuel in boiler of the power house and other units like steel melting shops and rolling mills.

The three blast furnaces in Bhilai, will together produce 1,110,000 tons of pig iron per year.

The Bhilai Steel works receive their iron ore requirements from Rajhara, about 55 miles south. Two and a half million tons of iron ore will be required annually.

The annual coke requirements of the steel works have been estimated at 1,100,000 tons and those of limestone at 765,000 tons.

SINTERING PLANT

Normally the iron ores charged in the blast furnace are of the size bigger than 12 millimetres. Ores less than 12 mm., called fines, are rejected.

Similarly, coke charged in the blast furnace, must be bigger than 25 mm. size and the coke of smaller size, called coke breeze, is screened out.

In the sintering plant, which is being put up within the Steel Works, the ore fines, coke breeze along with limestone and dolomite will be crushed, mixed and then by heating at high temperature fused into lumps of sizes between 12 mm. and 80 mm. to be used, as charge in the blast furnaces. The sintering of the fines ensures maximum utilization of natural resources, leading to great economy in the production of pig iron and steel. The consumption of coke in the blast furnace is also reduced by the use of sinter.

About one million tons of sinter will be supplied annually by the sintering plant of the Steel Works.

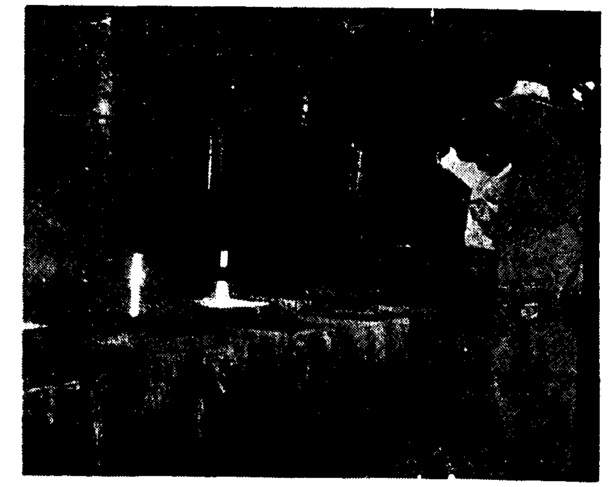
The sintering plant will have two sintering machines. The sintering area of each of these machines will be 50 square metres.

STEEL MELTING SHOP

The conversion of pig iron into steel is done at Bhilai in the Open Hearth Furnace.

The open hearth plant consists of several buildings, including the stock yards for raw materials, mixer house, mould preparation department, stripper yard, etc.

The Bhilai Steel Works will have six open hearth furnaces of 250-ton capacity each. The fuel used is a mixture of blast furnace and coke oven gas with provision for usage of oil or tar for luminosity of flame. Three furnaces are now in operation.



Steel Plant of Bhilai—Steel being poured in ingot moulds

The open hearth looks like a shallow bath. The hearth is 14.5 metres long, 5.3 metres wide and 0.95 metre deep. There are five doors in front for charging the raw materials in it. Molten pig iron coming from the blast furnace is charged into the open hearth furnace along with the required quantities of materials like steel scrap, limestone and iron ore. About 25 percent scrap is charged. Cold materials like pig iron as well as ferro alloys needed to make up the chemical composition to required specification, are also charged in the open hearth furnace for making steel.

After about 11 to 11-30 hours' heating, when the temperature of the metal goes up to 1585–1600°C, the molten steel is collected in big ladles and poured into cast iron moulds from which it is taken out in the form of ingots, in the stripper yard. An ingot is a rectangular block of steel weighing from 5 tons to 15 tons, depending on the size of the mould into which the molten steel is poured.

ROLLING MILLS

Steel ingots are then sent to Rolling Mills for rolling them into different shapes. In the rolling mills the ingots are heated to about 1050°C temperature in what are called Soaking Pits, and then taken out, one by one, by tong cranes and put on working roller stands for rolling, first into blooms and then into billets.

Blooms, which are bigger in size are then converted into billets, which are smaller in size, in the billet mill. Later, when the Rail and Structural mill is ready, the blooms will also be taken to this mill to be rolled into rails and structurals. The billets will be taken to the merchant mill for being rolled into bars, rods, etc.

The main plant structures and annual production targets for Bhilai are as follows :

			Annual targets in tons
Coke	...	3 Batteries of 65 ovens each.	1,145,000
Pig iron	...	3 Blast Furnaces. (Volume 1,033 cu. m. each)	1,110,000
Steel	...	6 Open Hearth Furnaces. (250 ton capacity each)	1,000,000
Rolling	...	4 Mills :	
		Blooming Mill (1,150 mm.)	859,000
		Billet Mill (700/500 mm)	427,000
		Rail & Structural Mill (950/800 mm)	365,000
		Merchant Mill (350 mm)	255,000
TOTAL FINISHED ROLLED STEEL PRODUCTS	...		770,000 TONS

POWER GENERATION PLANT

Power for the Steel Plant is being supplied by the Thermal Power Station of the M. P. Electricity Board at Korba, 135 miles from Bhilai. The Steel Plant itself has a Power Plant of 24,000 k.w. capacity, which serves as a supplementary source of electric power and is a continuously operating station for generating power required for the works. The Plant consists of three boilers, two turbo alternators of 12,000 k.w each and four turbo blowers. The turbo blowers deliver air under pressure for the Blast Furnace. The boilers of the Power House work on coal from Korba together with the available surplus Blast Furnace and Coke Oven gases.

WATER

Water for the Steel Works is obtained from the Tandula and Gondli reservoirs of the Madhya Pradesh Government, 50 miles to the South. Water from these reservoirs is brought through the Tandula Canal and stored in a large tank lying to the south of the Works. This has a capacity of 24 million cubic metres. This tank supplies water to another tank closeby where the industrial water is cooled after it has circulated in the Steel Plant.

AUXILIARY SHOPS

The normal maintenance of a steel plant of the magnitude of Bhilai calls for well laid-out repair shops. Full repair facilities have, therefore, been provided in the Steel Works. The main repair shops are: a foundry shop capable of producing all ingot mould and stool requirements and in addition another castings upto 9,500 tons ; a forge shop ; a steel structural shop ; a machine shop ; an electrical repair shop ; a building repair shop ; and a locomotive repair shop.

Most of these shops are in operation and are helping in the fabrication of many of the items required for construction and to maintain smooth operation of the different units of the steel plant. Besides, there is a unit for the extraction of oxygen from air. This plant is already in production and supplies to the construction and erection departments on an average, 120 cylinders of oxygen daily, required for cutting and welding. Another oxygen producing plant is being constructed for producing the large quantity of oxygen required for steel melting.

WORK INVOLVED

The total work involved in putting up the steel plant includes : Earthwork, 1,05,78,719 cu.m., Concrete 7,22,399 cu.m., Steel work, 96,075 tons, Refractory 1,61,791 tons, Roofing & Cladding 6,54,751 sq. m., Mechanical equipment 1,20,597 tons, Electrical equipment 16,623 tons, Technical pipe line 11,547 tons, Ventilation Air Duct 35,500 sq. m., Underground communication 120·83 k.m., Railway permanent 101,54 k.m., Railway temporary 58·32 k.m.

THIS YEAR'S PROGRAMME

As pointed out above, the Bhilai Steel Works are to comprise of three coke oven batteries for production of coke, three blast furnaces for production of pig iron ; six open hearth furnaces for making steel and four rolling mills, besides several auxiliary units and repair shops and bye-products plants. So far, two coke oven batteries, two blast furnaces, three open hearth furnaces and two rolling mills, besides some auxiliary and repair shops, have been completed. The programme for the rest of the current year, therefore, includes completion of all the remaining units, namely one coke oven battery, one blast furnace, three open hearth furnaces and the two mills viz. the huge rail and structural mill, and the merchant mill.

RUSSIAN MACHINERY AND EQUIPMENT

Steel structures, machinery and equipment for the Bhilai Steel Plant have been received from the Soviet

Union under the various agreements signed between the Governments of India and USSR. These have been fabricated in about 400 different factories all over Russia.

About 4,76,000 tons of equipment materials have been received at Bhilai from USSR. The Soviet Government has also supplied the necessary technical personnel to assist in the erection and operation of the Plant.

The construction at Bhilai is, however, controlled by the Indian authorities of the project, the Russians giving technical help and guidance. As a result, a large organisation of engineers, supervisors and skilled and semiskilled men has been building up at Bhilai, who will be in a position to undertake future expansion work at Bhilai or put up similar other Plants elsewhere in the country.

About 675 Indians have been trained in the Soviet Union for the Bhilai Steel Plant.

A number of persons have been trained as operatives in the TISCO, IISCO and MISW. Operatives are also now trained in the units that have so far come up at Bhilai.

A technical training institute has also been started by the Project near the Steel Works. The institute is to train about 1,420 persons annually for maintenance and operation jobs in the Steel Plant.

USE OF STEEL IN GENERAL BUILDING CONSTRUCTION

The Indian Standards Institution has prepared the draft revision of IS:800-1956 Code of Practice for Use of Structural Steel in General Building construction.

This code was first published in March 1956. Since then a number of points have come up, based on which some of the important provisions of the code needed changing. The concerned technical committee felt that it is time now to revise the code. Accordingly, a draft revision of the code is being prepared and put on wide circulation for eliciting comments from all interested.

One of the important changes in the draft revision is with respect to the provision of permissible stress in bending. The draft revision now provides more accurate basis for arriving at the permissible stress by making use of the theoretical expressions instead of approximate formulae adopted earlier. Unavoidable imperfections inherent in the fabrication of the beams, which were not taken into consideration formerly, are also now provided in arriving at the permissible stress. Another important change in the draft revision is with regard to the general increase of all the permissible stresses in correspondence to the increase of the guaranteed minimum yield stress of structural steel. The increase in minimum yield stress of structural steel is being given effect to by revising the steel specifications in line with the appropriate British Standard Steel Specifications. Under details of design of the Code, some provisions where some anomalies existed, are also revised. Along with the draft revision, an explanatory memorandum is also attached. This memorandum explains details of some of the important changes incorporated in the draft revision.

This draft revision will be circulated by the beginning of October 1960 to interested producers, designers, fabricators, technologists and consumers from important private and Government organizations. The draft revision (which is in English) will be open for comments for a period of three months from the date of its circulation. The comments will be taken into consideration before the draft revision is finalized for publication.

*

OVER 400 NEW MACHINE MODELS

The Designing Institute in Dnepropetrovsk (Ukraine) is working on more than 400 new machine models for mechanizing labour-consuming processes in the iron and steel and mining industries. Some of them are already in production, for instance, an installation that handles whole freignt cars, doing a job that would require 300 workers. This self-propelled devise can lift whole cars up to a height of two storeys and unload coal and dry building materials. It can unload 60 cars in one hour.

Another machine opens up the tapping holes in blast furnaces. It is operated by one man.

All the models will be ready before the end of the Seven-Year-Plan.

German Steel Spotlights Import Curve

By A Correspondent

AN Italian cargo liner arrived at the Port of Los Angeles recently with a shipment of steel pipe and plate from Hamburg that was equal to 21 percent of West Germany's entire steel exports in fiscal 1959 (ended June 30).

According to the port's General Manager, Bernard J. Caughlin, the 2,718 tons of steel pipe and plate discharged from the ANTONIO was significant for a number of reasons.

"The shipment points up the continuing upward trend in steel imports to this area," he said. "This trend was particularly apparent during our fiscal '59 when 213,090 tons of steel mill products (including pipe and tubing and steel wire) crossed the wharves of the Port of Los Angeles. These imports were 66 percent more than the 128,127 tons of steel handled here in the preceding year."

Major exporters of steel to this port, in order of volume, were: Japan, Belgium, Australia, the United Kingdom, Germany, the Netherlands, France, Italy, Sweden and Norway.

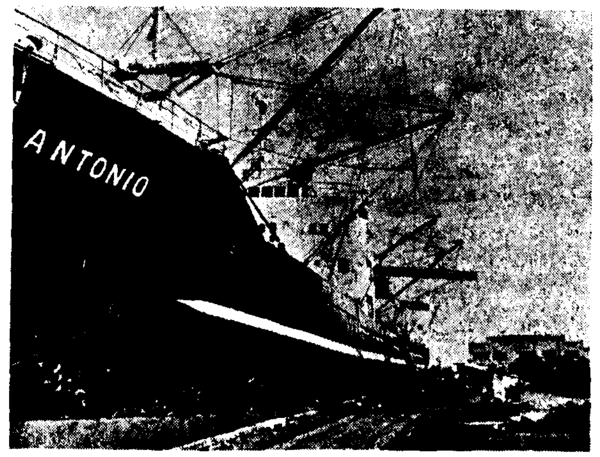
Caughlin cited these sizable gains in the economy of Southern California during calender 1959 as strong contributors to the rising curve in steel imports:

Business activity was at the highest level ever recorded, averaging about 11 percent higher than in 1958, according to the index of the Security First National Bank of Los Angeles.

Total employment in 1959 averaged around 3,665,000 or 4.5 percent more than in 1958. (The gain nationally was 2.5 percent). Employment in manufacturing climbed even higher — from an average of 864,962 in '58 to around 917,000 or 6 percent more in 1959.

Building and construction expenditures in the fast-growing Southern California market reached $ 3,482,000,000 last year — an increase of 14.7 percent over 1958 which was a record year.

"The building and construction industries," Caughlin reminded, "were the principal importers of the 213,090 tons of overseas steel mill products which passed through the Port of Los Angeles in our fiiscal '59. Continuing arrivals of steel in our current fiscal year



German steel pipe is unloaded from Italian flag motor vessel ANTONIO at her mooring in Port of Los Angeles. The ship discharged 2,718 tons of steel pipe and plate from Hamburg for the burgeoning Southern California market.

indicate a continuing demand by the building trades of Southern California for high quality foreign steel."

The following table gives a quick picture of where these trades obtained their imported steel mill products in the last two fiscal years:

STEEL IMPORTS TO PORT OF LOS ANGELES

(pipe, tubes & tubing; semi-finished, rolled or finished products; steel wire & manufacturers)

in tons

	fiscal 1959	fiscal 1958
Japan ...	68,532	... 15,450
Belgium ...	64,712	... 41,917
Australia ...	24,549	... 14,699
United Kingdom	21,217	... 26,225
Germany ...	12,621	... 8,870
Netherlands ...	8,995	... 15,379
France ...	1,496	... 553
Italy ...	372	... 3,373
Sweden ...	206	... 29
Norway ...	174	... 51

Caughlin admitted that the 66 percent gain in steel imports in the port's fiscal 1959 over 1958 was far below the national increase. Total U. S. imports in the full

(*Continued on page 61*)

A Review of Iron and Steel Industry in United Arab Republic

LOCAL CONSUMPTION OF IRON AND STEEL

AVERAGE local consumption of simple iron manufactures amounts to nearly 310,000 tons annually. They obtain 270,000 tons through imports and they cost about L. E. 12 million. The remaining quantity, about 40,000 tons, is produced by local factories which depend on scrap iron.

Foreign markets of iron are subject to many and severe fluctuations whether in price or available supplies and this has a bad effect on local markets.

The consumption of iron industries in the country is continually increasing. It was about 210,000 tons before the second world war, then it gradually rose until it reached 310,000 tons by 1950-52 at an increase of 100,000 tons. The ordinary consumption is expected to reach 400,000 tons in 1960, taking into consideration that the implementation of development plans will call for increased use of iron products.

IRON RAW MATERIALS

The available iron raw materials are of medium grade and the existence of these raw materials encouraged the authorities to set up an iron and steel industry in the United Arab Republic. These can be divided into three categories :—

Red Iron Ores : The main area in which they exist is the Eastern desert North-east of Aswan; it covers about 2,150 square kilometres. Nearly 600 samples have already been tested by experts from the United Arab Republic, Britain, France, Germany, Austria and other countries. The result of these tests shows that available raw material supplies are sufficient for the next fifty years at least. The extraction of these iron ores will not cost much, as they exist near the surface.

Black Magnetic Iron Ores : These ores are available in the Eastern Desert and on the Red Sea coast. There are about 330 strains extending over an area of 1·5 square kilometres. It is estimated that there are between 15 and 20 million tons of these ores.

Yellow Iron Ores : These exist in the Bharia oases and it is estimated that there are 25 million tons of these ores. It is also estimated that there are about 20 million tons in the Chouraby Mountain area. Tests have proved that iron ore deposits at Aswan on which the industry will depend for the present, are suitable for the production of steel.

OTHER ORES SUITABLE FOR THE IRON AND STEEL INDUSTRY

Other ores are required for the purification of iron or for the building of furnaces. These materials such as coke, limestone, dolomite, manganese, etc. are also available.

Coke Coal : No deposits have been discovered so far and they therefore depend on imports. The required quantities can be imported from India and Poland. There are, however, countries such as Italy in which Coke coal does not exist but in spite of this, Italian Iron and Steel Industry is progressing. Similarly, the non-availability of coal so far does not obstruct the iron and steel industry in the U. A R. The iron and Steel Plant imports 310,000 tons of coke coal annually.

Limestone : Abundant supplies are available. The Iron and Steel Plant uses 243,000 tons annually.

Dolomite Stones : All requirements of the Steel and Iron Plant, which uses 8,000 tons annually, can be met locally. These are available near Giza south of Assiut and near Tahta.

Raw Manganese : Abundant supplies are available in Sinai. The Iron and Steel Plant requires 12,000 tons annually. Silka and other materials are also available in plenty in different parts of Southern Region.

(*Continued from page 60*)

calender year totalled 4,400,000 tons, an increase of 259 percent over 1958. "But it must be remembered," he said, "for many American importers, last year's transactions were in the 'first time' category, created solely by the steel strike. In contrast, import minded builders and manufacturers of Southern California have used large quantities of steel from Europe, Australia and Japan for the past several years."

LOCAL STEEL AND IRON INDUSTRY

The banning of the export of scrap iron following the II world war (available quantities amounted to 400,000 tons) encouraged several local companies to turn this scrap into different products foremost among which were reinforced concrete iron rods which were in big demand in local markets. Three companies are engaged in this business but they cannot meet local requirements in full and in addition, there are only about 40,000 tons of scrap iron available annually which can hardly meet 50 per cent of the requirements of the three companies. Moreover, the steel industry cannot be successfully operated on the basis of iron ore imports as the price sometimes rises to as much as L. E. 34 per ton. The U. A. R. Steel and Iron Industry will completely depend on local raw materials.

