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on the Iron and Steel Industry

Moscow, USSR, 19 September – 9 October 1968

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by

I.A. Monasevitch
USSR

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SUMMARY

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Metal is the bread of industry. There are no branches of industry or transport, which can exist or develop without metal. Ferrous metallurgy is one of the most important heavy industries influencing, in many ways, the development of other fields of national economy. The industrialization level of a country is determined to a greater extent by the actual metal production and consumption.

Ferrous metallurgy is the basis for industrialization, while development of machine-building industry, transport, and construction industry provide for the establishing of iron and steel plants.

The ferrous metallurgy being developed brings about the establishment of a complex of industries and involves the construction of a series of enterprises specializing in iron ore mining and dressing, production of refractories and non-metallic minerals and their products, coke-chemical industry, hardware manufacturing, electric power generation, transport development, etc.

The current and perspective consumption of iron and steel is the major factor that stimulates the construction of iron and steel plants.

Metal demand is determined for the period required to put a new plant into operation at the full capacity.

Metal demand is studied for the whole country and, separately, for its various metal consuming industries. These are considered to be the major metal consumers: machine-building and metal working industries, capital construction, railways (rails, rail-joint bars, bogie wheels and axles, etc.), repair and maintenance services of all spheres of national economy, steel feeds for the manufacture of pipes, hardware, tinplate etc.

When metal demand is determined, not only the domestic consumption is considered but the volume of exports as well.

Metal demand of various branches of national economy is determined through both, the current consumption and perspective consumption, as well as through long-term planning, expert estimation of these branches development and probable metal consumption rates required to carry out the effective production in various branches of the national economy. After the demand of various rolled products according to kind and size is estimated, in the USSR practice, the perspective balance of demand and production of metal is worked out considering the actual production of the existing plants. The scarce rolled products thus ascertained constitute the basis upon which the reconstruction of the existing plants or construction of new ones are planned and designed.

Depending upon the size and character of the scarcity of rolled products, the scope of production, specialization and range of products are designed and calculated, and this action, in its due turn, influences the availability of rolling-mills and tube mills.

Voluminous metal demand provides for the designing and construction of specialized plants, and this circumstance reduces the production waste. When the demand is small the construction of an universally ranged plant may prove to be feasible.

Ferrous metallurgy requires much material for production From 5 to 7 tons of raw materials and fuel are required to produce one ton of rolled products.

Therefore, the availability of the appropriate iron ore deposits and coal fields are of the primary importance for the creation of ferrous metallurgy.

Preliminary geological surveying is required in order to estimate the actual deposits of iron ore sufficient for development of ferrous metallurgy. Detailed prospecting of the deposits is usually done for the purpose.

The field's trend, outlining, depth of occurence, mining conditions, i.e. the complete information required to estimate the reserve are ascertained. The conditions of iron ore mine constructing and its feeding to the iron and steel plant are also searched into.

The reserves estimation should be carried out according to the actual amounts of iron extracted, i.e. considering the inavoidable losses of iron ore met with in the process of its mining and dressing.

Preliminary work should be carried out on a large scale for the purpose of establishing of the ore quality, iron content and main detrimental impurities (sulphur, phosphorus, etc.). When the iron content is below the required level, the ore is analysed for the dressing ability in order to have its iron content raised and detrimental impurities removed.

The similar work is to be done with regard to coal deposits, especially for cocking coal.

The coal elucidated reserves, its chemical analysis and dressing ability, quality testing results should determine the necessity of establishing iron and steel plants.

Apart from iron ore and coking coal, the availability of other necessary raw materials, such as limestone, manganese ore, refractory materials (clays, dolomite, magnesite, quartzite) is required for establishing ferrous metallurgy.

Recently the use of natural gas or fuel oil in ferrous metallurgy has been introduced into broad practice, and this provides for the economy of coke in iron production.

Hence, the availability of natural gas and oil reserves is also one of the main factors of ferrous metallurgy development. Metal scrap availability reduces the need for pig iron for steelmaking or removes it nearly completely when non-integrated plants are established. Therefore, the availability of metal scrap and its permanent sources may also suggest the establishment of small non-integrated metallurgical plants.

The possibility to generate electricity at a low cost is considered to be an important factor in constructing the plants with electric arc-furnaces.

