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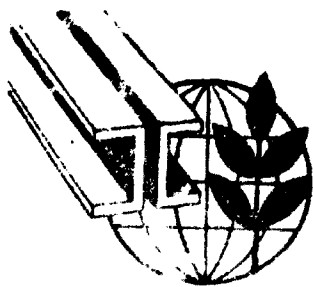
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Second International Symposium  
on the Iron and Steel Industry

Moscow, USSR, 19 September - 9 October 1968

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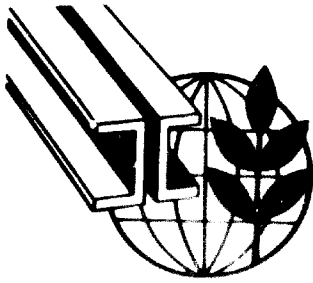
STATE OF DEVELOPMENT OF IRON AND STEEL  
INDUSTRY IN DEVELOPING COUNTRIES

by

P.A. Shirvayev *Shiriaev*  
Professor  
Institute of Steel and Alloys  
Moscow, USSR

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO.

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SUMMARY

WAYS OF DEVELOPMENT OF IRON AND STEEL  
INDUSTRY IN DEVELOPING COUNTRIES <sup>1/</sup>

by

P.A. Shirjaev  
Institute of Steel and Alloys  
Moscow  
USSR

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We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.

1. Taking into consideration the importance of ferrous metals and the role of the iron and steel industry in technical progress and industrial development, it is expedient to speed up the establishment and development of the iron and steel industry in many developing countries as a basis of really independent economy of these countries.

2. The creation and development of the iron and steel industry in developing countries must be an integral part of the general plan for industrialization. The success of designing, constructing and operating the iron and steel works in developing countries to a great extent depends on the effectiveness of state firms and on the interest the government shows.

3. Taking into consideration the current trends in the development of engineering, technology and establishment of metallurgical production, it is most expedient that in the nearest future integrated iron and steel works be constructed following the classical technological cycle which begins with the coke- and iron-making.

The best capacity of each unit, viz. blast-furnaces, oxygen converters, rolling mills, must be chosen subject to the annual capacity of the works (up to 0.2 million tons of steel, 0.5 - 1.0 million tons of steel, 3 - 6 million tons of steel) as well as to the speciality of the works and the assortment of rolled products.

As in most developing countries there is no developed industry or sufficient resources of metal scrap, constructing non-integrated metallurgical works is, with some rare exceptions, hardly sound from the economic point of view.

Giving preference to the coke and blast-furnace technological cycle for integrated works, one should not exclude the possibility of utilizing other technological processes for producing ferrous metals, such as cokeless metallurgy and operating electrical iron-making furnaces.

In a number of developing countries it may be economically justified to construct iron and steel works even if the cost of the local metal is higher than that the world prices.

4. There are favourable pre-conditions for the development of ferrous metallurgy in developing countries. Half of the population of the world live in these countries, they account for almost half of the world deposits of iron ore and natural gas and for 85 pct of those of oil. More than 20 pct of the world total of iron ore is mined in these countries, but the production of steel in these countries is but about 4 pct of the world output.

In most of the developing countries the production of ferrous metals does not exist at all or exists on a rather limited scale, India, the UAR, Brazil, Mexico, Argentina, Venezuela

and Chili being an exception.