DEVELOPMENT OF IRON PRODUCTION

After exhaustive studies, it was decided to set up the Steel and Iron Industry by using high furnaces and import their coke coal requirements. But following the generation of electric power from the High Dam this industry can be expanded and electric furnaces introduced. Five International offers were made to produce 220,000 tons of steel and iron annually. The most favourable offer was made by the German *Demag* Company and on 11—2—1954, an agreement was signed to set up an iron and steel plant with a productive capacity of 235,000 tons annually of unwrought steel, which amounts to 180,000 tons of wrought products. Subsequently an agreement was reached to raise the plant's capacity to 265,000 tons of unwrought steel which is equal to 200,000 tons of wrought steel. These include Railway sleepers and steel sheets. The plant also provides the requirements of the iron plant.

SECONDARY PRODUCTS

The waste of high furnaces is used in the production of cement and sound and fire-resisting building materials. The plant also produces 50,000 tons annually of phosphorous fertilisers. Gases produced as a result of the processing of iron, which amount to 700 million cubic metres annually, are used to operate a 45,000 kilowatt power station. The iron and Steel Plant requires 25,000 kilowatt annually and the rest is used by Cairo power stations.

ECONOMIC BENEFITS

The steel and Iron Plant will produce during the initial stage 265,000 tons of unwrought steel and iron.

Regarding the secondary benefits of the Industry, it must be mentioned that many organic and non-organic chemical industries were established. Activities in quarries also increased and there was a bigger demand for transport facilities to carry raw materials to the plant.

A river fleet was established to carry coal to the Steel Plant. In general the establishment of this industry has been an important turning point in the country's bid to set up heavy industries.

CAST IRON AND PIPES

This industry was established in 1954 when a plant was set up to produce cast iron from available scrap iron supplies. The factory also turns out water pipes and pumps.

There are three factories which produce corrugated iron sheets from scrap iron and scrap materials left behind by fighting forces following the second world war.

The United Arab Republic can be said to have made creditable progress in the manufacture of iron and steel in a short span of time.

SIBERIAN PLANT TO HAVE WORLD'S HIGHEST TECHNOLOGICAL STANDARDS

The Taishet Iron and Steel Combine in Irkutsk Region, Siberia, will have the world's highest standards of technology, the newspaper *Stroitelnaya Gazeta* (Construction Gazette) reports.

The project of the Taishet combine has been designed at Moscow's Institute of Designing Iron and Steel Works.

The design envisages the use of the largest, highly mechanised and automated units.

The newspaper points out that technological processes for which formerly five different buildings were used will now take place in one building. This will save up a lot of construction materials, as well as materials going into the making of lighting and heating facilities.

DURGAPUR STEEL PLANT SECTION

ROLLING MILL PLANT NEATLY DESIGNED

THE Rolling Mill Plant of the Durgapur Steel works comprises a 42″ Blooming Mill, a 32″ Intermediate Blooming Mill, a Continuous Billet Mill, a Medium Section Mill and a Continuous Merchant Mill, together with all associated auxiliary equipment. A plant for the production of finished steel railway sleepers is also included.

The rolling mill plant has been designed to process initially at least 940,000 tons of ingots annually, into salable products ranging from 12″ square heavy forging blooms to 12 mm. diameter rounds and including a range of billets, sleeper bar, and sections. The throughput of the blooming and intermediate mills can be increased by the addition of further soaking pits. A 7-ton ingot of about 28″ square section by 6 ft. long has been selected as the most economical size from which to produce the quantities and range of blooms required to serve both the billet and the structural mills. Other sizes of ingots can, however, be rolled to meet the requirements of special products which may be specified from time to time.

The layout of the plant has been planned to provide adequate flexibility of operation, while in all sections, the design makes provision for subsequent increase in capacity to meet the possibility of future expansion.

The contract for all the plant in the rolling mills area of the Durgapur Steel works was placed with Davy and United Engineering Company Limited of Sheffield. Because, however, of other important commitments at the inception of the project, it was agreed that Davy-United should spread the manufacture of certain of the mill units amongst other builders in the United Kingdom. Under this arrangement, Davy-United, while maintaining full contractual responsibility for all the mills, and auxiliary equipment, have themselves built the 42″ mill plant the Morgan continuous billet and merchant mill plants together with certain interconnecting tables and all colling beds, finishing equipment, transfer banks and saws. The 32″ intermediate mill and roughing stand of the section mill, together with their manipulators and main tables, were sublet in their entirety to the Brightside Foundry and Engineering Company Limited of Sheffield, while the intermediate and finishing stands of the section mill were sub-contracted to W. H. A. Robertson and Co Ltd., of Bedford.

The plant now in production at stage two of the phased construction programme consists of the 45″ and 32″ Blooming Mills, the Continuous Billet Mill and the Sleeper Plant.

The blooming mill, designed for an ultimate capacity which would enable it to roll over a million tons of steel ingots a year, receives its ingots from the soaking pits *via* an electrically propelled ingot chariot and roller tables. Each ingot is weighed and turned if required by an overhead type ingot weighing and turning device which is positioned over a section of the approach tables to the mill to enable one ingot to be rolled while a second is being weighed and a third is held ready on the ingot receiving table. An uninterrupted supply of ingots to the 42″ mill is thus assured, a feature which helps a high production rolling rate to be maintained.

The Blooming Mill which is driven by two 3,000 h. p. motors through universal spindles and couplings, has rolls of 42″ nominal diameter and a length on the barrel of 102″. These heavy rolls are fitted on the roll necks with bearings of white metal with bronze inserts, carried in water cooled chocks and lubricated by pressure grease from an automatic system. The massive cast steel housings weigh 80 tons each.

The 16-inch diameter mill screws are driven through gearing by two 125 h. p. motors to provide a screwing speed of up to 228 inches per minute. The openings between the rolls are clearly and accurately indicated on an 8′-9″ diameter dial. The top roll assembly is hydraulically balanced and both top and bottom roll assemblies can be removed from and returned to the mill as a single unit seated on a sledge which is operated by an electrically driven winch gear. Spare rolls and chocks are assembled directly adjacent to the mill in order that roll changing time may be cut down to the absolute minimum with a consequent benefit to production rolling time.

Assisting in the positive feeding of the ingots into the mill rolls at both ingoing and outgoing sides are breast and first rollers while the guiding of the ingots into the correct roll "gates" is performed by electrically driven sideguard type manipulators. The manipulator heads at both sides of the mill are mechanically coupled to ensure that they are always in perfect alignment, while special limit switches and spring loaded mechanical stops prevent the manipulator rack beams from overrunning. All the drive mechanism for the manipulators is situated on the driveside of the mill thus leaving completely clear access on the opposite side of the mill for roll changing and other operations. On the driveside of the mill at the ingoing side, the manipulator head is fitted with built-in electrically driven tilting fingers for turning over the ingots and blooms as required. Spring-loaded shock absorbers together with slotted links are included to protect the tilting lever mechanisms from any impact loads and accidental jamming of the tilting fingers which might occur during operation.

While ingots are normally rolled down to 12″ square in the 42″ Mill, a small tonnage is rolled to a minimum 9″ square for heavy forging blooms.

After reduction to required size the rolled blooms are conveyed directly forward by roller tables to a 1,200 tons hot bloom shear, where they are cropped or divided before passing on to the next stage of production.

This shear, which is located 100 ft. beyond the 42″ Mill, is an electrically driven open-sided unit of the upcutting type. Having a blade load of 1,200 tons, it is capable of cropping or dividing hot blooms up to 16″ × 16″ in cross section at a rate of 6 cuts per minute when on maximum sizes.

The shear is driven by two 600 h.p. motors through a triple reduction gear box incorporating a two-speed change mechanism.

Motor operated stop and measure gear is fitted which can be accurately set to measure bloom lengths from 4 ft. to 15 ft. before cutting. The shear and its ancillary equipment are all remotely controlled from an air conditioned cabin designed and situated to give the operators an unobstructed view.

Blooms leaving the shear proceed over roller tables either to the 32″ Intermediate Mill situated 180 ft. away, or are transferred to the adjacent heavy forging bloom stock bay by means of a chain type transfer bank incorporated in the shear runout table.

An independent scale washdown system is provided and the mill train with its main and auxiliary tables are pressure oil lubricated from two separate recirculating systems of 60 g. p. m. and 150 g. p. m. respectively. A recirculating pressure oil lubrication system is also provided for the shear gearbox while all points requiring grease lubrication are fed by a series of automatic pressure grease systems.

INTERMEDIATE BLOOMING MILL

The introduction of an Intermediate Blooming Mill into the rolling line at Durgapur was decided on as a means of maintaining a high throughput of blooms required for subsequent reduction by the following mills. This arrangement offers not only a sustained high production rate since it reduces the pass schedules necessary on the 42″ mill, leaving it free to concentrate on the rapid breakdown of the initial ingot, but is also economic in operation for the range and type of product envisaged at Durgapur.

The 32″ Intermediate Blooming Mill, which was built by the Brightside Foundry and Engineering Co. Ltd., will normally produce blooms from 7″ to 9″ square. It uses rolls of 32" nominal diameter, 84" long on the barrel, and carried in white metal bearings. The mill is driven by a 4,500 h. p. motor running at 80/120 r. p. m., through universal spindles and a pinion housing. Twin motor screwdown gives a screwing speed on the top roll of 167" per minute, roll balance is effected by opposed screws and a quick release device is incorporated to simplify and accelerate roll changing.

The sideguard type manipulators are fitted with tilting fingers on the ingoing side. The manipulator heads are driven through gear boxes by four 85 h. p. motors giving a maximum traversing speed of 163 ft. per minute. Twin breast rollers are fitted at both ingoing and outgoing sides of the mill, driven in pairs through gear boxes, slipping couplings and universal spindles.

Auxiliary equipment provided for the mill includes a 700 tons hot bloom shear of basically similar design to the heavy bloom shear provided for the 42" Mill. This shear is driven by a 600 h. p. motor and can cut blooms up to 12" x 12" or equivalent cross section at a rate of 6 cuts per minute on the maximum sizes.

After being cropped and divided by the 700 tons shear, located 220 ft. away, material rolled in the 32" Mill is then either fed straight forward to the following Continuous Billet Mill or is transferred into one of two transverse stock bays by chain type transfer banks incorporated in the shear runout table.

At the present stage of Durgapur development, blooms reaching this point will be stocked for outside sale. By the completion of Stage III of the Durgapur overall installation programme in approximately 12 months' time, the Medium Section Mill will be operating ; after reheating, quantities of blooms from this stock pile will then be further processed in this mill. Blooms from the 32" Mill will also ultimately provide the raw material for the Axle Forge, which will form part of the Wheel and Axle Plant scheduled to come into operation at Durgapur at Stage IV in July 1961.

An independent scale wash down system is also provided for the 32" mill. The mill pinions and shear gearbox are lubricated from recirculating pressure oil

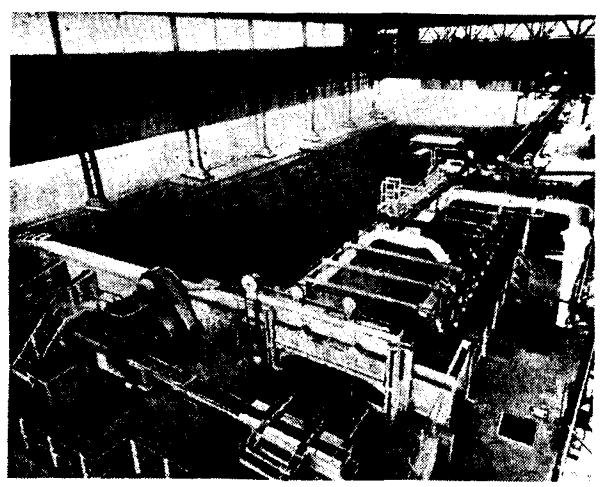
SLEEPER PLANT OF DURGAPUR STEELWORKS

THE initial trials at the Sleeper Plant of Durgapur Steelworks were successfully carried out when the sleepers were produced for the first time at the Plant Site.

This plant is designed to produce sleepers for both Broad Gauge and Metre Gauge railways.

Sleeper bars are produced in the Continuous Billet and Sleeper Bar Mill and cut to length in the Sleeper Plant by a down-cut shear and transferred by means of a conveyor to a walking beam type of furnace for reheating. This furnace is fired by Mixed Coke Oven and Blast Furnace gas obtained from the works system, and is capable of heating 15 tons of sleeper bars per hour.

The Lighting up of No. 2 Battery of the Coke Ovens Plant by Mr. Malcolm MacDonald, High Commissioner for the United Kingdom in India, on 12th October at the Durgapur Steelworks now being built by the British Consortium—ISCON



The Sleeper Plant

From the furnace, the bar goes directly to the 250 ton press, where both the sleeper forming and hole punching are carried out in one operation.

The sleepers are carried by conveyor to the tar dipping tank being descaled enroute by means of high pressure water jets. After dipping and cooling, they are weighed, inspected and stacked to await despatch.

The Sleeper Plant has been built by Davy and United Engineering Co. Ltd.—a Member Company of ISCON — the British Consortium constructing the Steelworks at Durgapur.

Soviet Air Conditioners

Air conditioning is used widely at Soviet factories. It helps improve working conditions of steel-makers, miners and chemists. Air conditioners are manufactured by a plant near Moscow. "Our air conditioners", Alexei Myerkin, an engineer of the plant, said, "create normal temperature and air humidity at steel-smelting furnaces, in foundries, chemical plants and mines. A push of a button produces the desired warmth or coolness. We have prepared a new portable air conditioner for mass production. It can be placed, for example, in the cabin of a crane operator in a hot shop of an iron and steel plant. "Air conditioners will be used in dwelling houses as well. Our factory has produced an air conditioner working on semi-conductors. Resembling a radio receiver, it will maintain any given temperature and replace steam heating".

systems while automatic pressure grease systems are provided for all other points on the mills, roller tables and ancillary equipment.

CONTINUOUS BILLET MILL

Blooms and slabs rolled in the 42″ and 32″ Mills, which are required for conversion into billets or sleeper bar, are fed straight forward without reheating to a Morgan Continuous Billet and Sleeper Bar Mill This principle of straight line feeding and the conversion from ingot to billet in one heat are both essential requirements in a modern billet plant sheduled for continuous high production. Sustained high output of close tolerance product is also a main feature of Morgan Continuous Mills.

This mill forms a very flexible installation capable of producing billets from 2″ to 5″ square, shaped sleeper bar ½″×13½″ and slabs which will be required for certain merchant mill sections. All sizes of billets included in this production programme will be rolled from 7″×7″ blooms, while the Sleeper Bar will be rolled from 3½″×14″ slabs. The output potential of a modern continuous mill of this type will be judged by the fact that its delivery speed reaches 650 ft. per minute on certain billet sizes and 640 ft. per minute on sleeper bars and that it has been designed for an initial production averaging around 12,000 tons of assorted rolled product in a six-day week, operating on a 2-shift basis.

The mill consists of a roughing train with two horizontal and two vertical stands, and a four stand finishing train. Two 24″ vertical roll stands, installed as stands IV and V, are designed for the reductions required in the billet programme and also for edging passes when rolling sleeper bar or other flat sections. The horizontal stands, 2H and 3H, will serve both the billet and sleeper bar programme and have rolls of 48″ barrel length. For the four finishing stands, alternative roll housings are available for either billet or sleeper bar production, the billet rolls having a barrel length of 32″ and sleeper bar rolls a barrel length of 22″. The two roll housings for each stand are interchangeable and the four stands not in use are located adjacent to the mill, fully erected, to facilitate a rapid change-over to suit any rolling programme.

An up-and-down-cut crop shear, capable of cutting steel which is either at rest or in motion. Immediately precedes the mill train. If a cobble should occur it is possible to cut the bloom or slab when in motion so that some portion can be saved.

On the vertical stands oil film roll neck bearings are pre-assembled with the rolls in order that the complete assembly may be handled in a single lift for changing. The vertical rolls are driven through single helical reduction gear units, spiral bevels and helical pinions by 800 h. p and 1,000 h. p. motors respectively.

The horizontal rolls are carried in Morgoil roll neck bearings and are driven through reduction gears and pinion stands. The horizontal roughing stands Nos. 2 and 3, are driven by 800 h. p. and 1,000 h. p. motors respectively and the four finishing stands by one 7,000 h. p. synchronous motor, which also drives the 2,500 Kw generators supplying the D. C. power to the roughing stand motors. This 7,000 h. p. motor, incidentally, is the largest single electric motor installed at Durgapur.

All rolls and chocks for both vertical and horizontal stands will be assembled in the roll shop and then located near the mill to facilitate rapid roll changing by means of roll change rigs used in conjunction with the overhead crane. This operation is further speeded by positioning the mills spindles with hydraulic jacks and cradles, to enable the roll ends to be entered into the coupling boxes with the minimum of delay. Both the horizontal and vertical roll stands are hydraulically adjustable for pass alignment.

SHEARING THE ROLLED PRODUCT

An electrically driven flying shear located some 20 ft. behind the last stand, crops the front end of the product and continues to divide the remainder uniformly into selected lengths of from 14 to 37 ft. as required. The shear, which is capable of cutting a cross sectional area of 30 square inches in alloy steel or 40 square inches in low carbon steel is driven by four 165 h.p. mill type motors. Accurate cutting to length is achieved either by a photo-electric cell, an electric counter working in conjunction with the measuring rail, or hydraulically by a rotary limit switch driven by the shear. The shear is designed to cut the longer billets on a start-stop cycle, while for shorter lengths it will merely slow down between cuts.

Sheared billets or sleeper bar are conveyed to the cooling beds or piling rolls respectively over a 140 ft. length of roller table which serves the flying shear. Actuating mechanism for the automatic operation of the flying shear is built into the table as well as measuring rolls and pinch rolls which control the length of the sheared product. This table also has a water cooled section for controlling the temperature of the sleeper bars, which are piled in bins situated between the piling rolls and skew, assembly table. Billets and slabs are conveyed individually on the connecting table section of the piling bins to the skew table. This table automatically assembles them in batches, prior to automatic transfer to one of three cooling beds.

Sleeper bar is lifted from the piling bins by special C hook onto the cooling beds and, after cooling, into the mill stock area, prior to transport by rail to the sleeper plant

The three cooling beds, each 34 ft. wide by approximately 85 ft. long, deposit billets or slabs into bundling pockets situated in the billet stock bay; from where they are taken as required for further processing in the merchant mill or for sale.

Two separate hydraulic systems and three automatic lubrication systems are provided for the mill which also has its own individual scale disposal system.

ROLLS AND ROLL SHOP

The Roll Shop came into operation at the same time as the first of the rolling mills. The shop, approximately 450 ft long, is served by two overhead cranes of 10 tons capacity and 60 ft. span. Rolls are stored in an adjacent bay, which is complete with storage racks and is served by one 10 ton overhead crane having a 40 ft. span. The Roll Shop is located in a central position in the rolling mills area to give direct access to the billet, merchant and section mills. The heavy rolls for the primary mills will be turned on two Davy-United 26″ roll lathes sited conveniently adjacent to these Mills.