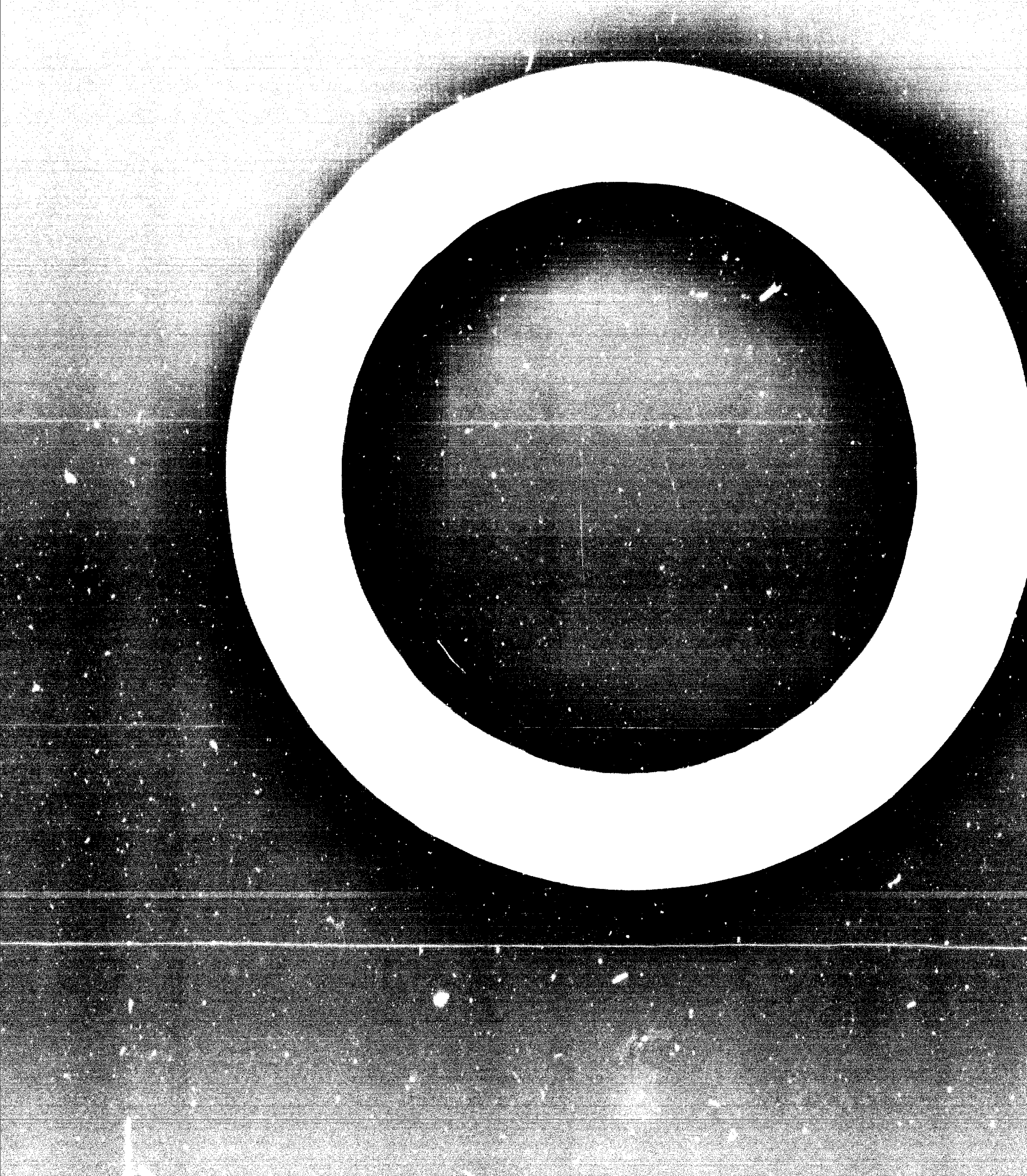
Workers, engineers, technicians and office personnel are required in large numbers for operation of a metallurgical plant.

The available arrangements for training qualified workers, engineers and technicians are quite significant for the development of metallurgy.

The construction of ferrous metallurgy plants is conditioned to the availability of technically developed industry, building materials as well as of civil engineering personnel. It also requires sizable capital investment as, according to tentative estimation, the construction cost of a big up-to-date plant proves to be over 300 dollars per one ton of steel output. Hence, the development of ferrous metallurgy is associated with large capital investment. The availability of capital investment is taken into consideration as an important factor too, when the establishment of ferrous metallurgy is contemplated.