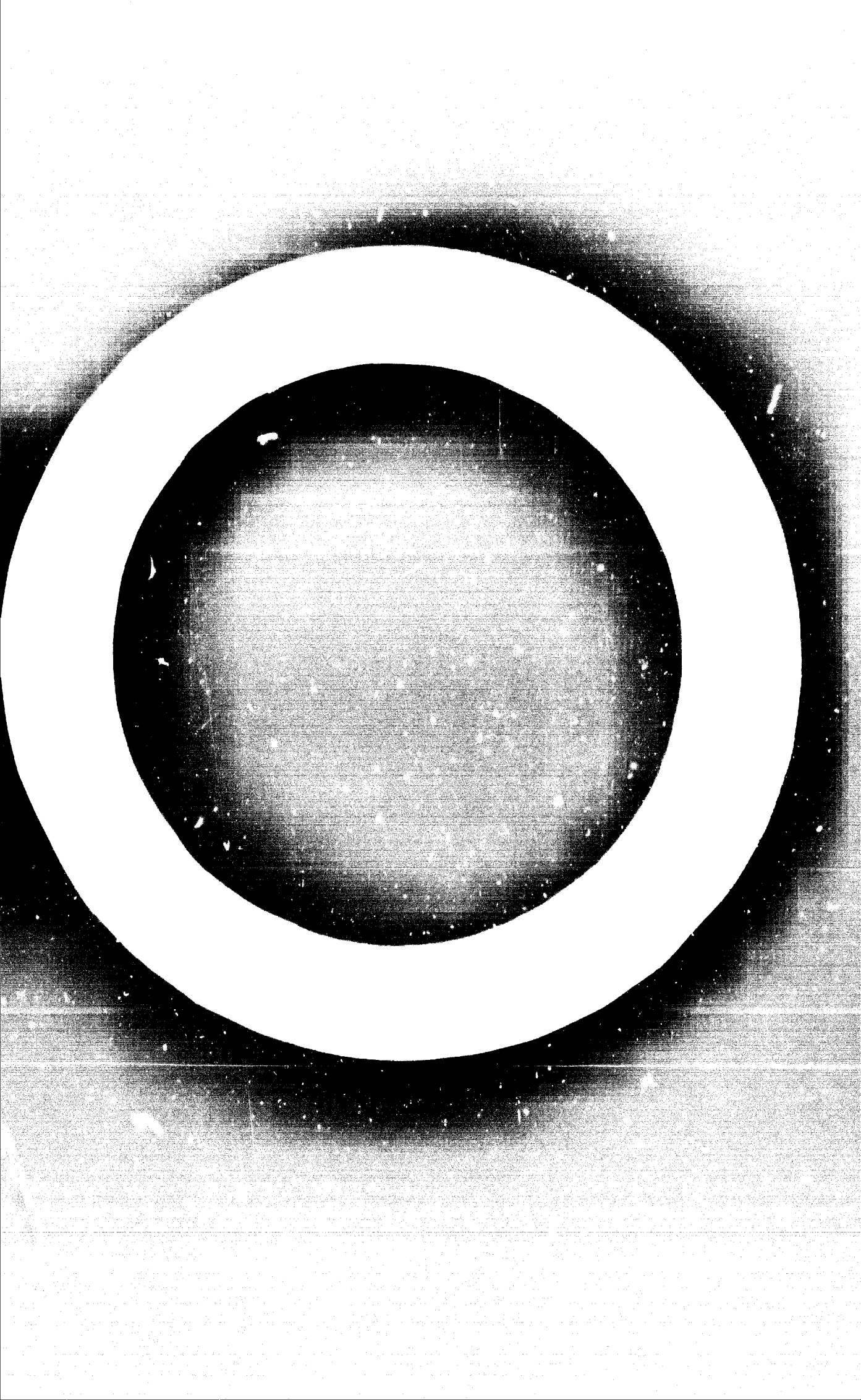
5. When solving the questions connected with constructing metallurgical plants one should proceed from the principle that the national iron and steel industry should have the priority in its establishment and development, as it is one of the most important conditions for the industrial development and economic independence of the developing countries.

The experience of the countries which are members of the Board of Mutual Economic Assistance and participate in the work of its standing committee for iron and steel industry and in "Intermetall" in economic, scientific and technological cooperation is cited in connection with planning the development of the national iron and steel industry of developing countries.

6. When in some developing countries there is no opportunity to create their national iron and steel industry in the near future, it is promising from the economic point of view to construct metallurgical enterprises on a regional basis, i.e. jointly by a group of countries of the given region. The construction should be carried out under mutually advantageous conditions and be subject to the approval and participation of the governments of the interested countries. In this case one can work out various plans of how to locate and construct separate units of the iron and steel industry in the countries of the given region.