The initial fills of rolls for the 42″, 32″ and section mills are being supplied through Davy and United Roll Foundry Ltd., Billingham. They are manufactured in various qualities each individually selected for different mill production requirements. A complete set of master templates for the rolls, a set of working templates and all necessary roll turning tools are included. Davy and United Engineering Co. Ltd., Sheffield, have produced all the roll designs for these mills and also the necessary guides and guards.

The comprehensive supply of rolls for the Morgan continuous merchant and billet mills have been manufactured by John M. Moorwood Ltd. Sheffield, and grooved where required to Morgan roll designs.

This company has specialised in the manufacture of rolls for Morgan Continuous mills for many years and has developed special roll techniques to meet modern requirements in fast continuous rolling of billets slabs, sheet bar and merchant products They supplied through ISCON, the complete initial fillings of finished grooved rolls including all the grooving tools and precision master gauge templates for the billet mill and has also received direct from Hindustan Steel Ltd. an order for all the initial roll spares to enable the mill to be put into operation. Use of specially toughened alloy S. G. Rolls in the roughing stands and supermetal Mooralloy rolls in the finishing stands provides a well balanced and economic roll complement.

Messrs. Moorwood are also supplying the complete initial fillings of finished grooved rolls, including tools and templates, for the continuous merchant mill together with all the spare rolls required to commission the mill into service.

Rolls are transferred into the Roll Shop from the mill bays on specially designed transfer bogies. The merchant and billet mill rolls are brought into the Roll Shop complete with their chocks and the assemblies are stripped and cleaned in areas designed for this purpose. Rolls for the section mill are chocked up in the mill bay itself in an area adjacent to that reserved for the spare housing assemblies. Guides for the billet, merchant and section mills are stored in special areas in each mill bay. In addition, in the section mill bay are housed guide setting frames for the 24″ mill guides.

The Roll Shop has been initially equipped with eight roll lathes and there is ample space for this number to be increased when required. The merchant mill rolls will be turned and grooved on two Craven 17″ lathes, two Swift RL2 lathes are included for the billet mill rolls, while four Davy-United 22½″ lathes are provided for the section mill rolls.

In accordance with modern practice, all tool grinding machines and equipment are located in one room together with the template making equipment, thus forming a comprehensive tool room where all tools required for roll turning are produced and maintained.

SLEEPER PLANT

Also coming into production at the completion of Stage II is a Sleeper Plant, situated adjacent to the rolling mills area, which will be capable of producing 60,000 tons of steel railway sleepers annually. This plant occupies a place of high importance in current India development plans and particularly in the expansion programme already scheduled for the Indian Railway system. Therefore, to maintain a steady rate of production, the Sleeper Plant at Durgapur has been equipped with a comprehensive conveyor system. Initially only broad gauge sleepers will be produced, but provision has been made to enable the plant to be adapted for the production of metre gauge sleepers in the future.

The plant's normal schedule of operation is as follows: Sleeper bars in 36 ft. lengths are transferred by rail wagon from the billet mill and unloaded into the stocking area of the Sleeper plant itself. From this stocking area bars are lifted in piles of 20 on to a depiling bank from which single bars are moved as required on to a gravity type roller table which feeds an open-sided bar shearing machine. This shear has a blade load of 180 tons and is designed to cut bars into standard 9 ft. lengths.

After shearing, the bars travel along the runout table to the furnace loading position from which they are then charged into a Stein & Atkinson gas-fired reheating furnace of the continuous walking beam type. It is fired with mixed blast furnace and coke oven gas having a calorific value of 300 BTU/cu. ft. at 90,000 cu. ft./hr. and has been designed for an output of 15 tons per hour of sleeper bars up to 9 ft. x 13⅛″ x ½″, weighing 171 lbs. each. After the bars have been heated to the right temperature for the subsequent forming operations to be carried out, they are discharged directly to a 270 ton hydraulic forming and punching press. In one operation on this double acting press, the sleepers are accurately shaped at the rail seat and also have their characteristic trough section formed. Rail fixing holes are then punched in each sleeper. The press is driven by pump and accumulator and has a maximum working pressure of 1,500 p. s. i.

After the forming and punching operations, the sleepers are turned over and skidded to a chain driven variable speed conveyor on which they are manually brushed to remove scale, and if necessary water cooled to the correct temperature for dipping before entering the tar dip tank. In the tar dip section the hot sleepers receive a controlled protective coating. Tar for this section of the plant is brought from the coke ovens by rail tanker wagon and pumped into a 7,000 gallons capacity storage tank, from where it is gravity fed into the dip tank. The tar in the dip tank is regulated to the correct temperature for the applicable composition by steam heating coils and a water cooling system. Fume removal is considerably aided in the tar dip section by enclosing this area in a tall narrow building which will provide natural upward draught for extraction.

After dipping, the sleepers travel at 6 f.p.m along a chain driven cooling coveyor of sufficient length for the coating to solidify and condition before arrival at the stacking bay. At the end of the cooling conveyor, the sleepers are lifted by a mono-rail type piler and despatched in piles of 10 on to the following stack conveyor. After weighing, the sleepers are deposited in the finished stock bay to await delivery.

All essential services such as gas, oxygen and compressed air supplies and electrical power distribution have been engineered including a water circulation system. Adequate provision has been made for fire fighting equipment and a system of roadways and railways linked with the main works system has been laid down to provide free access to all receipt and despatch points in the rolling mills area. The high bays throughout the mills area are lit by a system comprising twin blended lighting units, each having a 1000 watt tungsten and a 1000 watt mercury fitting and lamp, while fluorescent or tungsten type lighting is installed for all offices, ablution blocks, control pulpits and motor room basements. The rolling mill control pulpits and control cabins for the ancillary equipment are fitted with air conditioning units designed for manual control by the mill operators and capable of maintaining a steady flow of clean cooled air under all normal ambient temperature conditions.

BUILDINGS AND CRANES

The structural steelworks for the soaking pit building has been constructed by Joseph Parks and Sons Ltd. and the buildings have been designed to provide the best possible working conditions under the climatic conditions likely to be met. The main bay is 475 ft. long and 100 ft. wide between crane rails, while an annexe on the west side of the building is 380 ft. long by 21 ft wide.

The design, fabrication and assembly of all the steel framed buildings in the Rolling Mills Area and in the Sleeper Plant have been undertaken by Sir William Arrol & Co. Ltd.

The main bays of the rolling mills are 102 ft. wide and have crane gantries of 95 ft. span. Buildings housing the rolling mills together with the roll shop, finishing and stock bays, together cover an area approximately 3,300 ft. long x 760 ft. wide. The Sleeper Plant with its stock bay has an overall length of 855 ft.

Sir William Arrol & Co. Ltd., have also been responsible for the design, fabrication and site erection of all the electric overhead travelling cranes in the Rolling Mills Area. These cranes, which are all of steel construction, range in capacity from 5 tons to 75 tons, the 75-ton cranes being required for roll changing on the 42″ Mill and also for stand changeover operations on the Medium Section Mill.

—Courtesy " The Hindu "— Durgapur Steel Project Supplement

A Year of Significant Progress in Bhilai

ADDRESSING a gathering of Indians and Russians in Bhilai on India's Independence Day, N. C. Shrivastava, General Manager of the Bhilai Steel Plant, said that engineers and workmen engaged in the construction at Bhilai had done a splendid job of which they could be proud. He said, "The erection of the huge steel plant is nearing completion. There are plans for expansion to two and a half million tons and preparation of detailed report for the expansion scheme is already in hand."

Shrivastava said that the last twelve months have once again seen very significant progress at Bhilai. The Steel Works and the new town have both acquired a more finished appearance. On this day last year the heating of the second coke oven battery was started. A number of other units were thereafter commissioned in quick succession. As a result, the production of coke and pig iron was doubled. The making of steel began in October. Most important of all, rolling of steel started with the commissioning of the blooming and billet mills. In mines too substantial progress has been made. Erection of the mechanised mine at Nandini has been completed and at Rajhara it is now in the advanced stage of completion. We have by now produced nearly seven lakh tons of pig iron and almost two lakh tons of steel ingots. Over one and a half lakh tons of steel billets have been rolled. Bhilai iron and steel have gone to every corner of the country as also to foreign countries. Bhilai already sold iron and steel worth over 16 crores of rupees.

He continued, "We are ready now to enter the final stage in production programme. The third battery of coke ovens has been lying ready to be heated for some weeks. It will be started as soon as sufficient coal stocks are built up at Bhilai. Erection of the third blast furnace is nearing completion. It will be commissioned when additional coke becomes available from the third battery. Steel output will increase with more pig iron becoming available."

Shrivastava declared that Bhilai had provided good training ground for young Indian engineers. The experience they gained here would be useful to them for all times to come. Indian engineers who worked at Bhilai and gained familiarity with the intricacies of steel work would be associated in planning and designing the expansion scheme. They would form the nucleus of the designing organisation for the future steel works.

Concluding, Shrivastava said, "A big work has been completed at Bhilai but bigger work is yet to follow. We have to consolidate the position already gained and run the Steel Works efficiently and economically. Moreover, the target of expansion to two and a half million tons has to be planned and achieved. Success of the country's industrial development plans depends on increased steel output. I hope with renewed faith in ourselves and with confidence in our future that we shall not fail to fulfil the targets. The friendly relations between Indians and Russians which have contributed so much to our success so far will surely help us in fulfilling the task ahead."

Shrivastava also acknowledged the meritorious services for a long period rendered by many of the Soviet experts who had since returned to their homes after completing their assignments here. He also paid tribute to the two Russian engineers who lost their lives at the erection sites while on duty due to unfortunate accidents.

INCREASING BHILAI'S CAPACITY TO 2½ MILLION TONS OF STEEL A YEAR

Soviet Engineers are now working on designs to increase the capacity of the Bhilai works to 2·5 million tons of steel a year. This job has been assigned to the State Institute for Designing Iron and Steel Works which had prepared the designs for the first section of the plant with a capacity of 1,000,000 tons a year.

The new technical design envisages the enlargement of the existing blast furnace, open-hearth and the rolling mill departments. New, even more powerful equipment will be installed at the plant. This includes 500 ton open-hearth furnaces, two blast furnaces and several rolling mills.

The first section of the Bhilai Iron and Steel Works built with the assistance of the Soviet Union will shortly be completed. Before the end of the year several more open-hearth furnaces, a blast furnace and two rolling mills will go into operation at the plant

CONSTRUCTION PROGRESS AT BHILAI

The Rail and Structural mill of the Bhilai Steel Works is coming up according to schedule, and is expected to go into production soon after the monsoons. The third coke oven battery is ready to be heated up. The blast furnace No. 3 has been commissioned. The construction of the open-hearth furnace No. 4 has been completed and work is now in progress on the erection of the remaining two open-hearth furnaces and the main oxygen plant.

COKE BATTERY NO. 3

The third coke oven battery is now ready for heating. Erection of coal bridge No. 2 is getting completed. Erection work on coal bin, coke wharf and coke crushing station is going on smoothly.

In the bye-products section, benzol rectification plant and the tar distillation plant are nearing completion. Work on the 3rd saturator of the ammonium sulphate plant is progressing satisfactorily.

BLAST FURNACE NO. 3

Erection of the third and the last blast furnace was completed on August 27.

SINTERING PLANT

Civil works in switch post and oxygen storage have been completed. Slabbing and cladding works are also progressing simultaneously. About 88 per cent of the overall concrete has been poured.

OPEN-HEARTH FURNACES

Mechanical erection of open-hearth furnace No. 4 has been completed. Erection of furnace Nos. 5 and 6 is now in progress. The mixer in the steel melting department is nearing completion, with the refractory works having been taken in hand.

ROLLING MILLS

Concreting, technological pipeline and structural erection in the rail and structural mill is progressing satisfactorily. Erection of mechanical equipment is going on in the working and finishing stands, cooling beds, etc. The progress of mechanical erection work is commensurate with the schedule to put the structural section of the mill into operation during October, this year. Work on the reheating furnaces has been taken up.

Merchant Mill : In the merchant mill also the mechanical erection is progressing satisfactorily.

Auxiliary Shops : Majority of the machines in the foundry have been put into operation.

Erection of machineries in the main oxygen plant is progressing according to schedule.

Shipping : Three more ships carrying about 3,722 metric tons (gross) of cargo arrived at Vizagapatnam and Bombay ports during the month of July 1960. So far 163 ships have come from USSR carrying approximately 479,850 metric tons (gross) of equipments and materials required for Bhilai Steel Works.

RAW MATERIALS POSITION

The erection of crushing and screening plant of Rajhara Iron Ore Mines is progressing satisfactorily and is expected to be completed by September, 1960.

Limestone : Crushing and screening plant at Nandini Mines is ready for being switched into operation.

MAGNITOGORSK STEEL WORKS—3RD OPEN-HEARTH FURNACE LAUNCHED

A third open-hearth furnace has been launched at the Magnitogorsk Steel Works. This is the third open-hearth furnace to be commissioned under the Seven-Year Plan. In one heat it produces 20 per cent more steel than similar furnaces existing at this plant. It is fired with coal gas with residual fuel carburation. Control of steel smelting is largely automated.

The Magnitogorsk Steel Works—the first Soviet steel plant built in the Southern Urals—is undergoing reconstruction and in five years will become the most automated plant of its kind.

Towards the end of the Seven-Year Plan the Magnitogorsk works will produce about 12 million tons of steel a year—half as much as was produced last year by all West German steel mills. At the present time the biggest steel plant in the world is the Gary Plant of the United States Steel Corporation which produces something like eight million tons of steel a year.

Twenty per cent of the output increment at the giant Urals steel works will be achieved through automating and mechanising production as a result of which labour efficiency is expected to rise by 60 per cent. While the capacity of the plant will practically double, its labour force will increase by 1965 only by 20 or 22 per cent.

The Magnitogorsk works is one of the six steel plants of the Soviet Union which within 4 or 5 years are to reach a very high level of automation. Their experience in applying new machines and processes will later be extended to other Soviet iron and steel works.

Quality Control of Drop Forgings

By a Special Correspondent

THE success and perhaps even the survival of any Company in a competitive market is largely dependent on the quality of its products and this is particularly so in the drop forging industry.

For many years the engineering industry has depended on drop forging for the production of vital components and this has been particularly the case in the fields of automobile and aircraft manufacture.

Drop forging is specified for vital components, not because it is a cheaper process than other forms of metal shaping such as casting or welding. In some cases it is cheaper and in other cases it is not. It is specified primarily to meet quality requirements.

We are all aware of the fact that with present day techniques very excellent castings and welded components are produced. By and large, however, it is probably fair to state that more consistent reliability is expected from the drop forging process. Accordingly, it is incumbent on the drop forger to ensure that the quality claimed for his process is in fact substantiated.

Broadly, the qualities expected in a drop forging are adequate strength, freedom from objectionable surface defects, optimum machinability, minimum of distortion in heat treatment and machining and dimensional stability in service. In special cases attention has to be given to other properties such as resistance to oxidation or creep at high temperatures and resistance to corrosion.

Prior to a consideration of the quality control procedures involved, a brief description is given of the Company with which the writer is associated, its customers and its quality objectives.

The Company which is Garringtons Limited, produces well over 100 million drop forgings per annum. The vast majority of these are made from steel the usage of which is in excess of 130,000 tons/annum. Typical forgings are shown in figs. 1 and 2.

There are two Works in the Midlands. One, at Bromsgrove, employs approximately 2000 personnel. The other, at Darlaston, employs approximately 1000 personnel.

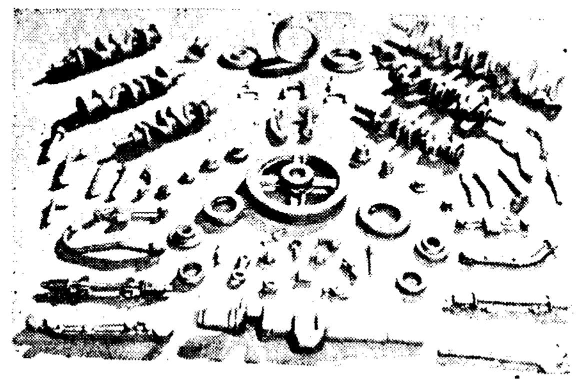


Fig. 1

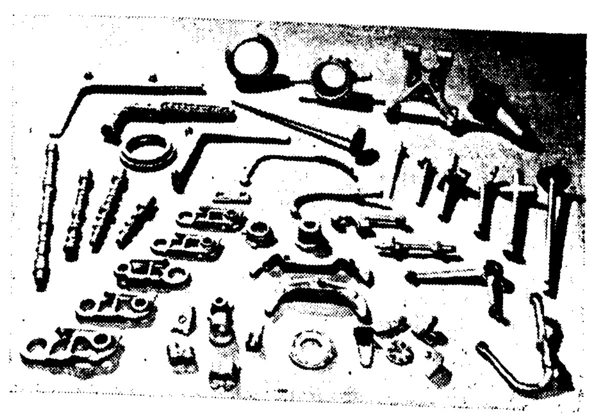


Fig. 2

In these Works the plant comprises mechanical presses, drop hammers, mechanical and electrical upsetters. The mechanical presses are fed with induction heated billets or bars; the furnaces associated with the drop hammers are oil fired.

There is also adequate plant for subsequent operations such as heat treatment, pickling and shot blasting. In certain cases the forgings are heat treated, finished machined and locally hardened by flame heating or induction heating, and in some cases finally electroplated. A third Works in South Wales is engaged in the manufacture of compressor and turbine blades mainly for the aircraft industry, and also in the production of cold forgings. In this latter Works the raw materials used are Nimonic Alloys, stainless steels, aluminium alloys, aluminium bronze and to a lesser extent titanium alloys, in addition to plain carbon and alloy steels.

THE CUSTOMERS

The customers are mainly in the automobile, agriculture and aircraft industries or are related to these. In terms of tonnage, the aircraft work is small in comparison with work for the automobile and agricultural industries but it, nevertheless, consumes a considerable proportion of technical effort and quality control in view of the high quality standards required.

QUALITY OBJECTIVES

The quality objectives are twofold :—

(a) Satisfied customers

(b) A minimum of processing trouble and scrap within our own Works

Briefly, the quality requirements of the customers are :—

AIRCRAFT INDUSTRY

The emphasis on quality which, of necessity, has always been in aircraft work, becomes more acute as air travel becomes faster with further flights and heavier loads. As a supplier of turbine and compressor blades for aircraft engines, we are very conscious of the possible consequences of the failure of one of these blades in service. Absolutely no effort is spared to ensure that the forgings supplied to the Aircraft industry are of first class quality in every respect.

AUTOMOBILE INDUSTRY

In this industry the emphasis on good quality is understandably on highly stressed or vital components such as steering components, con. rods, crankshafts and gears. In addition, however, there is the perpetual demand for uniformity in properties in batches of forgings to ensure smooth working of the automated machine lines. Here such factors such as machinability, distortion in heat treatment are of vital importance.