Here is the summary of the principal considerations for the construction of ferrous metallurgy:

1. Necessity for the industrialization of a country.
2. Metal demand.
3. Availability of iron ore deposits and fluxes or permanent supplying sources of metal scrap.
4. Availability of coking coal fields and other raw matetials required for iron and steel manufacture.
5. Provision of necessary personnel.
6. Civil engineering ability.
7. Procurement of the required capital.



GENERAL TECHNICAL AND ECONOMIC BACKGROUND OF DEVELOPMENT OF FERROUS METALLURGY

In present society ferrous metals and their production are of exceptional importance. Ferrous metals form the material basis of culture. Industry and transport cannot exist or develop without metal. Machine-tools, machines, different mechanisms and devices, tools, building constructions, means of conveyance and communication are either wholly or partly made of metal. In everyday life and practice of our contemporary, metal is required for most various needs.

The level of the industrialization of the country is to a great extent determined by the development of metallurgy. A developed machinery industry requires a considerable amount of metal. The development of ferrous metallurgy in its turn stimulates the advancement of the machinery industry as well as that of other branches of industry and transport.

Ferrous metals have gained such importance thanks to their mass production, relative cheapness and sufficient strength which ensures the required service life of machines, buildings, constructions.

The technical and economic level of the development of the country is to a great extent determined by the consumption of ferrous metals and is usually characterized by the per capita steel consumption. Thus the consumption and accordingly the production of ferrous metals are of great importance for the developing countries.

The level of industrial production of pre-revolutionary Russia was considerably lower then that of developed countries. In 1913 only as much as 4.3 million tons of steel were produced in Russia, although there were large resources of ore and coal in the country. During the following years of World War I (1914-1918) the production of ferrous metals decreased.

In 1967 the steel production in the Soviet Union topped the one-hundred-million-ton level, reaching 102.1 million tons a year. The Soviet Union holds the first place in steel production in Europe and the second place in the world. During the fifty years of Soviet power steel output in our country increased 25-fold. Such great development of the iron and steel industry is caused by the requirements of the industrialization of the country. Before the Revolution the iron and steel industry of Russia was mainly concentrated only in two regions, viz. in the Ukraine and in the Urals. Since then great changes in the geographical locations of ferrous metal production have taken place in the USSR. A new complex of coal mines and metallurgical plants has been created in Siberia, works have been built in the Far East, Central Asia, in the north-western and other regions of the country.

New metallurgical works have been erected in Georgia, Azerbaidjan, Kazakhstan, Uzbekistan which were backward national regions of Russia.

Thus, for example, a large integrated iron and steel works equipped with the up-to-date equipment is being constructed and is already in operation in Karaganda.

The construction of metallurgical plants in the regions mentioned made it possible to utilize the local resources of raw materials and fuel, to create a basis for industrialization and to draw the domestic national workers and engineers into production.

The experience in the development of ferrous metallurgy in the USSR can be successfully used for the advancement of ferrous metallurgy in the developing countries.

The most important pre-conditions for the establishment and development of the iron and steel industry are the following:

1) a sufficiently high level of the present or future consumption of ferrous metals,
2) the availability of the resources of iron ore and of other necessary raw materials and fuel,
3) the possibility of drawing in and training personnel for constructing and operating the metallurgical enterprise,
4) the availability of finances for capital investments,
5) the existence of a building industry of some kind.

1. Demand for Ferrous Metals

The demand for metal determines the scale of production, the nature and the assortment of the products, the specialization of the metallurgical enterprises and, to a great extent, their technological structure.

The principal consumers of ferrous metals are different branches of the machinery industry such as the automobile industry, transport machine-building (railway cars and locomotives), shipbuilding (river boats and sea-going vessels), agricultural machine-building (tractors, plows, harvesters and other implements), building of heavy equipment (boilers, turbines, mining, metallurgical, chemical equipment, cranes etc.), machine-tool building, building of electrical equipment, production of other types of machinery as well as the production of household equipment (refrigirators, washing machines and so on).

The machinery industry consumes different types of rolled steel products, viz. hot- and cold-rolled strip and sheets (especially for car manufacturing), steel plate (especially for shipbuilding), structural steel and others, as well as iron for casting.

Besides the machinery industry another large consumer of rolled products is industrial and civil engineering which mainly consumes structural shapes (beams and channels, angles), rods and wires for reinforced concrete as well as sheet steel for roofing and containers, steel and iron pipes and tubes for different conduits, wire ropes, nails and so on.