7. The fulfillment of any plans of either national or regional character is determined to a considerable degree by the mobilization of efforts and domestic resources of the interested countries as well as by close scientific, technical and economic cooperation and assistance of the countries. The industrially developed countries must also play their positive role in some form. The forms of cooperation of the USSR and developing countries in designing and constructing metallurgical works is cited in particular as an example.

8. Detailed recommendations for constructing new iron and steel works or for modernizing those which are in operation in the developing countries can be prepared after special work and thorough investigations have been carried out in each country or a group of countries.



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## ROLE OF DEVELOPMENT OF IRON AND STEEL INDUSTRY IN DEVELOPING COUNTRIES

The peoples of the countries which have won political independence are now struggling to liquidate the aftermath of the colonial supremacy. They are striving to develop really independent economy, to train specialists from the local population.

The rate of the economic development of these countries is, however, not high enough and it is desirable to increase it.

Up till now many countries of Asia, Africa, Latin America do not participate in the international division of labour in due measure. For example, during the last years the trade between industrially developed countries has been growing at a higher rate than their trade with other countries. In 1963 - 1966 the commodity circulation between the industrially developed countries increased by about 40% in terms of cost. During the same period the commodity circulation with the developing countries increased 1.3 time slower.<sup>1/</sup>

The natural resources of these countries are vast, but the countries considerably lag behind the industrially developed states in the per capita production of industrial products.

Because of this a problem of rendering economic and technical assistance to the developing countries has faced U.N.O.

The many years of the work of U.N.O. and its specialized agencies, of a number of international funds and the so-called assistance programs witness to the fact that the countries of Asia, Africa and Latin America attach great importance to the cooperation with these bodies.

An attempt is made in the present paper to elucidate some general trends in, and possible ways of the development of iron and steel industry in the developing countries as a basis of really independent economy of these countries.

### 1. The Role of Iron and Steel Industry in Technical Progress and Industrial Development

At present industrial production is experiencing a scientific and technical revolution caused by the rapid development of fundamental sciences, such as physics, chemistry, mathematics. Mankind has entered the atomic age, the age of complex automation, jet propulsion,

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<sup>1/</sup> N.Liventsev, Master of economic sciences. "Problems of Export of Developing Countries", Ekonomicheskaya Gazetta, No. 27, July 1968, p.46.

electronic engineering and cybernetics. The achievements of mankind in technical progress could not have been possible but for the wide application of steel. Ferrous metals are the main structural material for industry and for machine-building in particular. Studies show that ferrous metals will play this role for many years to come despite the considerable development of non-ferrous metallurgy and the production of synthetic materials with pre-determined properties, such as plastics, polymers and so on. The importance of ferrous metals is determined by their relative cheapness and their unique universality which allows for creating various chemical, mechanical and other properties, as well as for manufacturing items of different geometrical forms and dimensions.

A special group of speakers on the questions of steel trade and of demand for steel in the developing countries note in their report that substitutes have ousted from consumption not more than 5 - 10 per cent of the total amount of steel consumed in industry. At present the output of the countries producing substitutes as well as their operating costs have not apparently reached such a level which will enable them to seriously influence the volume of consumption of ferrous metals.<sup>1/</sup>

The iron and steel industry is one of the most important foundations of the development of modern industry and of operational equipment of all branches of national economy. A systematic rise in the production of ferrous metals and the improvement of their quality provide for the expansion of production, for a longer service life of machine-tools, machines, mechanisms, various apparatuses, tools, buildings and constructions, for increasing the productivity of social labour.

The fund of metals accumulating in each country, the per capita level of production and consumption of steel are the most important indices of the country's technical and economic development, self-dependence and independence.