AGRICULTURAL TRACTORS & COMMERCIAL VEHICLES

This is one of our greatest export lines where quality is of importance in competitive world markets. Here we are competing for business in areas where the service conditions are often far removed from those in this country, due to differences in road conditions, climate and standard of maintenance.

QUALITY CONTROL PROCEDURES AT GARRINGTONS

Certain procedures are carried out prior to, during and subsequent to the manufacture of drop forgings with the intention of controlling quality and these are discussed below :—

Metallurgical and Inspection Departments exist with the prime object of testing and sorting etc. The personnel in charge of these Departments make assessments of quality sometimes in matters which are not easy of resolution or assessment. These personnel and the Departments in their charge are the prime movers in quality control but the results of their work is fully valid only by the co-operation of most personnel employed in the Works.

A complete analysis of the steel to be used is rendered useless if the steel consignment is wrongly labelled or wrongly colour coded, or if the cut pieces from the billets or bars are mixed with cut pieces of another specification on the shop floor, or if the steel supplier has supplied an incorrect billet in an otherwise correct consignment.

Induction heating has the advantage that once set to the correct temperature it will maintain that temperature for the complete die run of the forgings. Unfortunately, however, oil fired furnaces do not have such consistent control. Accordingly we are dependent on the furnace operators to ensure that the furnace temperatures are maintained correctly between visits of the patrol pyrometer inspectors, who check the furnace temperatures with optical pyrometers.

Thus it can be seen that the quality controller is dependent to a great extent on the co-operation of personnel in other Departments and sometimes in other Companies.

The quality control procedures at Garringtons are broadly summarised as follows :—

1. *Technical Study of the Customers' Enquiry*, during which decisions are made regarding die design, raw material specification and processing specifications.

2. *Inspection and Testing of Raw Material.*

3. *Quality supervision and sampling during forging operations* (e.g. furnace temperature control, dimensional checks and surface inspection).

4. *Quality Supervision and Sampling in the subsequent operations, e. g. during the operations of heat treatment and pickling.*

   Control of furnace temperatures, furnace atmospheres, quenching media, analysis of pickling baths. Micro-examination and hardness testing of heat treated forgings.

5. *Inspection aud Sampling of the Finished Forgings* for dimensions, hardness, surface defects, microstructure.

6. *Despatch Procedure.*
   Supply of test certificates, and in some cases also test bars to the customers. Advice Notes. Special delivery in cast segregation. Special despatch identification when required.

7. *Liaison with Customers.*
   Investigation of customers complaints.

TECHNICAL STUDY OF THE CUSTOMERS ENQUIRY

A minor fault overlooked at this stage could have costly consequences. Accordingly, the metallurgical and engineering personnel involved in this work hold responsible positions.

It is important that the die design is such that the drop forgings can be produced in an economical manner and also that the resultant grain flow in the forgings will be the most serviceable and will minimise the chances of laps or metal strain occurring during forging. The grain flow in a pinion forging is shown in fig. 3.

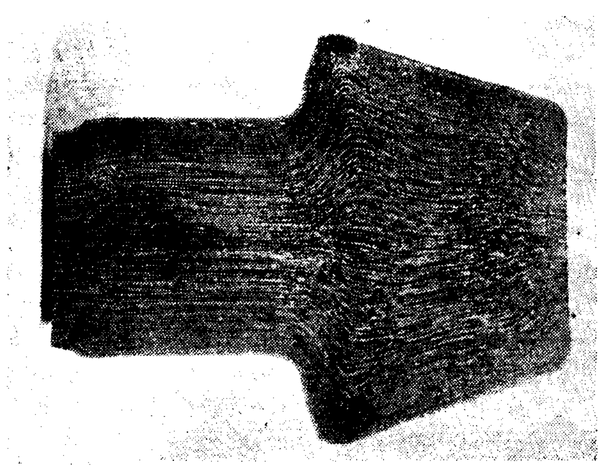


Fig. 3

It occasionally happens that a customer requires properties in the forgings which are not obtainable from the steel which is specified. Good machinability may be an important factor, in which case the process by which the steel is made is of paramount importance, e.g. open hearth or electric. These are but a few examples of many factors that have to be taken into account in the study of the customer's enquiry.

Subsequent to this study, and assuming that an order has been placed, then a master record of all details of raw material and processing specification is circulated to the appropriate Departments.

INSPECTION AND TESTING OF THE NEW MATERIAL

The greatest proportion of the raw material is in the form of steel billets or bars in the size range ½″ dia. to 6″ square.

The quality control of the raw material is, of course, of prime importance, because unless it is correct, subsequent operations may be a waste of time and effort. In a Works such as Garringtons, where the output and rate of working are high and associated with expensive plant, stoppage of production due to faulty material cannot be tolerated to any marked extent.

Consequently, very strict rules are laid down regarding the use of raw material. These are :—

(a) The material must not be used until released by the Laboratory.

(b) Each forging which is prod·ced must bear a three letter code, by which the steel identification is known.

After unloading from the lorry or wagon in which it has been delivered, each consignment of steel is inspected by the Steel Stores Inspector for evidence of harmful surface defects, or evidence of bent billets or bars which could cause trouble during the cropping operation.

The necessary samples are then cut off for Laboratory tests and the cast number stamped on each test piece, which is then forwarded to the Laboratory.

Meanwhile, the steel is placed in storage racks clearly labelled with full details of size, specification, cast number, supplier and die number for which the steel was ordered. Each bar end is painted with a colour code denoting the steel specification.

Of the samples sent to the Laboratory, there is always one from each cast for chemical analysis. In fact, should the same cast of steel be rolled into various sizes, a sample for analysis is supplied from each size.

On arrival of the test piece at the Laboratory, full details of the steel are entered into a Code Book and the steel is allocated a three letter code. Against this code are eventually entered the following details :—

Date of receipt of the sample
Steel Order Number
Date of release of steel for production
Size of billet or bar
Specification
Cast Number
Steel Supplier
Weight of steel received
Die No. for which the steel was ordered and the die number for which it was released.
Results of chemical analysis
Results of all other laboratory tests carried out, e.g. mechanical properties, grain size and cleanliness tests etc.

Thus there is a complete record of each size of each cast of steel received in the Works.

Details of the inspection and testing of the raw material which is carried out in the Metallurgical Laboratory are as follows :—

METALLURGICAL EXAMINATION OF FORGING QUALITY STEELS

SURFACE QUALITY

The assessment of the suitability of the surface condition of a particular cast of steel is often a difficult matter. Consideration is given to the distribution and magnitude of surface defects, taking into account the nature of the forging operation, the type of forging plant to be used and machining tolerances. Press forging combined with H. F. heating of the steel stock is considerably more critical of surface defects than hammer forging combined with oil or gas fired furnace heating of the steel.

The degree of surface perfection required is greater for an upset forging than for a "lay-in" forging on which the main forging action is at 90°C to the axis of the steel stock. Upset forging creates a very severe strain on the surface layers of the steel and it will readily reveal any surface defects.

Laboratory examination of surface quality includes pickling in either hydrochloric or sulphuric acid and also the up ending test shown in fig. 4. In this test the steel stock is heated to the appropriate forging temperature and forged to approximately one half of its original length with a minimum number of blows.

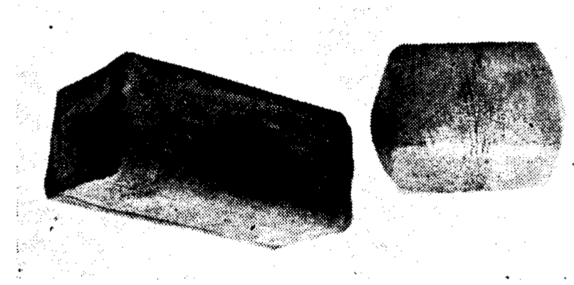


Fig. 4

Samples for pickling and up ending are chosen from certain billets or bars which show signs of surface defects during a visual examination of the bulk consignment.

CHEMICAL COMPOSITION

Chemical analysis is carried out on each cast of steel, even though in the vast majority of cases a test certificate covering both chemical analysis and mechanical properties is supplied by the steel makers.

Prior to the analysis by wet methods and by the spekker photo electric absorptiometer, the sample is qualitatively checked on the steeloscope to ensure that it is of the correct general composition. Subsequently, by conventional methods, Carbon, manganese, silicon, sulphur and phosphorus are checked on plain carbon steels and these elements together with the appropriate alloying elements in alloy steels. In cases in which there is a hardenability specification an estimate is made of residual elements such as nickel, chromium, copper, molybdenum and tin.

MECHANICAL PROPERTIES

Forged test bars from each cast of steel are given the heat treatment appropriate to the specification and from these, test pieces are machined and tested for yield point or proof stress, ultimate tensile stress, ductility and impact value.

In special cases creep testing is required.

HARDENABILITY

In some cases hardenability is specified to guarantee the attainment of certain required conditions during heat treatment, machining or in service. For example during the water quenching of a .50% carbon steel in certain sections there is usually a risk of cracking. This may be minimised or even eliminated by a hardenability control which limits the total percentage of residual elements. Control of hardenability is also of importance in reducing the distortion of gears during hardening. In other cases it may be necessary to ensure adequate depth of hardening to facilitate machining or to withstand service conditions.

Hardenability is determined by either the Jominy or Rockwell inch test, depending on the class of steel being examined. In the Jominy test, a 1″ dia. specimen of the steel is heated to the appropriate hardening temperature and quenched under standard conditions on its end face. Two parallel ground surfaces are prepared along its length and Vickers hardness readings taken on these at intervals of 1/16″ progressing from the quenched end along the length of the specimen. From the resultant data a hardenability curve is constructed.

In the Rockwell inch test the 1″ dia. and 4″ long specimen is heated to the appropriate hardening temperature and completely quenched. It is then cut transversely half-way along its length and Rockwell readings are taken on two diameters at 90° at intervals of 1/16″ from the surface to center. The mean readings of the two diameters are determined and the hardenability in Rockwell inches is determined from the formula :—

$$\tfrac{1}{8}\ (\tfrac{1}{2}S + H1 + H2 \ldots\ldots H7 + \tfrac{1}{2}C)$$

Where S is the surface hardness, H1 the hardness at 1/16″ depth, H2 the hardness at ⅛″ depth etc. and C is the centre hardness.

GRAIN SIZE

Examples of fine and coarse grain steel are shown in Figs. 5 and 6. The specification of grain size is now quite common practice to ensure minimum distortion during heat treatment or consistent machining characteristics or in the attainment of specific mechanical properties.

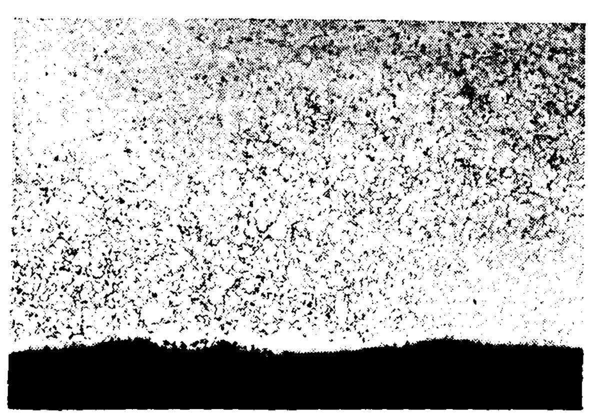


Fig. 5. Fine grain steel. Mag. X 100

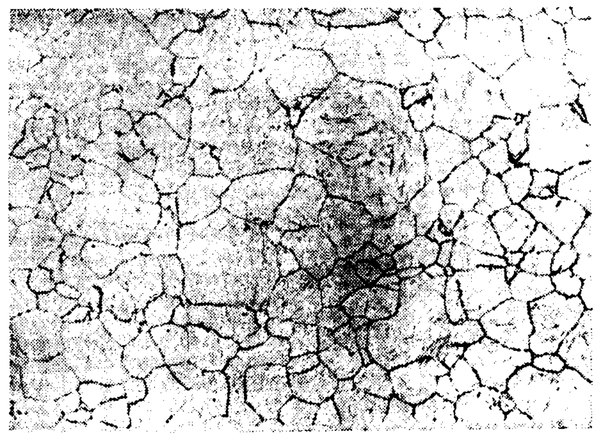


Fig. 6 Coarse grain steel. Mag. X 100

Fine grain steels have better impact properties than coarse grain steels, whilst the latter have greater hardenability, higher tensile strength, better creep properties and lower ductility. Generally fine grain steels are more difficult to machine but give a better machined finish. Because of their greater hardenability coarse grain steels are more prone to distortion and cracking during heat treatment.

CLEANLINESS

Steel cleanliness has an important bearing on cracking during heat treatment, machinability, resistance to fatigue in service and forgeability. Because of difficulties associated with its definition it is only in exceptional cases that a definite standard of cleanliness is specified by the engineer.

Machining problems can arise due to having too few sulphides or too many or too large silicates, oxides or nitrides. Fig. 7 shows a field of sulphide inclusions which are beneficial to machining whilst a harmful silicate is shown in fig. 8.

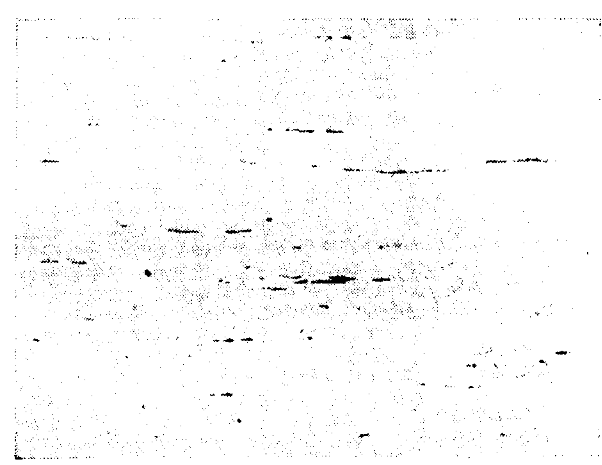


Fig. 7. Sulphide inclusions. Mag. X 100

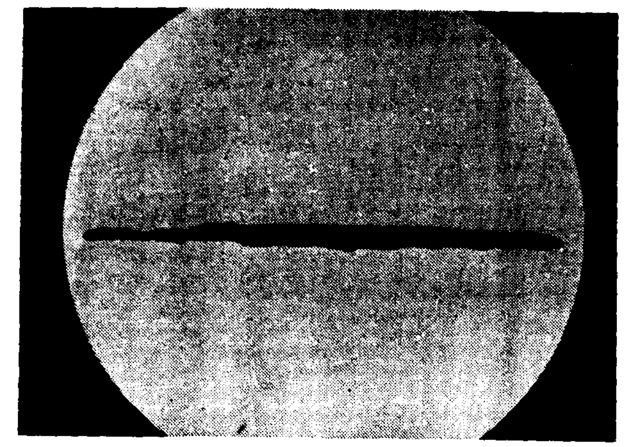


Fig. 8. Silicate inclusion. Mag. X 100

During forging there is a tendency for the inclusions to concentrate on the flash line. They then act as stress raisers during hardening or in service and may cause cracking. Unless they are very large or in heavy stringer formation, inclusions are not normally troublesome during forging. In fact, dirty steels are somewhat less prone to overheating than clean steels. The harmful effect of iron sulphide on forging is of course well known, but nowadays its occurrence is a rarity.

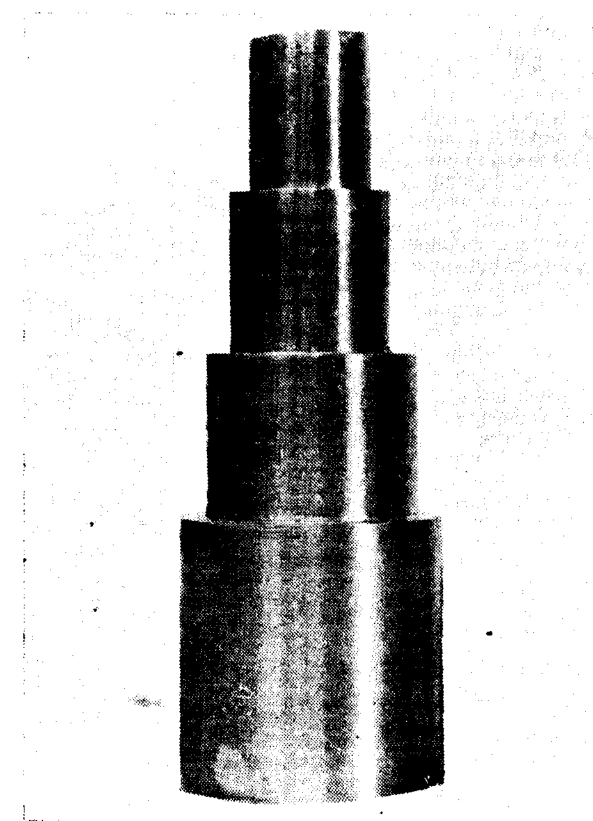


Fig. 9. Step-turn test piece for assessment of cleanliness

The cleanliness of a cast of steel is liable to be very variable and its assessment often presents a difficult problem.

The procedure at Garringtons is firstly in the magnetic crack detection of step-turned billets or bars as shown in Fig. 9. Stringers are readily detected by this method. In certain cases this is followed by micro-examination of selected areas of the steel and inclusion counting based on either the Fox or Jernkontoret methods. The Fox count is quicker in operation. The Jernkontoret count has the advantage of a definite classification of the inclusions as sulphides, alumina, silicates and oxides, and this is of particular value in estimating the effect of the inclusions on machinability. Whatever method be used, careful polishing of the specimen is essential to ensure freedom from pitting, scratching and distortion of the inclusions. Fox count and Jernkontoret inclusion count charts are shown in figs. 10 and 11, respectively.

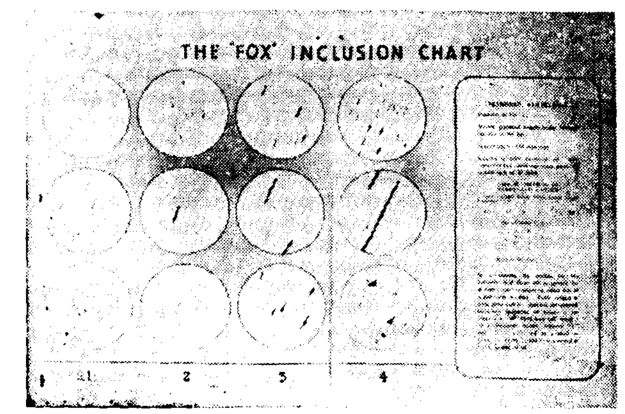


Fig. 10. Fox inclusion chart

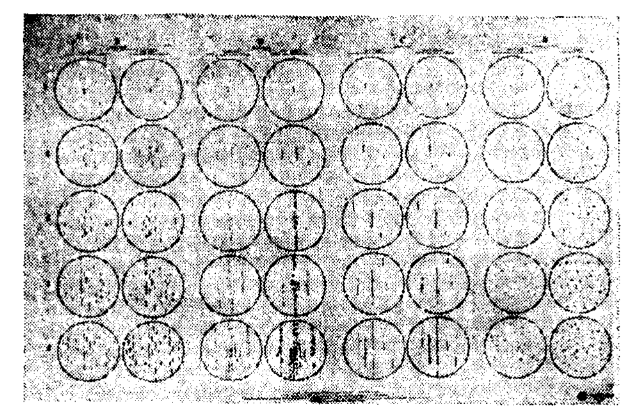


Fig. 11. Jernkontoret inclusion chart

SEGREGATION
AXIAL SEGREGATION OR PIPE

Piping is liable to cause rupture along the axis of the steel stock during forging; steel with centre segregation may become locally burned or overheated due to an abnormally high carbon. Fracturing or macro-examination of a pickled transverse section or sulphur printing are methods by which piping and axial segregation are readily detected. Piping in a stainless steel compressor blade is shown in fig. 12.