Some branches consume large amounts of special types of steel products. For example, railway transport uses rails, joints, sleeper plates, wheels; the petroleum and gas industry uses case and drill pipes and pipes for gas und oil pipelines; the canning and container making industry uses tin plate coated mainly with tin and lately with aluminium, chromium and plastics as well.

Taking into account the relatively long time it takes to construct a metallurgical enterprise especially in the countries which establish metallurgy anew, not only the actual but also the future demand for ferrous metals is of the greatest interest.

If long-term plans for the development of the national economy of the country are available, the future demand for metal can be assessed more exactly. In this case the demand for metal can be calculated directly using the figures of the envisaged production of various machines and equipment, of the volume of construction, oil and gas extraction, building railways and pipelines and the quotas of metal consumption for manufacturing a car, a tractor, machine-tool, a building and so on.

When the initial data of plans for the development of various branches of industry and transport are not available, rough and approximate calculations of the future demand for metal are possible. They can be calculated by statistical methods through analysing the actual metal consumption for the past period, finding out the trends in the development and forecasting for the future.

In calculating the consumption of metal it is necessary to take into account the possibilities of profitable export of ferrous metals into the neighbouring and other countries.

If there are iron and steel works in the country, their production should be taken into account when calculating the future metal consumption. It is usual to calculate the demand for metal and compare the data with the capacities of the operating shops.

The revealed deficit in some types of rolled products serves as a basis for planning the expansion of the existing works and for erecting new ones.

Possible surpluses of some types of products over their home consumption define the tasks of the export of metal.

The demand for rolled products and the balances of their different types are defined in the so-called assortment groups, i.e. in types (shapes) and the dimensions of the cross-sections.

In calculations assortment groups form the basis for the choice of the types of rolling mills. Therefore the range of rolled products must correspond to the main types of rolling mills.

Thus, for example, the rolled shapes include plate rolled on the reversing plate mill; sheet rolled on the continuous strip mill; cold-rolled sheet produced in cold rolling shops, sheet iron also produced by cold rolling only to a greater thinnes and requiring additional processing for applying a protective coating.

Profile iron usually includes rails and heavy sections rolled on rail-and-structural steel mills; bars of medium and small cross-section with a diameter of 25-40 to 80-100 mm and of 8-10 to 25-30 mm respectively, which are produced on jobbing and light-section mills respectively; rod iron with a diameter of 5-6 to 8-10 mm produced on specialized wire mills.

One also differentiates various special shapes such as railway wheels rolled in railway-wheel shops; seamless tubes and pipes of different diameters manufactured from round billets and ingots on pipe and tube mills; welded pipes and tubes manufactured from strip breakdown by furnace or electric welding, and others.

During the last decades the dynamics of the changes of the structure of the rolled shapes is characterized by an increase of the share of flat products, especially of cold rolled sheet. Sheet is used on an ever-increasing scale in the machinery industry for manufacturing stamped parts and welded constructions and in other branches of industry as profiles formed of bent sheets or pipes and tubes made of welded sheets, or for the production of tins and other containers.

The share of pipes and tubes, wire and wire products (wire ropes, nets etc.) also increases in the range of rolled products.

The share of profile iron, especially of railway materials and heavy structural profiles decreases. It should be noted, however, that many developing countries have entered the path of industrialization and started extensive construction work in industry and railway transport. There the share of profile iron particularly of rails, structural profiles and reinforced rods will apparently increase for a certain period of time.

The types of rolling mills to be installed is determined in accordance with the requirements and the deficit in certain types of products.

From the economic point of view it is most profitable to build large specialized works equipped with mills of high productivity for the production of sheet and bar as well as high capacity steel melting equipment and blast furnaces.

The capacity of modern rolling mills is, however, very great. For example, for a continuous strip mill it is estimated to be 3-4 million tons a year and even more; for a group of bar mills supplementing each other, such as a rail-and-structural steel mill, a jobbing mill, a light-section mill and a wire mill, the figure will be approximately the same.

Construction of such works is expedient and justified if the future metal consumption is of a corresponding volume. If the requirements are not so great, smaller iron and steel works are constructed equipped with combination, semi-continuous or straight-line mills for the production of a mixed range of products.

In many cases it is rational to establish manufacturing of various items from the rolled products at the iron and steel works.