Taking into consideration the importance of ferrous metals for modern civilization, it is expedient to speed up the creation and development of iron and steel industry in many developing countries. This will enable the peoples of these countries to use the fruits of the rapid technical progress more fully and effectively.

## 2. The Development of Iron and Steel Industry as an Integral Part of the Plan for Industrialization

An effective development of the productive forces of each country is determined by a correct establishment of the ratio between the principal branches of industry and of the national economy.

Industrialization envisages both an increase in the share of industry in economic structure and some changes within the branches of industry.

The government sector and the state planning of the development of production play a great role as they make it possible to solve the problems of breaking down the economic structure inherited from the colonial period and to ensure a proportional development of separate industries. All these tasks are difficult to solve on the basis of private enterprises and unforeseeable market relations because the private sector obeys the unpredictable laws of buying and selling and striving for profit and does not obey the general necessity of the national economy to utilize the available mineral and other resources in the most rational way.

Realization of the plans for industrialization helps the developing countries to speed up the attainment of economic self-dependence in addition to political independence. The USSR may

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<sup>1/</sup> NCE U.N.O., the Committee for Ferrous Metallurgy. "World Trade in Steel and Raw Materials for Steel in the Developing Countries", ch. 1, p.9, November 17, 1966.

serve as an instructive example in this respect. In a historically short period of time the Soviet Union has transformed from backward agrarian tsarist Russia which was under foreign influence in many respects into a great industrial power.

The creation and development of iron and steel industry in the developing countries must be an integral part of the general plan for industrialization in accordance with the concrete conditions existing in separate countries and with the possible mutually beneficial relations with other countries.

The success of designing, constructing and operating iron and steel works in developing countries to a great extent depends on the effectiveness of state firms and on the interest the government shows.

The establishment of metallurgical production and constructing enterprises which consume metal require the employment of a considerable number of local population, which contributes to increasing the employment of the people in the developing countries. Constructing metallurgical works in these countries creates the necessary conditions for strengthening really independent national economy, contributes to the industrialization of the country, to the development of the engineering industry and other metal-consuming branches of industry. It also contributes to raising the living standard of the peoples.

### 3. The Main Technological and Economic Factors to Be Taken into Consideration When Substantiating the Ways of Development of Iron and Steel Industry.

The current trends in the development of engineering, technology and maintenance of metallurgical industry are mainly based on further development of the classical technological cycle which begins with the production of coke and iron. In other words, it is necessary to develop the existing integrated iron and steel works and to construct new ones which include coke and chemical shops, blast-furnace shops, oxygen-converter shops, and rolling shops as well as non-integrated works which consist of shops for electrical steelmaking and rolling shops. Continuous casting of steel is considered to be the principal method for producing billets and slabs.

To intensify the metallurgical processes oxygen, natural gas and other reagents are used on a large scale. Technically pure oxygen is the basis of the oxygen converter process of steelmaking. The experience of the USSR shows that injection of natural gas into the blast-furnace made it possible to lower the consumption of coke and to considerably improve the economic characteristics of the blast-furnace production. Automation and complex mechanization are introduced into the iron and steel industry as well as in other branches of industry on a large scale. They are introduced into production processes and transportation as well as into the spheres of directing and planning metallurgical production.

At present no adequately developed technological cycle, nor necessary equipment, nor reliable technical and economic characteristics are available for establishing large tonnage production of ordinary metal employing the new technology, viz. cokeless metallurgy.

As in most of the developing countries there is no developed industry or sufficient resources of metal scrap, constructing non-integrated iron and steel works is, with some rare exceptions, hardly sound from the economic point of view.

Therefore it is necessary to concentrate the efforts on the preferable construction of integrated works with the classical technological cycle envisaging coke- and ironmaking with the maximum possible orientation on the local sources for the supply of raw materials and fuel.

Naturally one should not exclude the prospects of building small non-integrated works in the developing countries later on when favourable conditions arise, in particular when metal scrap and cheap electrical power become available and when specific demand for rolled

products arises, just as it occurs in some districts of the USA where lately a number of small non-integrated metallurgical works, the so-called "Mini" steel plants have been built.<sup>1/</sup>

The choice of the optimal capacity of the future iron and steel enterprises and units is an important question for a separate developing country and the more so when the construction carried out on a regional basis.