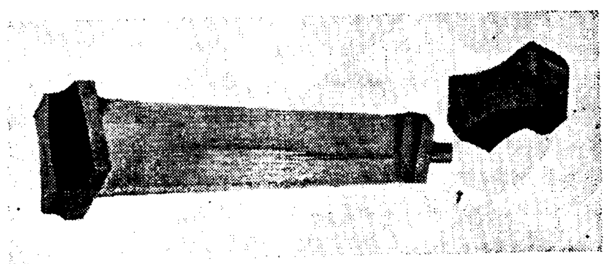


Fig. 12. Piping in stainless steel compressor blade

BANDING

A banded structure is shown in fig. 13. As the term suggests, this is a condition of the steel in which certain constituent elements are concentrated in certain planes and deficient in others. Consequently, there are alternate bands of different microstructure and hardness which may result in heat treatment, machining and service problems. Fundamentally, banding is due to chemical segregation in the ingot for a variety of reasons. Sometimes it can be reduced in its severity by adequate re-heating of the ingot prior to rolling. It is usually accentuated by forging and by certain critical heat treatments such as cyclic annealing. It is invariably minimised by hardening and tempering.

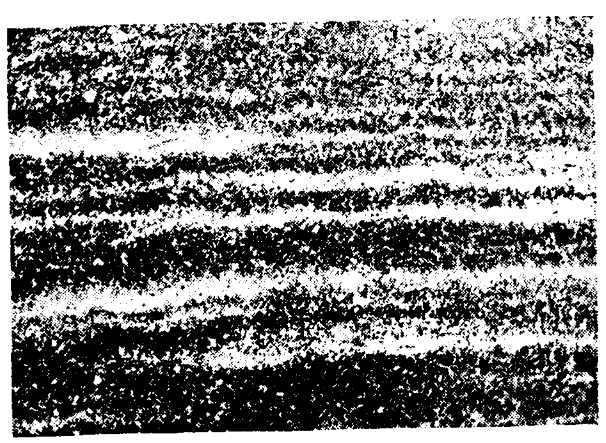


Fig. 13. Banding in steel. Mag. X 100

LEAD SEGREGATION

A more correct term for this fault is lead aggregation. During its addition to the molten steel, the lead tends to sink to the bottom of the ingot mould and lead segregation is encountered when bottom cropping is inadequate. Also the practice of lead addition to top poured small ingots is liable to cause aggregation in high regions of the ingot. Lead aggregation is troublesome when components are heat treated in the finish machined condition when the lead particles are liable to run out leaving cavities in the surface.

Lead aggregation is best detected by the lead print method. A section of the steel is linished and filed and placed in contact with a special lead print paper which has been soaked in 5% caustic soda solution for approximately 2 mins. The paper is then transferred to a 5% solution of sodium sulphide. Reaction between the lead ions and the sodium sulphide results in the formation of lead sulphide which imparts a brown colour to the print.

BURNING & OVERHEATING

Fortunately, burning or over-heating of steel stock by the steelmaker is a rare occurrence and in the case of overheating its ill effects are usually overcome by subsequent forging.

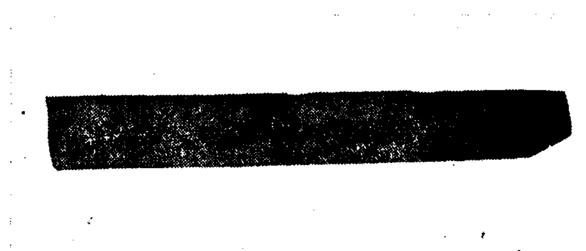


Fig. 14. Burned steel bar

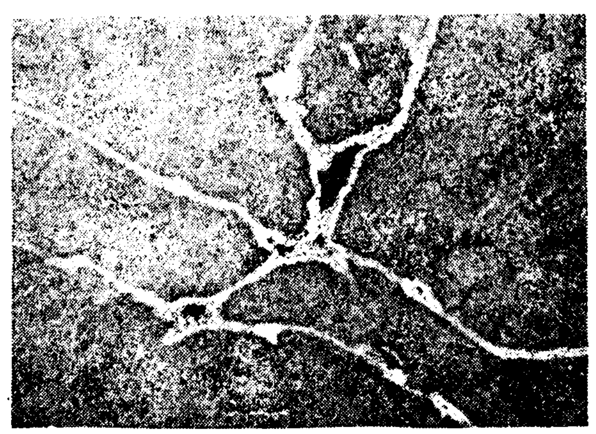


Fig. 15. Burned steel Mag. X 100

Burning is readily recognised by visual examination, as can be seen from fig. 14, and the effect on the microstructure is shown in fig. 15. A burned steel cannot be salvaged. Over-heating may vary from a mild form which can be cured by high temperature prolonged normalising treatment to the other extreme just short of burning which will not respond to any form of corrective

treatment. Although overheating results in a marked drop in the impact value, other mechanical properties such as tensile strength and ductility are not appreciably affected. An overheated steel is usually most difficult to refine by hardening unless given a preceding normalising treatment.

In the Writer's experience, the best means of detecting overheating is by etching in Wesley-Austin reagent (10% nitric acid and 10% sulphuric acid in water). Fig. 16 shows the microstructure of an overheated steel after the Wesley-Austin etch. The heavily delineated boundaries of the large grains which remain after removal of the etch is the evidence of overheating. Fig. 17 shows the same steel with a nital etch in which the very large grains are delineated by a ferrite network.

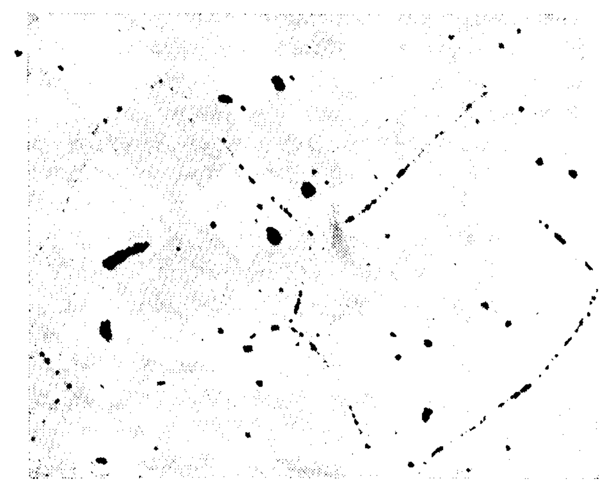


Fig. 16. Overheated steel. Mag. X 100
(Wesley Austin etch)

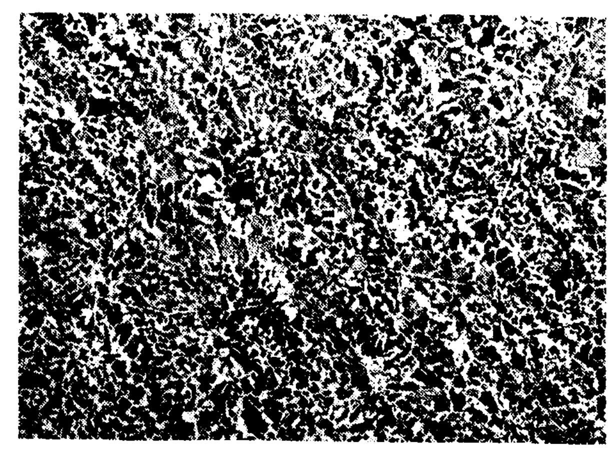


Fig. 17. Overheated Steel. Mag. X 100 (Nital etch)

Quality control of the raw material, however, is not confined to inspection and testing. The results of such are recorded and the performance of each supplier is tabulated and circulated each month to interested members of the management. By this means it is possible to determine the suitability or otherwise of particular suppliers for specific jobs. In the event of persistent fault occurring in any particular property it is possible to draw the supplier's attention to this fault and in some cases this may effect a remedy. In other cases a change of supply may be necessary.

It is the responsibility of the quality controller to assess to what extent he can afford to depart from perfection in striking the happy balance between having adequate supplies commensurate with the minimum of Works scrap and having satisfied customers.

Our Raw Material Inspection records show that successful operation is possible only by planned selection of suppliers. The steel from one source is, generally, less clean than from another. One supplier is good for surface quality, another is bad. One has a poor record on grain size steels. Another has a poor record on machinability etc. The record of each supplier is taken into account in the purchase of steel for specific jobs. Also taken into account are the type of forging operations involved e. g. whether upsetting or lay-in forging, and the means of heating and plant to be used e. g. whether induction or oil heating, press or hammer forging.

H. F. heating with its minimum of scaling is more exacting on surface quality than oil fired heating with its liberal scaling. Also press forging with its restricted number of blows often inflicts more punishment on the steel than hammer forging with more blows and more coaxing of the metal into the dies.

QUALITY SUPERVISION AND SAMPLING DURING FORGING OPERATIONS

Having released the raw material, which is then sawn or cropped to correct lengths, the next step is forging on mechanical presses, upsetters or on drop hammers.

Factors examined during these operations are dimensions, surface finish, furnace temperature, (in some cases furnace atmospheres have to be controlled e. g. in forging nickel base alloys, titanium alloys and in precision forgings where oxdidation and decarburisation have to be avoided).

In the early stages of forging there is also examination for evidence of laps or metal strain, which may have been caused by faulty die design. Inspection at this stage is carried out on a patrol basis. As the dies undergo progressive wear, the forgings obviously become dimensionally less accurate until eventually because of this, the job has to be stopped for replacement of the dies.

As all new jobs are proofed prior to going into production it is unusual to find a fault which is attributable to die design.

Although there is an initial surface inspection of the billets or bars, small defects are sometimes brought to light during forging operations. Fortunately this does not happen often.

Furnace temperatures are regularly checked by patrol inspectors with optical pyrometers. In the event of the furnace temperature having been found to be too high, the forgings are quarantined pending the results of Laboratory examination.

If burning is found, which rarely happens, the forgings are scrapped. If overheating is found, an attempt is made to reclaim the forgings by long time, high temperature, normalising treatment.

QUALITY SUPERVISION AND SAMPLING IN SUBSEQUENT OPERATIONS

HEAT TREATMENT

Approximately 50% of all production is in the heat-treated condition either as normalised, annealed or hardened and tempered. In the case of finish machined products such as wrenches, hammers, track links etc., they are further locally hardened in specific areas by flame or induction heating.

It is most important, therefore, that having produced good forgings following careful inspection of the raw material and its processing, that they should not be scrapped in the heat-treatment operations.

All heat treatment operations are under the supervision of a qualified metallurgist. Patrol inspectors check the furnace temperatures with potentiometers and optical pyrometers and in addition pyrometers are calibrated and repaired by instrument mechanics employed in the Metallurgical Laboratory.

After hardening prior to tempering, random hardness checks are made to facilitate the selection of the correct tempering temperatures. In specific cases, samples are taken for micro-examination in the Laboratory to ensure good core properties prior to release from the Hardening Shop. In some cases fracture testing, bend tests and magnetic crack detection are carried out on the heat treated components.

INSPECTION & SAMPLING OF THE FINAL PRODUCT

The extent to which final inspection is carried out is dependent on a number of factors which include the nature of the forging, its past history in relation to defects and any reported defects during manufacture.

For example, all con. rods for one particular customer are subjected to 100% hardness testing and 100% surface inspection under a magnifying glass.

Turbine blades in Nimonic 100 are checked for grain size in the Laboratory to the extent of one per 100.

In cases where the forgings are intended for less exacting service and are supplied as forged or normalised, they may be subject only to surface inspection.

In between these limits, the extent of final inspection varies greatly dependent on the nature of the forging and its past history.

DESPATCH PROCEDURES

Advice Notes are, of course, supplied with each consignment, giving full details of the forgings in regard to quantity, specification, etc. Each forging bears a three letter code, as has been already noted, so that in the event of any subsequent complaint full details of the steel which has been used will be known.

LIASION WITH CUSTOMERS, INVESTIGATION OF CUSTOMER COMPLAINTS, RECORDING OF CUSTOMER REJECTIONS

This final stage is most important in quality control. The above noted work is done with the prime object of having satisfied customers. We believe that the only sure method of gauging the customers reactions to quality is by regular visits of our Liaison Personnel to their Works.

By this means molehills are often prevented from growing into mountains and in general a happy relationship is assured.

Customer liaison and complaints are handled initially by a Liaison Metallurgist and a Liaison Inspector solely engaged on this work.

PREPARATION AND CARBONISATION OF COAL

By

N. N. Das Gupta, A. K. Chakravarty and N. N. Chatterjee

(Central Fuel Research Institute)

INTRODUCTION

In the past the requirement of coal for coking was low in India and coke oven operators had ample choice in the selection of good coking coals for the production of metallurgical coke. The coal producers vied with each other in supplying coal of the best coking quality to the coke ovens and even resorted to selective mining for this purpose. This, coupled with non-adoption of stowing practice and irrational use of good coking coal for such purposes as steam raising in railway locomotives, led ultimately to the rapid depletion of the better grades of coal which occur only in limited areas of the coal bearing regions of the country. Some concern over this was no doubt felt in earlier years as the demand for coking coal increased and it became more and more evident that future supplies of coking coals will have to be drawn from sources producing coals of poorer quality both in respect of ash and coking characteristics. It also came to be realised that beneficiation of these coals in some form or other will be necessary to maintain the supply of coal of requisite quality to the merchant ovens producing foundry coke and the coke ovens of the steel plants which were then solely in the private sector.

The problem assumed greater importance in recent years with the erection of a number of steel plants in the public sector during the successive five year plans. The magnitude of the problem became immediately evident when it was realised that the coal supplies to the steel plants would have to be stepped upto about 16 million tons of washed coal (23 million tons raw coal) in the year 1965 from only about 3 million tons in the year 1955. The problem that faced the country was of a two fold nature. With the exhaustion of the better grades of coking coals having lower ash occurring chiefly in the Jharia coal field, those of higher ash were not considered suitable for use unless they were upgraded to reduce their ash within tolerable limits. In the interest of conservation of the comparatively limited reserves of coals of the prime coking variety, ways and means had also to be found for utilization of the poorer coking or even non-coking coals of which fairly large reserves are available. This could only be done by adopting suitable methods of selective preparation and blending of the poorer coking coals with the standard coking coals before carbonisation and also by adopting appropriate techniques of carbonisation which would produce coke of acceptable quality for steel making.

The present paper deals with some aspects of the work done during the past few years in the Central Fuel Research Institute on coal preparation and carbonisation in so far as they relate to the supply of coking coals to the steel plants of the public and private sectors.

THE REQUIREMENT OF BLAST FURNACE COKE AND THE NEED OF COAL WASHING

While it is possible to utilize high ash, low grade coals for steam generation in specially designed boilers, the coals required for the manufacture of metallurgical coke, besides being of the coking variety, have to be of better quality in respect of ash and certain other impurities which have to remain within specified limits. This is because purity and mechanical strength are the two essential characteristics of blast furnace coke. Uniformity in the properties of coke is also considered to be of great importance for the smooth operation of a blast furnace.

The maximum allowable limit of ash in the coke depends on the nature of the iron ore to be smelted. With high grade Indian iron ores (over 60% Fe) a higher percentage of ash is tolerated than in many foreign countries working on lean iron ore. In India an ash limit of 22·5 per cent in coke is tolerated as per specifications. In Indian practice the ash in the coke is found to be beneficial upto a certain extent in providing the necessary slagging material in the blast furnace. Studies on the influence of ash in coke have shown that in general, a decrease of 1 per cent ash in coke increases the production of pig iron by about 5% and decreases the coke consumption by about the same extent.

A coke for blast furnace use has also to be hard and strong so as to withstand the rigours of handling during its transport and, more important, the stress and strain to which it is subjected in the shaft of a blast furnace. Weak cokes result in the production of more fines in the blast furnace which tend to block the void in the furnace charge thus resisting free flow of air and gas and impede smooth operation.

The physical properties of coke are believed to be of even of greater importance than the chemical purity. Comparative studies have shown that greater uniformity and improved physical structure of coke bring about an increase of as much as 60 per cent in the pig iron production while 40 per cent of the increase in production is due to ash reduction. While there are relatively few coking coals which satisfy the rather stringent requirements and which can be used direct in the coke ovens for making blast furnace coke, a large proporation of the coking coals now produced is of comparatively high ash and, therefore, need cleaning to the required standard before carbonisation. The improvement in the properties of coke effected by washing is presented graphically in Fig. 1.