For example, at the works where bars are rolled rod iron is manufactured into thin wire, wire ropes, nets, nails, bars are manufactured into seamless pipes and tubes as well as into bolts, nuts etc.

At the works where sheet is rolled sheet with various coatings (such as tin, zink, plastics) is produced, sheet is manufactured into welded pipes and tubes with a diameter ranging from several millimeters to a meter and even more, into bent profiles substituting bar shapes and so on.

2. Resources of Raw Materials

The principal type of iron and steel works is an integrated works with processing iron ore and coke in blast furnaces. Therefore the availability of iron ore and other necessary raw materials, viz. limestone, manganese ore, refractory materials (dolomite, magnesite, clay) in the country, is the most important pre-condition for creating and developing ferrous metallurgy.

The very first task is to find and to thoroughly study the resources of iron ore and other raw materials. Necessary geological prospecting is carried out to find iron ore deposits, to determine the conditions of their occurrence, the resourses and the quality of the ore, its mineralogical and chemical composition (the percentage of iron and other components, in particular detrimental impurities such as sulphur and others).

Naturally rich iron ores which can be directly used in blast furnaces include magnetite, martite and hematite ores, containing not less than 50-55 pct of Fe, and brown hematite and siderite ores with a lower content of Fe.

Poor ores are used in metallurgy after their benefication, the initial content of Fe being 30 pct and higher. In some cases, however, the content of Fe may be considerably lower.

It should be noted that lately even relatively rich ores are subjected to benefication, especially if the ore in question is easily beneficated magnetite. This is done to improve the parameters of the work of the blast furnace, especially for lowering the coke consumption.

In some cases the source of raw materials may be deposits of complex ore where, besides iron, non-ferrous metals such as chromium, nickel, titanium and others are found. Such ores usually require a more complicated preparation for processing. These complications and the increase in the cost of the construction of the plant are sometimes compensated for by the production of valuable non-ferrous metals as a by-product or by the production of naturally alloyed iron and steel.

From the metallurgical point of view iron ores with the basic rock containing a high percentage of calcium oxide and a permissible percentage of magnesia are of a higher value. They allow reduction of limestone in the blast-furnace burden, as compared with the ores in the acid silica rocks.

It is desirable that the content of alumina should not exceed 45-50 pct of that of silica in order to avoid difficulties in slagging off. The content of sulphur and phosphorus in ordinary blast furnace ores must not exceed 0.3 and 0.1 pct respectively.

Ores with a higher content of sulphur require crushing followed by sintering to remove sulphur.

If the ores contain a high percentage of phosphorus, high-phosphorous iron is produced to be treated into steel in accordance with a special process. Phosphorous slag received as a by-product is used as a fertilizer in agriculture.

Iron ores should not contain appreciable quantities of arsenic, lead, zink, copper and so on.

When evaluating the reserves one should proceed from the necessity to ensure the supply of the iron and steel works with the ore of the proper quality for a period of 30-40 years and longer, taking into account the inevitable losses of ore when transporting it and preparing for smelting.

To supply the works with the annual production of 1 million tons of steel and 1 million tons of iron the deposits of rich ore containing, for example, 55 pct Fe should be 60-80 million tons, and the deposits of poor ore containing about 30 pct Fe should be in the range of 150-200 million tons.

The most common and simple methods of the benefication of iron ores are washing, dry and wet magnetic separation and gravitational methods such as jigging, separation with screw separators and in heavy media separators.

Hematite and brown hematite ores which are difficult to dress are subjected to more complicated methods of benefication such as floatation, roasting to magnetize followed by magnetic separation and various combined systems of dressing.

As a result of the benefication of poor ores concentrates containing 60-65 pct Fe are obtained and sometimes the percentage is even higher.

Modern enterprises for processing iron ore produce raw materials which are well prepared for use in the blast furnace. When processing rich ores they produce sized ore of a relatively narrow range of size (from 6-10 mm to 30-50 mm) and ore fines to be sintered at the plant. When processing poor ores they produce pellets or sinter by agglomerating the concentrates after benefication.

Lately the agglomeration of fine concentrates is mainly performed by pelletizing to receive pellets which are stronger and better transportable than sinter.

To lower the coke consumption limestone is excluded from the burden of the blast furnace. It is added to the sintering burden to roast together with ore fines in order to get fluxed sinter. Fluxed pellets are produced when crushed limestone is added to the burden before pelletizing.

The iron ore raw materials received at the metallurgical works are subjected to blending at the mechanized storage to limit the deviations in the content of iron, silica and other components to the minimal range of the order of ± 0.5%.

An important kind of raw material is limestone used in iron and steel production.

The most important requirement to the quality of the limestone is the content of calcium oxide which is to be about 50 pct, while the content of silica is not to exceed 2-3 pct, it is to be even lower for the limestone used in steel making.

The annual consumption of limestone amounts to 0.4–0.6 million tons at the metallurgical works with an output of 1 million tons of steel.

To ensure the supply of such an amount it is necessary to prospect 30–40 million-ton reserves of limestone.

To ensure the required content of manganese in pig iron a small addition of manganese ore to the blast furnace burden is necessary, the amount of addition depending on the manganese content of the iron ore itself.

Besides, manganese ore with a high content of manganese or the concentrate of beneficated poor manganese ore is necessary for the production of manganese ferro-alloys for steel smelting.

A considerable amount of various refractories, powders and masses is necessary for metallurgical production to line coke furnaces, blast furnaces, steel making furnaces, heating furnaces, ladles and so on.

The principal types of raw materials for manufacturing refractories are dolomite used for lining oxygen converters, open-hearth and electric furnaces, magnesite, chromite, refractory clays, quartzite and others.

Just as in the case with iron ores, it is necessary to establish the availability of the resources of manganese ore, limestone, dolomite and other refractory materials, to carry out their geological prospecting and technical research and then to organize their mining.

Besides integrated iron and steel works producing metal from ore, works consisting only of steel making and rolling shops are also built.

The principal raw material for steel rolling works is steel scrap.

The pre-condition for the erection of such enterprises can be the availability of constantly renewed and unused resources of scrap. The latter can be formed when processing ferrous metals at engineering enterprises and as a result of depriciation of industrial equipment and spare parts, machines, ships, railway rails, metal domestic appliances etc.

The volume of the annual accumulation of scrap depends on the volume of the output of the machinery and metal-working industries and on the size of the metal fund already accumulated in the country. Part of the collected scrap is usually utilized in the charge of steel-making installations of fully integrated works where it is used together with the scrap formed at the works itself as well as in the foundries of machine-building plants. The rest of the scrap is re-melted at steel-rolling enterprises of rather small capacity. It is usually done in electric furnaces to produce both carbon and high-grade alloy steels for different purposes.

3. <u>Fuel and Power Resources</u>

As is known, coke made from coking coal is necessary for iron production.

It is more economic to use for coking coals which naturally contain a small amount of ash, the latter ranging 6–10 pct. Coals with a high percentage of ash are subjected to benefication by various methods which depend on the type and dressability of coal. Washing is the most common practice.

Coals which are hard to dress require more complicated methods of benefication, sometimes heavy media methods are used.

As a result of coal benefication concentrates and an intermediate product are received. The former have the ash content lower than that of the original coal and are used for coking. The latter has a high content of ash and is use as a low-grade power fuel and partly goes to waste.

The sulphur content of coal must be as low as possible (0.5–1 pct). Coals with a sulphur content up to 2 pct are also used, but it makes the melting of pig iron with the required sulphur content more difficult.

The cokability of coal is characterized by the thickness of plastic layer which must be not less than 15 millimeters. It corresponds to a content of volatiles of about 28-29 pct.

Lumps of 20-25 mm are usually used for blast-furnace coke, lumps of more than 40 mm are used in large blast-furnaces.Coke screenings of less than 20-25 mm are used as fuel when sintering and for other needs.

An important characteristic of coke is its mechanical hardness; when coke is intended for large blast-furnaces, the importance of this charecteristic increases. The mechanical hardness of coke meets the requirements if after testing the coke in a rotating drum 74-78% of fractions remain of the size exceeding 40 mm.

In order to get good coke combined coal charges are prepared which include various grades of coking coals differing in their cokability.

If necessary less scarce poorly-coking high-volatile coals may be used in the charge, but to a limited extent.

An iron and steel works with an annual output of 1 million tons of iron and 1 million tons of steel annually requires 1-1.5 million tons of coking coal.

To supply the metallurgical works with coking coal for a long period the required deposits may be evaluated as 50-80 million tons.

It is necessary to carry out geological prospecting and pilot-scale testing of coals for their dressability and cokability in order to determine the availability of the resources of coking coals and the suitability of the latter for metallurgy.