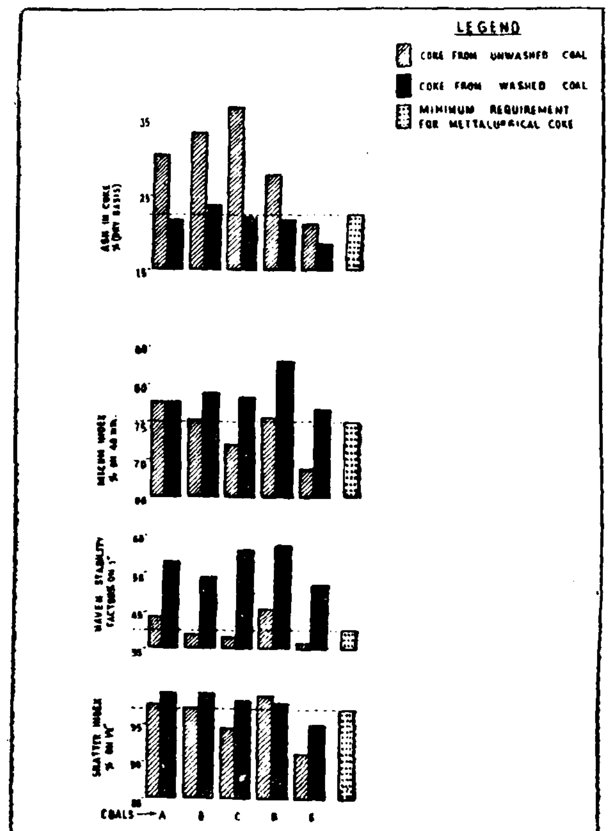


FIG. 1. INFLUENCE OF WASHING ON PROPERTIES OF COKE

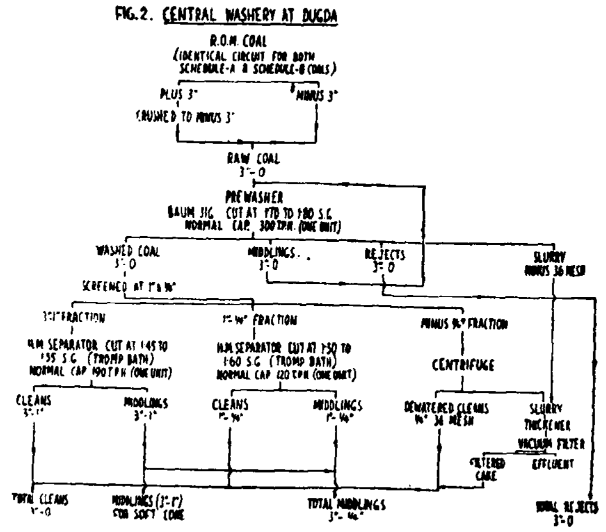
Planning of Washeries

WASHERIES IN THE PUBLIC SECTOR

The Indian coals are as a rule rather difficult to wash and their washability characteristics show wide fluctuation. The Central Fuel Research Institute has been studying the washability characteristics of Indian coals on a laboratory scale since its inception and later on a semi-pilot plant scale. More recently the Institute has been engaged in investigating the problems on a pilot plant scale at its 40 tons/hour composite washery. In recognition of its work the Institute has been entrusted by the Government of India with the planning of coal washeries for the public sector which includes the designing of the various washing schemes to be adopted at the different washeries, scrutiny of the tenders received from various washing plant manufacturers in the world, taking part in the guarantee tests of the plants, etc. The problems of designing washing schemes for Indian coals are somewhat different from those obtaining in the European countries and the U. S. A. Most Indian collieries have small outputs and coal washing at the individual pit-head does not prove economic. The solution lies in grouping a number of collieries despatching coal through a common railway marshalling yard and to ensure minimum haulage, locating a washery with an economic capacity near the yard. The movement of raw coal and of washed products will have to be unidirectional as far as possible. It is sometimes convenient to classify the raw coals into different categories according to their washability characteristic and to wash each category of coal separately.

It also becomes necessary to provide some sort of pre-blending or pre-mixing arrangements to take care of the inconsistency in the quality and size of the raw coals to be treated at the washery. The incorporation of a pre-washer (primary washer) in the washing plant also helps in preparing a consistent feed to the main washers by eliminating the obvious dirts (deshaling).

FIG. 2. CENTRAL WASHERY AT DUGDA



'Composite washing systems' are ideally suited for upgrading coals of widely varying characteristics dealing with the entire size range of raw coal with high efficiency. The washing systems adopted for the five Central Washeries to be set up by the end of second Five Year Plan period comprise: Heavy Medium Units for 3"-1", 3"-½", or 3"-¼" size fractions and Baum Jigs, Feldspar Jigs or Cyclone Washers for the slack size below 1", ½" or ¼" depending on the quality of the feed. The flow sheet of a 600 t. p. h. Central Washery being erected at Dugda where coal from 26 different collieries will be worked after sorting into two schedules is presented in Fig. 2. The particulars of the coal washing plants already in operation or under construction or negotiation in the public and private sectors are given below:

TABLE 1: WASHING PLANTS IN INDIA FOR COKING COALS

Location	Type of Plant	Capacity tons/hr.	Steel plant to which washed coal will be supplied
Private Sector : (In operation)			
1. Jamadoba (TISCO)	Chance H. M. S.	300	TISCO
2. West Bokaro (TISCO)	Chance H. M. S.	130	TISCO
3. Lodna (Turner & Morrison)	Feldspar Jig	70	IISCO
Public Sector : (In operation)			
4. Kargali	WEMCO type H. M. S. & Baum Jig.	460	Rourkela Steel Plant and Bhilai Steel Plant
5. Durgapur	Drewboy H. M. S. & Feldspar Jig.	360	Durgapur Steel Plant
Under Construction or Negotiation:			
6. Dugda	Jig and H. M. S.	600	Bhilai Steel Plant & Rourkela Steel Plant
7. Patherdih	Baum Jig & H. M S. or H. M. Small Coal Washer.	400	IISCO
8. Bhojudih	H. M. S. & Cyclone	250	TISCO

PREPARATION OF COALS FOR CARBONISATION

The need of Fine Crushing

Coal is a heterogeneous mixture of discrete petrographic constituents besides mineral impurities with which it is associated since the stage of its geological formation. Because of the difference in the characteristics of these different constituents, the coals have to be crushed to a certain degree before carbonisation in order that the constituents may be distributed fairly uniformly within the mass of coal charge. This becomes all the more necessary when the coking mixture of a coke plant consists of a large number of coals drawn from different areas. While it is adequate to crush the coals to a fineness of about 80 per cent through 3 mm., some coals of the more inert type having comparatively high ash needs a finer degree of grinding.

The Technique of Selective Crushing

Indiscriminate crushing in conventional hammer mills suffers from the disadvantage of crushing the softer, more fusible 'brights' of the coals to a greater degree of fineness and leaving the harder, less fusible or non-fusible 'dulls' in a coarser state. The particles of the latter present in the coke mass are potential sources of fractures and fissures in the coke and may thus be responsible for its poor strength. Specially designed impact type of mills are in use which effect a somewhat controlled crushing of the coals. In this case the initially crushed products are led over screens of predetermined size and the over size later recrushed in a separate mill to a greater degree of fineness. The manner of crushing influences the coke quality to a great extent. A few examples of this are given in Fig. 3.

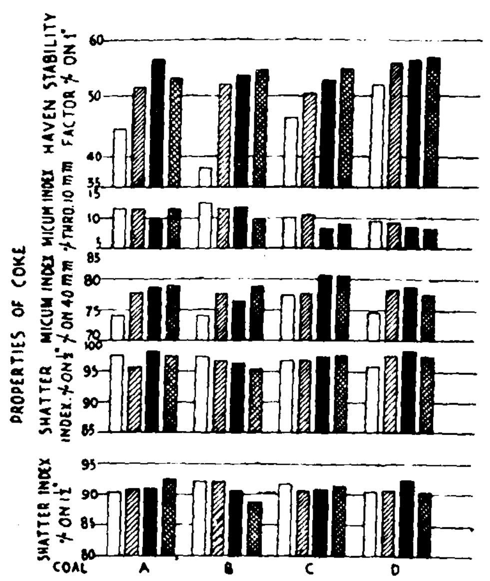


FIG. 3. EFFECT OF SELECTIVE CRUSHING

LEGEND:
- 80% THROUGH 1/8"
- 100% THROUGH 1/8"
- 100% THROUGH 1/8" SELECTIVELY CRUSHED (+1/8" TO PASS THRO 1/16")
- 100% THROUGH 1/8" SELECTIVELY CRUSHED (1/8" TO PASS THRO. 30 MESH)

BLENDING OF COALS FOR CARBONISATION

Blending of coals means much more than mere mixing of two or more components. To ensure uniform composition of the final blend it is necessary to have separate storage arrangement of coals of different types. Suitable appliances appropriate to the types of coals are needed for primary, intermediate and finer grinding of the coals. The need of a proper mixing device is one of the essential pre-requisites of efficient blending.

Extensive studies carried out at Central Fuel Research Institute on Indian coals for the past few years clearly show that an overall improvement in the coke properties is obtained by finer crushing of the coals. While material remaining on 6 mm size is particularly undesirable, it is found to be invariably beneficial to crush the coal to a fineness of 100 per cent through 3 mm. This can better be achieved by a single crusher using a 3 mm. screen and recycling the oversize through the crusher. Alternatively, the coarsely crushed coal after primary crushing to about 10 mm. could be made to pass over a 3 mm. screen, the minus 3 mm. size material taken straight for coking and the plus 3 mm. size material could be crushed in a secondary crusher to make the entire material pass through 3 mm. size or still finer if so desired. In both these operations the main objective is to crush mildly the softer vitrain and give finer crushing to the harder, durains and inerts.

INDUSTRIAL IMPLEMENTATION OF THE RESULTS

Durgapur Coke Ovens

The planning of coal preparation plant at Durgapur Coke Oven of the West Bengal Government has been based on the findings of the researches carried out in the Central Fuel Research Institute. These coke ovens use a ternary blend of three distinct groups of coal for each of which there are different crushing mills matching the petrographic and coking characteristics of the individual coals. The essentially bright high and medium volatile Raniganj coals are crushed to a fineness of 80-90 per cent through 3 mm. and the comparatively low fluid, high volatile Jharia coals are finely crushed to 100 per cent below 3 mm. adopting the technique of selective crushing.

There is also provision for adding 3-4 per cent of crushed coke-breeze (1 mm.) to the coking mixture.

COKING BLENDS FOR THE STEEL PLANTS

Bhilai and Rourkela

Some of the coking type of coals occurring in the Jharia field even when washed were considered inadequate to meet the growing demands of the steel industries. Alternative sources of prime coking coals had therefore to be sought in other regions. Investigations at Central Fuel Research Institute showed that coal from the Kargali seam of the Bokaro coal field was suitable source of coking coal when reduced in ash by washing. The coal from the Kargali washery is since meeting the major requirements for Rourkela and Bhilai.

Exploratory tests have also proved the possibility of utilizing 15 to 20 per cent of the non-coking coals (e. g. Hingir-Rampur, Talcher and I b River of Orissa and Korba of M. P. field) and 30 to 40 per cent of the semi to poorly coking local coals (e. g. Jhilimilli of M. P. field) in these steel plants. These proposals are now being considered by Hindusthan Steel Ltd.

Durgapur

There are substantial reserves of the medium to high volatile coals of weakly to medium coking types in the western part of the Raniganj coalfield. The majority of these coals were hitherto used for steam raising, export or gas making. Only a small percentages of these medium volatile coals has so far been used for coking and the higher volatile weakly coking coals were never seriously tried in the past for coking purpose.

Based on the results of exhaustive tests carried out in the Central Fuel Research Institute, the following coking mixture is being used in the Durgapur Steel Plant: 45 per cent of Jharia low volatile coals and 35 and 20 per cent respectively of medium and high volatile coals of the Raniganj field.

Confirmatory tests in commercial ovens have proved beyond doubt that the possibility of producing hard and strong metallurgical coke from suitable blends containing as much as 60 to 80 per cent of the high volatile Raniganj coals and 20 to 40 per cent of suitably selected low volatile Jharia coals. It is thus found possible to use for coke making 100 per cent of such coals which are considered unsuitable for coking under normal carbonisation technique.

SUMMARY AND CONCLUSIONS

The process of coal washing is not a straight forward proposition. The precise nature of the washery has to be decided on the merit of the washing characteristics of the coals in order that a more homogeneous product may be obtained taking into consideration the economic implication and local conditions.

All coals have also to be given a certain degree of crushing prior to their carbonisation. The manner of crushing again depends on the nature of the coals, some of which may be used in a coarser grain size while others specially need fine crushing. More and more attention is being given in most countries to the subject of preparation of coals and their blending for coking because a judicious choice in this respect results in the production of coke of superior quality and enables at the same time utilization of substantial proportion of substandard coals for coking.

VAST IRON ORE DEPOSITS DISCOVERED IN SIBERIA

The iron ore reserves of Gornaya Shoriya, Ampalyg and the mountainous regions of Altai (Western Siberia) and Hakassiya (South-East Siberia) have lately been estimated at 2,500,000,000 tons. This is enough for a 50 years long operation of Siberia's giant iron and steel works, forming part of the Soviet Unions third iron and steel producing centre being established in the Eastern regions.

The Gornaya Shoriya basin, whose ore workings will soon become the largest of their kind in Siberia, has been found one of the greatest promise. Geologists have discovered new ore deposits in this basin which has been supplying ore to the Kuznetsk Iron and Steel Mills for close on 30 years.

Shoriya's ores are of high quality. That of the Tashtagol deposit, for instance, is good for unbenificated steel and pig iron smelting. Besides, it contains some components needed for alloy steel production.

UKRAINE OVERFULFILS PRODUCTION TARGETS IN FIRST NINE MONTHS

The Ukraine has fulfilled by 102 per cent her gross industrial output programme for the first nine months of this year, the Central Republican Statistical Board reports. Industrial production was eight per cent up on the corresponding period of last year.

The increases over the corresponding nine months of last year were: 1·6 million tons of pig iron, 1·6 million tons of steel, 1·2 million tons of rolled metal, 3·7 million tons of coal, 2,000 million cubic metres of gas and 3,000 million kilowatt hours of electricity.

The Republic's overall increased productivity plan has been overfulfilled, with a productivity rise of 4·5 per cent over the corresponding period of last year.

THE STORY OF STEEL - ROURKELA STEEL PROJECT

By M. Ganapati
Resident Director, Rourkela Steel Project

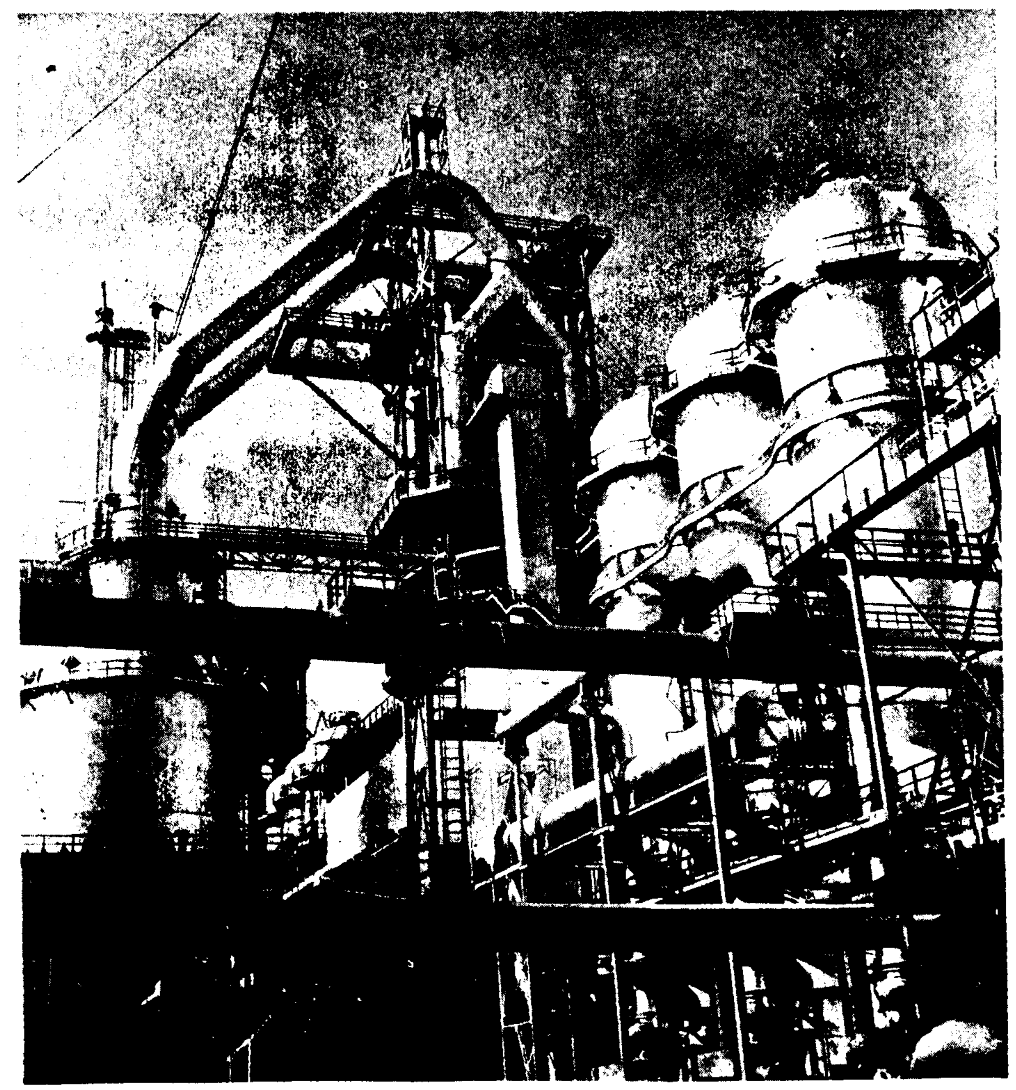
IT is common knowledge that Steel is the very backbone of our industries. Though our country is predominantly agricultural, a time has come when we have to be self-sufficient in all our needs of Steel, including the requirements for heavy, medium and light industries. Prior to the Second World War, our country was producing only about three-quarter million tons of ingot steel. During the War, the capacity was increased to about 1·1 million tons and, in the postwar years, Tata Iron and Steel Company, Indian Iron and Steel Company and the Steel Plant at Bhadravati produced only about 1·7 million tons. Compared to a production of over 100 million tons per annum in the United States of America, over 50 millions in the U. S. S. R., over 20 millions each in the United Kingdom and Germany, our production is but a fraction of our needs. No wonder, therefore, that steel shortage has been chronic in our country for decades now and has involved in the recent past in heavy imports of steel causing a drain of hundreds of crores of rupees by way of foreign exchange.

While the modest First Five Year Plan launched in 1951 laid stress on an immediate increase in Food Production, on River Valley Projects, Power Projects, Transport and other rehabilitation problems, the much larger Second Five-Year Plan laid considerable stress on the need for producing more Steel and set a target at six million tons of steel ingots per year by the end of the plan period. Tata Iron and Steel Company have been allowed to expand their capacity to two million tons of ingot steel per annum and the Indian Iron and Steel Company to expand their works to produce one million ton steel ingots. The remaining three million tons of ingots were planned to be produced in the Public Sector for which Hindustan Steel was set up as a Government undertaking. Three different sites for the location of the steel plants, one at Rourkela in Orissa, the second at Bhilai in Madhya Pradesh and the third at Durgapur in West Bengal, were selected taking into consideration the proximity to raw-materials—Iron Ore so far as Rourkela and Bhilai were concerned, and Coal so far as Durgapur was concerned—adequacy of supply of water, power and other facilities required for large projects. Our country is fortunate in her resources of high-grade Iron ore, second only to Brazil in the whole world. The Indian ore comprises of about 76% of the known resources in Asia and the Far-East, and amounts to over 20,000 million tons, while the coking Coal resources amount to over 2,000 million tons. Limestone, Manganese and other raw-materials required for steel-making are available in abundance in the country. It is, therefore, only a matter of exploiting the natural resources of raw-materials to be able to produce more and more Steel, depending upon our needs from time to time. Much valuable foreign exchange will be saved by producing steel in our country in adequate quantities. We will be able to produce steel not only to meet our own requirements, but in time to come we would be able to produce enough to export to our neighbouring countries in Asia and the Far-East which lack steel-producing facilities. Agricultural implements, industrial machinery and equipment are all required to be produced in increasing quantities, thus meeting the crying needs of a developing economy. In the search for raw-materials, we shall be exploiting the abundant natural resources of our country more and more. The By-products of the Steel Industry, including chemical fertilisers made from the Coke Oven gases and the Nitrogen released from certain steel-making processes, would add to the much needed-production of Fertilisers in our country. Above all, the Steel and other allied industries would add considerably to the employment of labour and will thus help raising the standards of living.

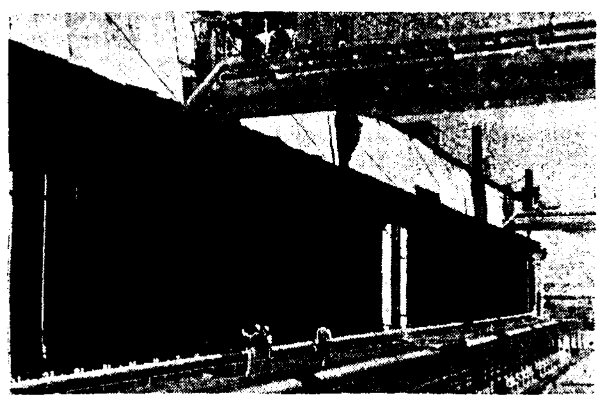
The Rourkela Steel Project was conceived as far back as the end of 1953 for the production of half a million tons of plates, sheets and strips, but was modified late in 1955 to a one million ton project, when a thorough re-assessment of our requirements of steel indicated the necessity of setting up three steel plants in the Public Sector, each capable of producing one million tons of steel ingot. As Flat products were more in demand than others, the first steel plants in the Public Sector was designed for the manufacture of entirely flat products, namely, Plates, Sheets and Strips and Tin Plates. The Rourkela Steel plant consists of 3 Blast Furnaces each of 1,000 tons daily capacity; 3 Coke Oven Batteries of 70 ovens each, each battery producing 1,275 tons of coke per day; together with a very complete By-Product Plant for the recovery and distillation of by-products, such as, Benzene, Toluene, Xylene, Phenal, Cresol, Napthalene, Solid Anthracene, Ammonia and Tar; a Power Plant generating 75,000 KW of power from waste gases and Coke Breeze which are all by-products of the plant; the Steel Melting Shop with four eighty ton Open Hearth Furnaces for the manufacture of 250,000 tons of steel

yearly by the Open Hearth process, and three L. D. converters each of 40 tons capacity which will all produce 750,000 tons of steel per annum by the L. D. process; and the very extensive Rolling Mills of 1·8 to 2 million tons capacity, consisting of a Blooming Mill, a Plate Mill to produce 200,000 tons of plates 3/8 inch thick and above, a Continuous Hot Strip Mill to produce 470,000 tons of hot rolled sheets and strips, of which 170,000 tons will be further reduced in the Cold Rolling Mills to thickness upto 0·19 mm., and 50,000 tons of tin plates by the Hot-Dip Tinning Process. The plant is capable of expansion upto two million tons and provision is being made for the installation of additional units of Blast Furnaces, Coke Oven Batteries, L. D. Converters and a few other units of additional equipment to produce two million tons of steel ingots without having to plan an entirely new layout. Such expansion during the Third Five Year Plan is presently under consideration of the Government of India, as this will be the quickest and cheapest means of increasing our steel-production in the Third Plan period.

The Rourkela Steel Plant has some very notable features, in that it would produce only flat products and will be the only Indian Steel mill to use the L. D. Oxygen Process. It would also have a Fertiliser Plant based on its by-products. The L. D. Process of making steel which was developed successfully in Austria as recently as in November 1952, consists in blowing 99·5% pure Oxygen at 8 to 10 atmospheric Pressures into a vessel containing 40 tons of hot metal with about 10% scrap steel for about 18/20 minutes to reduce the impurities in the hot metal. The Oxygen is blown through a water-cooled lance which is lowered into the converter



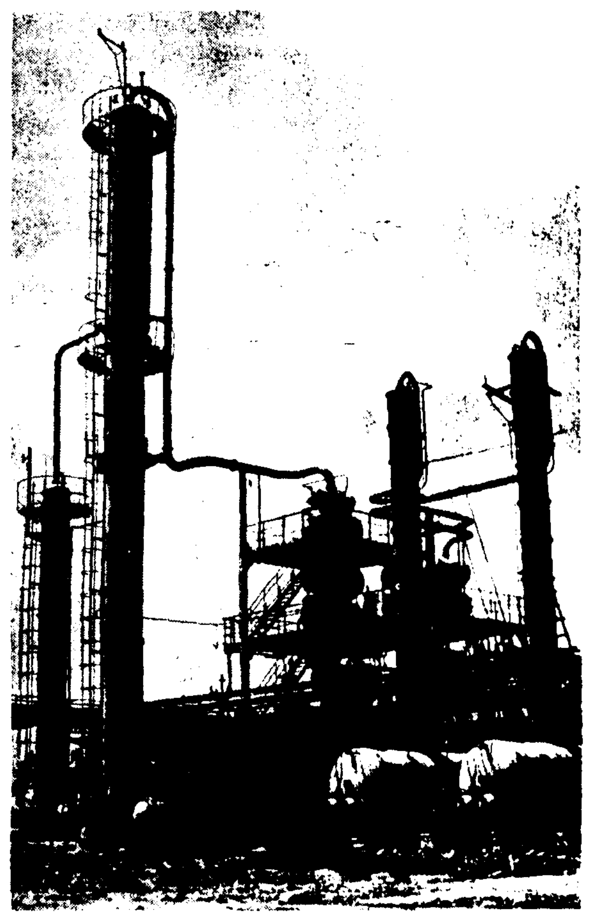
A view of the Second Blast Furnace along with the Gas Cleaning Plant at the Rourkela Steel Project vessel and kept at a distance of about three feet above the surface of the bath. The violent reaction which takes place around the zone where oxygen impinges reduces the impurities in this zone, allowing the purified steel to sink below and exposing further quantities of impure metal for oxidisation. Thus a chain reaction takes place for about 18/20 minutes, by which time the hot metal in its entirety is converted into steel. Fluxing materials like limestone, ore and dolomite are added to the convertor during the process of oxidisation, and when the steel is eventually poured into the ladles, necessary additions are made of ferro-manganese or ferro-silicon and Carbon to obtain the desired quality of steel. A 40-ton converter will nearly produce 40 tons of steel in as many minutes, giving the rate of about one ton per minute per converter. What is more, the ingots from the L. D. Converters are available at regular intervals for the Rolling Mills, and the heat loss is thus minimised.



A view of the Second Battery of Coke Oven at the Rourkela Steel Project

Hydrogen from the Coke Oven gases, together with the Nitrogen released from the Oxygen Plant, combine together to give Ammonia and Ammonium Nitrate which, with the limestone fines rendered surplus from the quarries, produce Calcium Ammonium Nitrate, a very useful fertiliser. The Rourkela Steel Project will produce about 600,000 tons of such fertilisers per annum as a by-product.

Construction of the one-million ton steelplant from scratch costing more than Rs. 200 crores is by no means an easy task, particularly so when the required very large numbers of engineers, technical personnel, skilled workers and staff numbering more than 50,000 are not so easily available and are mostly to be trained in the process of construction. Though work on the project could be said to have commenced in 1957, a real beginning in erection work started only by early 1958, and up-to-date nearly 6·7 lac cbm. of concrete in foundations and structures out of 8·5 lacs cbm. have been completed, while in the erection of plant and equipment 2·68 lac tons have been erected out of a total of 2·8 lac tons. Out of a total of 99,000 tons of refractories in lining, 91,000 tons have been done. On the whole, 75 to 80% work in this gigantic project has been completed in the small space of two years of intensive work.



A view of the Benzol Plant at the Rourkela Steel Project

Two Blast Furnaces, and two Coke Oven Batteries are already in commission along with the By-Product Plant. The Generator Sets of the Power House are also in commission. All the four Open Hearths and the three L. D. Converters along with the Oxygen Plant, as well as the Blooming and Slabbing Mills, have recently been commissioned. Work on the third Blast Furnace as well as on the third Coke Oven Battery is almost complete. The Plate mill is expected to be commissioned shortly, while the Continuous Hot Strip Mill will be commissioned towards the end of this year, and the Cold Rolling Mills by early next year.

The entire plant would thus be completed and brought under operation by the end of the Second Five Year Plan, namely by the 31st March 1961. Considering that the construction of the Rourkela Project is not a package deal, unlike the Bhilai and the Durgapur steel Projects, the results achieved can be said to be most gratifying. Certainly, this stupendous work would not have been possible but for the determined effort, close co-operation and team-spirit displayed by one and all connected with the project, including the very large number of German suppliers of plant, machinery and equipment, the Consulting Engineers and the Indian engineers, workers and staff numbering over 50,000 during the period of about twenty-four months commencing from early 1958. By all accounts, the task allotted to Hindustan Steel to set up three one million ton steelplants in the Public Sector costing nearly 560 crores of rupees during the Second Plan, is not only gigantic in size but full of complicated problems which have all been successfully faced, in the firm belief that no effort is too great in the cause of the Nation.

PRODUCTION OF PIPES AT ROURKELA

The pipe plant being set up for the production of steel pipes by the electric resistance welded process at Rourkela will produce 8,600 to 31,000 tons of steel pipes per month depending upon the size and specification of pipes. The plant will meet the immediate requirements of oil pipelines of the country and cater to future demands for pipes. Rourkela was selected for the location of the plant as stripes required for pipe manufacture could be rolled at the strip mill of the steel plant.

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LIME PLANT IN BHILAI

The lime plant of the Bhilai steel works has been commissioned on 26-5-60. The plant would produce 20,000 tons of burnt lime annually for use in the pig cast machines and open hearth furnaces of the steel works. The plant is a part of the refractory materials plant which also includes a dolomite department which started functioning early this year.

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OUTPUT OF IRON ORE

The output of iron ore reached the peak figure of 7·93 million tons in 1959 as compared with 6·13 million tons in the preceding year. This represents an increase of 1·81 million tons or 29 per cent over the 1958 figures. The increase in production was shared by all the producing States. The Share of Bihar and Orissa in the total production was 41 per cent and 33 per cent respectively. The production from these two States increased by 972,000 tons and 418,000 tons respectively. The output from Madhya Pradesh, which produces iron ore for the Bhilai Steel Plant, increased by 180,000 tons or 77 per cent. Bombay and Mysore showed an increase of 164,000 and 55,000 tons respectively.

POWER PLANT AT DURGAPUR

The United States has reached agreement in principle with the Government of India for a Rs. 12·9 crore project that will add 120,000 kilowatts capacity to the Durgapur thermal power station in the Damodar Valley in West Bengal, it was announced. Of the total amount Rs. 9·5 crores for foreign exchange costs will come from a loan from the U. S. Development Loan Fund. Details of the loan agreement remain to be worked out. The Durgapur plant, located in a heavily industrialised area at the edge of the Raniganj coalfields, is now being completed with an installed capacity of 150,000 kilowatts. The DLF loan will make possible the addition of two 60,000 kilowatt steam turbo-generators, two coal-fired boilers with 700,000 pound-per-hour capacities, auxiliary equipment including coal-handling facilities and electrical control and switchgear equipment. The power from the Durgapur project will be used in the immediate vicinity of the plant by expanding newly-contemplated industries in such fields as aluminium, steel, automobiles, jute, paper and glass.

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ROURKELA STEEL FOR GERMANY

A consignment of 2,000 tons of heavy steel slabs weighing 8 to 10 tons each was sent to West Germany recently. This forms part of an order for 12,000 tons of steel valued at Rs. 40 lakhs by a West German firm. The consignment includes a substantial quantity of steel produced at Rourkela by L. D. process. It is hoped that with heavy plate mill in Rourkela going into operation by the end of this year, wide plates would be available for use by India's engineering industries and more orders for steel could also be expected from West Germany.

The Importance of GHH for the Iron and Steel Industry

GUTEHOFFNUNGSHUTTE is the oldest enterprise of the heavy industry at the Ruhr, the largest industrial centre of the Federal Republic of Germany.

The Company had its origin in the middle of the 18th century when the countryside at the Ruhr was forest, heath and marsh all over and many boundaries divided the land into a large number of small states under the sovereignty of a lord spiritual or temporal.

When St. Antony, the oldest iron works at the Ruhr, started production in 1758, the foundations were laid for the creation not only of Gutehoffnungshutte, but also of the Ruhr industry as a whole. Marsh ores and limonites found in the near surroundings were used as the raw materials of iron production. The smelting practice was based on charcoal which was supplied from the piles in the neighbouring forests.

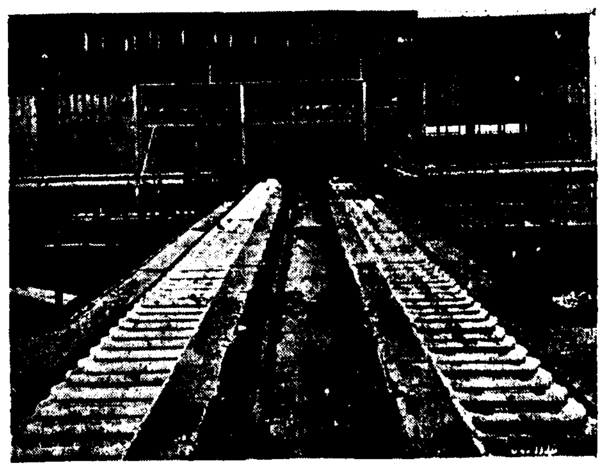
From the foregoing it becomes apparent that Gutehoffnungshutte since the very time of its origin has been closely connected with the iron and steel industry and dealing with its specific problems.

As early as 1814 the first steam engine was built at Oberhausen. Pumps and steam boilers followed, whilst the first winding engine for a coal colliery was constructed in 1824. The first Rhine steamer ever built in Germany was launched in 1830 at the ship-yard owned by the Company, and a complete coal mine was built during the period from 1847 to 1852. A bridge building department was added to the manufacturing resources in 1864. The first floating dock was built towards the end of the last century, while turbo machinery was incorporated into the GHH production program in 1905.

After World War II, the workshops damaged or destroyed by the hostilities had to be repaired and reconstructed. The latest experience available in the layout, design and construction of production shops and equipment inspired the work so that the GHH manufacturing facilities are amongst the most modern of Europe.

The GHH production program today predominantly covers large capital goods and complete industrial plants. Most of the products are engineered to suit the specific needs of the customers. The close contact maintained between GHH and purchaser permits a continuous exchange of ideas which are worked out by a staff of qualified designers and materialized in the numerous novelties introduced by GHH and tested in its own metallurgical and mechanical plants. This augments the wealth of experience accumulated by a Company which has always held a top ranking position in the field of the development and construction of equipment for the heavy industry. Experts from all over the world like to go to Sterkrade in order to gain an inside knowledge of the GHH plants and processes. Abroad GHH proffers its advisory engineering service for the creation and development of complete industries, especially in the coal and steel sector; in many instances such advisory service has resulted in the construction of large plants.

An important position among the many products covered by the GHH manufacturing program is held by plant and equipment for the iron and steel industry.



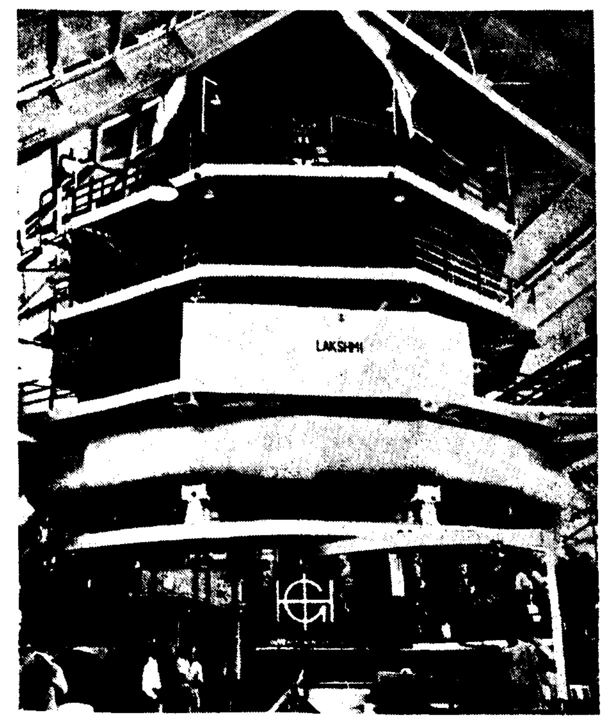
The heavy industries department specialises in the project engineering, supply and erection of complete industrial plants, predominantly for the steel industry, and in the supply of steel mill equipment. Originally it was created to handle internal construction projects. During the 30 years of its existence it has built a large number and variety of complete industrial plants, especially abroad.

As already intimated previously, the heavy industry department of to day is predominantly engaged in the construction of steel mill plant and equipment. With its supplies and activities GHH pays a valuable tribute to the progress of steel mill practice.

During the last years the Company has developed most modern blast furnace designs which fully meet today's requirements of engineering and economic

efficiency. The single-man control of hoisting is a particularly remarkable feature of GHH blast furnace plants.

In spring 1959 the largest blast furnace ever built in Western Europe was completed by GHH for August-Thyssen-Hutte of Duisburg. With its hearth diameter of 9 metres and total capacity of 1,600 cu. m. it produces now more than 2,000 tons of pig iron per day Charging is by skips having a capacity of 10 cu. m. The daily consumption of raw material is about 7,000 tons The storage bins are of structural steelwork, with a special heat protection system for those containing hot sinter. The entire plant was erected within the relatively short period of 18 months.



Close attention is paid to the problem of steel production by the use of tonnage oxygen. The oxygen steelmaking process for which GHH supplies complete plants with fully welded converters has spread all over the world within a few years. The steels produced in oxygen converters are of a high quality comparable to the O. H. grades. During the past few years GHH has delivered oxygen steelmaking plants and converters to countries in Europe and over the sea.

Besides, the first oxygen converters ever built were supplied by GHH to VOEST, Austria. Moreover, GHH built the up till now largest oxygen converters in Europe Their capacity is 60 tons. The first oxygen converters for North America and the first oxygen steel plant for South America were also supplied by Gutehoffnungshutte, who is now dealing with a Canadian order for 100 ton converters.

For another very promising oxygen steelmaking process, the so-called Graef Rotor-Process, GHH has acquired the manufacturing licence.