To save coking coal which is often in short supply metallurgists all over the world are trying to find ways for partial substitution of coke by other types of fuel which are widely spread and cheaper.

Injection of natural gas into the blast furnace has gained the widest application. Natural gas is supplied at a rate of 100 cu m per ton of iron, but if the blast is simultaneously enriched by oxygen, the rate is increased.

The use of natural gas allows saving up to 20-25 pct of coke and consequently of coking coals.

Natural gas is also used for technological purposes in the furnaces of other shops (open-hearth, rolling shops etc.) as well as in the power plants supplementing the resources of coke- and blast-furnace gases of the works.

The total annual consumption of natural gas may reach 300-400 million cu m at the metallurgical works with an output of 1 million tons of steel.

Besides natural gas, injection of fuel oil into the blast-furnace has found application and injection of finely-crushed non-coking low-ash coals, of a paste of fuel oil and coal and of other reagents is being mastered.

In the countries possessing large forest resources it is possible to substitute coke by char-coal if the volume of iron output is not great.

In some countries where coking coal is unavailable while natural gas, liquid fuel or non-coking coals are available and where the consumption of metal is rather small, they have to give up erecting blast-furnaces and to construct works for such a technique of metal production which eliminates the use of coke.

A great number of methods have been suggested for the cokeless or so-called direct reduction of iron from ore. However, very few of them have been tested for commercial production at small and medium-sized metallurgical works.

Most of the well-known processes may be divided into two principal groups in accordance with the type of fuel reducer used, viz. natural gas or solid reducers.

The reduction of iron from ore by gaseous fuel and the products of its conversion with oxygen, steam and carbon dioxide is mainly carried out in shaft furnaces and retort furnaces to produce sponge iron. The latter is in most cases remelted in electric arc furnaces.

Solid fuel is chiefly used in rotary furnaces as well as in low-shaft furnaces and electrical furnaces. Sponge iron is also produced in rotary furnaces after a magnetic separation of the reduced product.

The consumption of initial fuel per ton of sponge iron amounts to about 300 cu m of natural gas in the shaft furnace and to about 0.5 ton of run-of-mine coal and 100 cu m of natural gas in the rotary furnace.

In some countries where no considerable resources of coking coal are available, but which possess resources of cheap hydroelectric power, electrical blast-furnaces are used at metallurgical works of a relatively small output. The consumption of electrical power per ton of pig iron is high and amounts to 2,000-2,500 kwt/hr when smelting an ordinary ore burden.

Lately greater attention has been paid to the development and building of electrical blast-furnaces using pre-heated and pre-reduced burden, which allows the specific consumption of power to be lowered to 1,000-1,500 kwt/hr. In such processes the consumption of solid fuel for reduction is usually small and ranges from 0.4 to 0.6 ton per ton of pig iron.

Ferrous metallurgy is a big consumer of electrical energy. The power consumption of an iron and steel works with an output of 1 million tons of steel amounts to 60-100 thousand kwt if there are coke-ovens and blast-furnace shops; if electric steel-melting furnaces or electric furnaces are constructed, the power consumption increases accordingly.

A power plant is usually erected as part of the metallurgical works to utilize the buffer surplus of blast-furnace and coke gases and to have a stand-by source of electric supply. The plant is designed to partly meet the requirements in power. The main part of power requirements is to be met by the nearest sufficiently large power station of general purposes or by the district electrical power network.

The most important pre-condition for the development of the iron and steel industry is also continuous supply of iron and steel works with water of required quality in sufficient quantity as the works consume a great amount of water.

An iron and steel works with an output of 1 million tons of steel consumes about 100 thousand cubic meters of industrial water per hour. When a powerful source of water is not available or is rather far from the works a closed-circuit system of water supply is used. The same system is used for sanitary reasons to avoid polluting the source of water by the waste waters of the works. In this case to compensate for the loss of water in production and re-cycling, the requirements of fresh water amount to 5-7% of the total consumption of water for production.

As a rule, the total water resources of the country are not a limiting factor. Sometimes, however, there are difficulties in finding a sufficiently powerful source of water supply with an adequate debit of water throughout the year in the district most favourable for the location of a metallurgical works, viz. close to the sources of raw materials and fuel, to the centres of metal consumption and so on. Therefore a necessity often arises to regulate the natural flow of the river and to create large reservoirs to store great volumes of water.

4. Personnel

The most important pre-condition for the development of the iron and steel industry is recruiting and instructing the workers, technicians, engineers and other personnel and their practical training under actual service conditions.

The number of people working at the plant with an output of 1 million tons of steel depends on the structure of the works, their qualification and experience. It is estimated as 7-10 thousand persons including 700-1,200 engineers and technicians.

Part of the total labour force is comprised by specialists of metallurgical professions such as sinterers, dosers, gas watchmen, furnace attendants, converter operators, rolling mill operators and others. The rest are the workers of general professions such as lock-smiths, electricians, maintenance workers, crane operators, transport workers and others.

The preparation of workers of metallurgical professions takes some time for instructing them at special courses or schools and for their practical training at modern iron and steel works. Therefore it is to be arranged beforehand.

In some developing countries where metallurgical enterprises are being built, builders and fitters engaged in erecting the iron and steel works are re-trained into metallurgists as soon as they become free after commissioning some installation or a shop.

5. Building and Engineering Industries.

Building a large metallurgical enterprise with an output, for example, of 1 million tons of steel requires a great deal of equipment, depending on the structure and specialisation of the works it may amount to 100-150 thousand tons.

It is necessary to perform building works of great volume, viz. to assemble 100-120 thousand tons of steel structures, to place 500-800 thousand cubic metres of concrete and reinforced concrete, to lay 60-70 thousand cu. m of refractories, to do 500-700 thousand square metres of walling and roofing, to lay a great deal of surface and underground conduits and so forth.

To provide everything necessary for work of such a volume it is necessary that the building industry of the country should be at a certain level of development. In the country there should be enterprises to produce cement, materials for walls and roofs, timber, glass and a host of other building materials, steel structures, items of sanitary equipment and so on. Besides in the country there should also be bodies for general and specialised building and assemblage to deal with electrical equipment and network, with transport systems and so on.

The level of the development of the engineering industry is naturally of paramount importance.

Special metallurgical equipment for coking, sintering, iron making, steel making and rolling accounts for approximately half of the total weight of the required equipment. The rest is accounted for by standard general purpose equipment, viz. machine-tools, pumps, compressors, cranes, conveyors etc., and by various technological metal structures.

Special metallurgical equipment is ... ured at large specialized heavy machinery works and is usually imported. A conside ... unt of other equipment and technological metal structures can be, however, manufactured ... engineering enterprises using national resources thus cutting down the imports.

6. Capital Investments

The above mentioned facts make it clear that the development of iron and steel industry requires large capital investments.

In building modern iron and steel works capital investments per ton of steel produced considerably vary depending on the structure and capacity of the works, on the assortment of the products, on the quality of the raw materials used, on local prices and so on.

According to the data available, building of a large iron and steel works costs 300-500 U.S. dollars and even more per 1 ton of steel it can produce. The cost of small iron and steel works calculated per ton of its capacity is usually higher.

Besides it is necessary to make investments into mining and fuel industries, into building power stations, storage lakes, ferro-alloy, refractory and other enterprises, into building railways and highways and other means of communication to the site as well as into constructing other installations necessary for the operation of the iron and steel works. The capital investments into these co-operating enterprises amount to a considerable part of the cost of the iron and steel works itself.

In some cases when the resources of some or other types of metallurgical raw materials of fuel (for example, coking coals, coke) are not available in the country, metal production is organized on the basis of imported material. In this connection one should also mention the enterprises set up to process the imported semi-finished steel products, viz. works for rolling billets into finished rolled products; works for manufacturing wire, wire ropes, wire nets, nails from wire rod; works for producing tinplate, galvanized sheet and sheet with other types of coating from sheet; works for making seamless or steel pipes and tubes from round billets or skelps and so on.

The economic profitability of developing the metallurgical industry relying on imported materials is determined by the concrete conditions of supplying these materials, such as their quality, the conditions of transportation, their prices, the country's resources of foreign currency, the possibility of exchange of surplus materials for those which are lacking and so forth.

It is also necessary to take into account the prospects of co-operating the resources and efforts of two or several countries in creating and developing metallurgical production.

Thus the development the iron and steel industry requires mobilization of great material and financial resources.

At the same time it creates the necessary conditions for strengthening really independent national economy, for improving the balance of foreign trade, for saving foreign currency, for utilizing the local raw materials, for industrialization of the country and for increasing the employment of the population.

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