The first plants operating by this process at Huttenwerk Oberhausen have been supplied by GHH. Some other remarkable items of the GHH manufacturing program in the heavy industries field are: Iron ore sintering plants, pig casting machines, steel mill equipment and cars of any description. During the past few years the heavy industries department has been most heavily committed by orders from customers at home and abroad.

The relations which Gutehoffnungshutte maintains with India have a long tradition. They were only interrupted for a short time by World War II. However soon after 1945 when GHH had reconstructed its plants and factories, the first orders were again received from Indian customers. During the time meanwhile elapsed GHH has constructed a large number of industrial plants in India, and even today there are many GHH erectors engaged in various parts of India on the establishment of industrial plants and factories.

For the Rourkela Works GHH has been supplying the blast furnace plant, a pig casting machine as well as numerous blowers and compressors as described hereinafter more in detail.

Three 1,000 ton blast furnaces have been provided for the Rourkela steel project, which accounts for an annual production of approximately 1,000,000 tons of hot metal.

The blast furnaces are of American design. They have a hearth diameter of 7·4 metres, a height of approximately 30 metres from hearth bottom to throat platform and a payload capacity of approximately 1,000 cu. m. The total height above mill floor is approximately 65 metres.

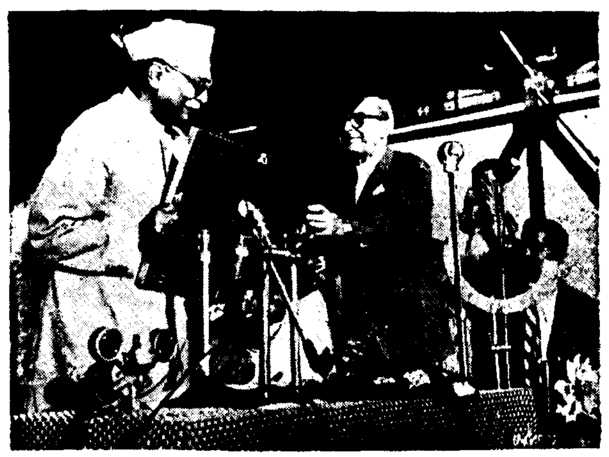
A group of three hot blast stoves is provided for each blast furnace. The hot blast stoves have a diameter of 8 metres, a total height of 37 metres and a heating area of approximately 34,000 square metres. They are rated for 1,40,000 cu. m/hr of blast to be heated up to a maximum temperature of 950 deg. C.

An ore and coke storage yard is available for quantities delivered in excess. As far as possible, it is intended to charge the ores and coke direct into the blast furnace bunkers, i e. without intermediate storage. The ores arriving have already been graded at the mine. An ore bridge with a span of 45 metres and a capacity of 20 tons is provided on the ore and coke storage yard.

The bunker installation has been provided for construction of reinforced concrete in order to increase the portion of the work which can be done locally by Indian contractors.

Each blast furnace disposes of 16 ores bunkers covering the requirement of raw materials for at least three days. The coke bunkers located at either side of the inclined hoist can accommodate the demand of more than half a day.

Within the Rourkela steel project Gutehoffnungshutte has built also the pig casting machine which operates as follows:



The filled 80 ton hot metal ladle arriving on a car is taken by the travelling crane of the cast house and placed on the tilting chair of the stationary trestle. Thereupon it is lifted and tilted by remote control. The hot metal flowing out of the ladle runs along a double launder from where it is discharged into the moulds of the casting machine. Each of the 760 moulds accommodates 50 kg. of hot metal. When the metal has covered approximately half the way from feed to discharge (the belt speed is infinitely variable between 5 and 12 metres per second), it is cooled by water according to requirements in order to ensure sufficient solidification. Any pigs (solidified metal) sticking to the moulds at discharge end are detached by a rapper. Through baffles and chutes the pigs pass from the machine into wagons.

Apart from the foregoing installations some further GHH equipment will be employed at Rourkela. For the major part such equipment has been supplied through other German contractors Particular reference should be made to four twin flow radial type blast furnace blowers with steam turbine drive and condensing plants.

Each of these blowers has been rated for 165,000 cu. m/hr. of air discharged at a pressure of 2 73 kg per sq. cm. absolute. The power rating of each turbine is 6,700 kw. The blower speed is 3,570 RPM. Three of the installations will be in actual operation, whereas one will serve as standby. GHH blast furnace blowers of the particular type referred to have already proved successful in India. Two installations of almost the same capacity have been operating in a steel plant at Burnpur since January 1958, whereas a third started up there in the month of July 1958.

A GHH back pressure steam turbine for generator drive has been supplied for the power station of the Rourkela steel plant. Three GHH turbo compressors for a capacity rating of 40,700 cu m/hr of air and a discharge pressure of approximately 6 kg per sq cm. absolute are installed in the tonnage oxygen plant at Rourkela. Two further compressors have been supplied fot oxygen flow.

The gas produced in the Rourkela coke oven plant will be handled by five GHH screw compressors, the largest so far built by the Company. Each of these three-stage machines has been rated for a flow of 23,000 cu. m/hr and a discharge pressure of 15 kg per sq. cm. absolute. Three GHH turbo blowers and three gas exhausters have similarly been supplied for the coke oven plant.

Schemes of this magnitude are no easy proposition for contractors supplying their equipment from distant countries.

For the erection of the blast furnaces Gutehoffnungshutte has sent more than 100 specialists to India. Local manpower was available in the number of approximately 300 to 400 men. Most of the Indian labour had never worked on any such scheme so that a certain time was necessary for training and acquiring the necessary skill.

In order to facilitate work at site, Gutehoffnungshutte has provided most up-to-date erection tackle.

For the start up of this blast furnace plant Gutehoffnungshutte provided a staff of experienced specialists who also instruct the Indian operators. Many Indian engineers who will be in charge of blast furnace practice at Rourkela have been trained by the Company in its own plants and design offices or in other German steel mills.

For Mysore Iron & Steel Works, of Bhadravati, GHH has supplied a pipe spinning factory with an annual capacity of 17,000 tons, the cast iron pipes produced ranging in diameter from 3 to 12 inches and in length up to 10 metres. A pan sintering plant for ore fines with furnace dust, mill scale, lime etc. is under construction for the same customer. It has been laid out for a capacity of 250 tons per day. A considerable increase of pig iron production arises out of the operation of this sintering plant.

The extraordinary wide field covered by GHH is backed by a most modern research institute where, apart from the testing of materials, experiments are made on a reduced model scale in order to allow conclusive assessments of how any product, structure or member thereof will behave in actual application. GHH is therefore able to solve even the most difficult problems and to reduce the risks of any new venture to an absolute minimum.

The present paper can only give a short abstract of the large variety of GHH equipment for the iron and steel industries. The examples chosen show however to how far a degree Gutehoffnungshutte contributes to the industrialization of India. It is clearly demonstrated that the Company disposes of the experience and capacity enabling it to participate on the move towards an improvement of their economic situation.

ROURKELA STEEL PROJECT—THIRD UNIT OF OXYGEN PLANT COMPLETED

The third unit of the tonnage oxygen plant at the Rourkela Steel project was switched on marking the completion of the plant in record time. The tonnage oxygen plant is a key unit of the Rourkela steel plant and is to supply low cost pure oxygen for the manufacture of 7,50,000 tons of ingot steel by the L. D. Process. It will also provide pure nitrogen to the fertiliser plant under erection. The plant which is the first of its kind in India has been completed in about record time. The two units already in operation have so far produced 15,780 tons of oxygen. The cylinder filling station which was started in March has filled up till now 6,000 cylinders. Filling up oxygen for medical use has just been started. The plant will also supply liquid oxygen to be utilised in ore mines for blasting purposes.

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NEW BLAST FURNACE AT JAMSHEDPUR WORKS

Tata's new blast furnace Number Six with a capacity to produce 1,650 tons of pig iron a day, was brought back into operation after necessary modifications. The new blast furnace, the biggest of its kind in Asia, is built by the American firm of Kaisers to aid the Tatas in its two million tons expansion Programme.

USE OF STEEL INGOT MOULDS

The steel ingot moulds, produced by the Durgapur steel works, were put into use for the first time in the plant when steel from the open hearth furnace was poured into these ingot moulds. The casting of these moulds, each with a cross section of 28-inch square and a length of 6 ft. started in the foundry of the steel works on 30-4-60. This has been found to be the most economical size for production of blooms which will be reduced further in the billet and structural mills. On completion of the plant, the foundry will be producing 20,000 tons of ingot moulds annually.

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SYNTHETIC LIQUID FUEL

The possibilities of producing liquid fuel from low-grade coals and blast furnace gases are now being investigated at the Indian Institute of Technology at Kharagpur. A 100-gallon per day capacity pilot plant for the production of synthetic fuel from coal has been designed and fabricated in the Department of Chemical Engineering of the Institute. Its working will provide data for the design, construction, operation and maintenance of a commercial plant.

NEYVELI LIGNITE PROJECT

By

E. Ayyadorai Asirvatham, B.A.
Information Officer,
Neyveli Lignite Corporation

COAL will continue to be the main source of energy in modern civilisation despite the development of atomic energy. This precious mineral is not available in the Madras State and therefore the discovery of extensive Lignite deposits in and around Neyveli is a boon to South India and the Madras State in particular. The Development and utilisation of Lignite as raw material for industry is of the greatest importance to this region.

The known reserves of Lignite in and around Neyveli are estimated to be of the order of over 2,000 million tons extending over an area of about 100 square miles. Out of this proved lignite field the most favourable area of about 5½ square miles estimated to have about 200 million tons of mineable lignite has been selected for mining. After exploiting this area other less favourable areas will be tackled.

On account of the occurrence of artesian aquifers below the Lignite seam, which is an unique feature in Neyveli, the Conventional underground method of mining has been given up and the open cast mining method adopted. In the mining area, there is an overburden of about 180' (about 60 meters), the lignite seam being 55'-66' (18-20 meters) thick. An initial overburden of about 27 million cubic yards of earth has to be removed before exposing the lignite seam for Commercial production. In view of the large quantity of overburden and of the presence of hard and abrasive Cuddalore sandstone in the overburden, highly specialised mining machinery i. e., Bucket Wheel Excavators, Belt Conveyors and Spreaders are being used.

As for the problem of control of the artesian water, it has been decided to have a pumping scheme as continuous as mining, pumping out about 48 or 50 thousand gallons per minute from a grid of 48 or 50 pump wells in a well designed pattern. This removal of massive quantities of water will depressurise the aquifer and make mining safe. The water that is incidentally coming from the mine will be stored in a reservoir and utilised for the Thermal Power Station, the Fertilizer Plant, the Briquetting and Carbonisation Plant, the Clay Washing Plant and for the township of about 9,000 or 10,000 houses.

The three important schemes that constitute the Integrated Lignite Project are (i) a Thermal Power Station with a generating capacity of 2,50,000 KW. of Power (ii) Fertilizer Plant producing 1,52,000 tons of urea per year and (iii) a Briquetting and Carbonisation Plant of a capacity of 3,80,000 tons of Carbonised Lignite Briquettes.

The Integrated Lignite Project provides for the mining of about 3·5 million tons of Lignite per annum. Even the most casual visitor to this Project will not fail to find great imagination in its conception, careful attention to detail in its planning, success in its execution to date and considerable hope for the future development of South India. The Neyveli Lignite Project is a tribute to the imagination, determination and technical skill of two governments, the Government of India and the Government of Madras. Many foreign countries have helped in the implementation of the Project through technical and financial assistance. The United Kingdom, Germany, the United States of America, the U. S. S. R. and Italy deserve special mention.

THE MINING SCHEME

The scheme consists of two phases, the development phase and the production phase. The dimensions of the mine cut are determined with reference to the consumption of lignite in the Industrial units and the estimated deposit of Lignite at the particular area. The first mine cut, in the selected mining area is 6100' × 950' at the top. During the development phase, three benches leading down to the lignite bed—the first two of 70' and the last of 40' will be formed. When these three benches are developed from either side, lignite seam measuring about 5000' × 300' will be exposed in the middle. By the end of this phase an overburden of about 27 million cubic yards of earth would have been removed and placed in a spoil heap situated just outside the Lignite bearing area. During the production phase three Bucket Wheel Excavators—two large (700 litres per bucket) and one Small (350 litres per bucket)—will be working in the three benches in the overburden and one small Bucket Wheel Excavator in the Lignite. The spoil earth will be filled back in the areas already worked by means of Belt Conveyor *cum*

slewable spreader system. The Mining will follow the pattern adopted in open cast Lignite mines in Germany and Australia. Messrs. Powell Duffryn Technical Services Limited, London are the consultants for the Mining Scheme. So far about 15 million cubic yards of the overburden has been removed and a maximum depth of 115 ft. from Ground level reached. Work with a large Bucket Wheel Excavator, a small Bucket Wheel Excavator, a system of ten belt conveyors and one spreader is being carried on now.

THE THERMAL POWER STATION SCHEME

The Thermal Power Station will have 5 units each having a generating capacity of 50 M. W with provision for 3 additional units. The water that will be pumped out to control the artesian pressure below the Lignite bed in the mine cut will be utilised for the boiler feed and as coolant. This Thermal Power Station will be the largest in the country and one of most modern in the world. This scheme is financed from out of the 500 million rouble credit offered by the Government of the U.S.S.R. The first unit of the Power Station is expected to be commissioned in the middle of 1961. A quantity of about 1·5 million tons of Lignite is expected to be used for the generation of Power.

THE FERTILISER PLANT

The scheme contemplates the production of 1,52,000 tons of urea per annum with a fixed Nitrogen content of 70,000 tons by the total recycle process using 800,000 tons of lignite. The contract for the erection of this Plant has been entered into with an Italian firm and a West German firm. It is expected that before the end of 1962, the erection of the Fertilizer Plant will be completed. Production on a large scale is likely to commence in February or March, 1963. It will be the largest of its kind in the world.

THE BRIQUETTING AND CARBONISATION PLANT

A Pilot briquetting and Carbonisation Plant, a gift from the United States was erected, and tests were carried out. From the data obtained from the experimental runs in the pilot Plant, the optimum conditions for manufacturing the ideal smokeless and odourless domestic fuel have been decided upon. The optimum moisture content for producing briquettes has been found to be 12% and the optimum temperature of carbonisation 500 to 550 C. The Briquetting and Carbonising of about 1·5 million tons of Lignite would yield 3,80,000 tons of the carbonised Briquettes 43,000 tons of char dust, 6,400 tons of motor spirit, 51,300 tons of tar and 1,032 tons of phenol.

Production of Carbonised briquettes at high temperatures with as little volatile matter as possible for metallurgical purposes is also a possibility.

A small Clay Washing Plant for washing the China clay available immediately above the Lignite sema will also be put up. A quantity of about 6,000 tons of pure white Clay will be produced every year and made available to private industrialists and others for the manufacture of HT and LT insulators, sanitary ware etc.

Side by side with the planning and execution of the constituent schemes, construction of residential and non-residential buildings in the township which is situated north of the mine beyond the lignite boundary has been taken up. It is proposed to construct about 10,000 houses in 30 blocks with all modern amenities. In addition there will be one block for Administrative office buildings.

The estimated Cost of Integrated Lignite Project is Rs. 93 Crores.

The management and Control of the Project have been entrusted to the Neyveli Lignite Corporation Limited, which is a 100% Government concern.

When the Project is completed it would certainly contribute to the prosperity and development of South India. It would not only increase the much needed power supply and supply the need of the agriculturists by adding to Fertilizer Production but would being smokeless fuel to thousands of homes for their domestic fuel consumption. It will also go a long way in the conservation of better grades of coal for other metallurgical purposes, thus giving a national importance to the Project The Project will be something like a catalyst, a sort of leaven to foster quick industrial development of the southern part of the Country.

High Pressures Herald a Revolution in Technology

By V. Pospelov

THE physics of super-pressures is a comparatively young science but it is already receiving a good deal of attention from specialists employed in many branches of engineering.

The term super-pressure refers to pressures above 1,000 atmospheres. In nature pressures of this kind exist only in the ocean depths and deep inside the bowels of the earth.

Only a comparatively short time ago did specialists begin to produce pressures equivalent to thousands of atmospheres. Notwithstanding this, more and more use is being made of super-pressures in the world of science and engineering.

MAN-MADE DIAMONDS

It is known that all substances consist of atoms which are constituted of nuclei with electrons revolving around them. Under the action of super-pressures the atoms of gaseous and liquid substances are compressed in consequence of which these substances are converted into solids. Super-pressures change the crystal pattern in solids. Further increases in pressure, after the atoms have been "solidified" to the highest point, produce a compression within the atmos, and the electrons are brought closer to the nucleus.

It has been found that all solid substances placed in a liquid under a pressure of about 20,000–40,000 atmospheres acquire entirely new properties.

Graphite and diamonds are varieties of the same chemical element, carbon, but they differ sharply even in appearance How unlike the gray unsightly graphite is the sparkling diamond! Using super-pressures specialists have in fact started producing diamonds. True, the man-made diamonds are so far small in size, but they may well be used for technical purposes.

Graphite passes into diamond in consequence of the changes in its internal crystallic pattern. Diamonds are produced under pressures ranging up to 100,000 atmospheres and a temperature of about 2,000–2,500 degrees. Special equipment has been designed for this purpose.

Studying the action of super-pressures upon solids, specialists have produced substances which are even stronger than the strongest natural material—diamond. One of the new substances is called borazon. It is produced, under a pressure of 100,000 atmospheres and a temperature of 2,000 degrees, from a chemical compound of boron and nitrogen, boron nitrate. The new mineral is extremely valuable since it can be used under a temperature of 2,500 degrees, which even diamonds cannot endure. Borazon is so tough that it leaves deep scratches even on natural diamonds. Borazon is apparently the first ultra-hard material to be obtained by means of high pressures and temperatures.

SUPER-STRONG METALS

Soviet scientists are conducting important investigations into the action of super-pressures upon other tough substances. A special laboratory has been equipped in the Soviet Union for studying the action of super-pressures upon metals, for designing powerful compressors and other special equipment. Pressures of thirty thousand atmospheres have already been produced in big reservoirs. It was discovered that under such pressures metals acquire entirely different properties; they become more plastic and enduring. That holds out a very great promise before engineering.

The most fragile pig iron is converted under great pressures into a very enduring material, while steel becomes several times stronger after compression in special reservoirs. A brittle material like marble becomes plastic to a considerable extent when subjected to all—round compression.

Special rolling mills where metal will be subjected to the pressure of 25,000—30,000 atmospheres are going to be built in the USSR. These rolling mills will have to be built in huge reservoirs where the liquid will be compressed by means of very powerful compressors.

There will also be units for drawing super-strong wire. Under a pressure of several thousand atmospheres it will be possible to produce a very plastic wire of aluminium, copper, iron and steel. It will then be possible to reduce greatly the thickness of steel cables and the expenditure of scarce metals.

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