The iron and steel industry belongs to the branches of industry where production is highly concentrated and specialized, which, in its turn, determines a high technical and economic level of the branch itself.

The studies of the experience in operating the metallurgical units and works in the USSR have been carried out for a long time and they show that it is economically profitable to concentrate the production in ferrous metallurgy and to use units of large capacity. These trends will remain unchanged in the nearest future too. Many years of Soviet experience in designing and operating iron and steel works have made it possible to work out the optimal parameters of the main metallurgical units, viz. blast-furnaces, steel melting furnaces, converters, rolling mills, as well as the optimal capacities of services and auxiliary shops characterized by high productivity. Thus, for example, it was established that under the conditions existing in the USSR the optimal size of the integrated iron and steel works powerful units and shops is when its annual capacity lies within the range of 6 - 7 million tons of steel.<sup>2/</sup>

It is, however, economically justified to construct works of a considerably smaller capacity in a number of developing countries which have not got sufficient conditions for establishing iron and steel enterprises of large capacity.

Such enterprises will create all the necessary conditions to satisfy the domestic demand of the country with her own metal, they will give an impetus to the development of the metal-working industry and the building industry, they will speed up the process of industrialization. An approximate structure of the metallurgical shops depends on the capacity of the works and the following figures may be cited. The blast-furnace shop of one 200 - 300cu m blast-furnace may be sufficient for the works with an annual capacity of up to 0.2 million tons of steel; one or two blast-furnaces of a 1.000 - 1.500 cu m volume may be necessary for the works with an annual capacity of 0.5 - 1.0 million tons of steel; two or four blast-furnaces with a volume of 2.000 - 3.000 cu m may be required for the works with an annual capacity of 3.0 - 6.0 million tons of steel.

One of the prerequisites for a successful performance of the blast-furnace lies in the proper preparation of the raw materials and fuel for the blast-furnace operation. The preparation includes crushing and grading the lumpy ore and fluxes, production of fluxed sinter from the ore fines, beneficiation of lean ores and production of fluxed sinter or pellets from the ore concentrates. Particular attention should be paid to the hardness of coke: the greater the hardness of coke, the greater may be the volume of the blast-furnace for the given volume of iron output. In most of the developing countries and the regions where they lie sufficient resources of high-quality coking coals are not available. As the blast-furnace process is at present the most profitable, maximal efforts should be exerted for prospecting coals suitable for coking, for improving the process of coking and for increasing

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<sup>1/</sup> C.L. Kuzrin. The Big Surge of "Mini" Steel Plants, The Iron Age, November 23, 1967, pp. 68-75.

<sup>2/</sup> Concentration of production and the optimal size of the metallurgical works of the USSR. - An article in the book entitled "Optimal Parameters of Industrial Enterprises (The papers of the conference on concentration of production and on methods of determination of the optimal size of the enterprise)", the Nauka publishing house, 1968. p.

the supply of raw materials and for enlarging the production of coke and by-products.

It is the oxygen-converter process that is mainly used for producing steels of wide assortment.

Different modifications of the oxygen-converter process may be used when working with iron containing a high percentage of phosphorus, manganese and other admixtures.

To ensure an uninterrupted production, not less than two converters are installed, one being in operation and the other standing-by or being relined. The capacity of the converters depends on the volume of production and ranges from 10 to 300 tons.

Converters of 10-15 - ton capacity can be installed at the works with an annual capacity of 0.2 million tons of steel; converters with a capacity of 50 - 100 tons are necessary for the works producing 0.5 - 1.0 million tons of steel per year; 150 - 300 - ton converters are required for the works which annually produce 3.0 - 6.0 million tons of steel.

Lately continuous casting of steel has been applied on a wide scale. This technique increases the amount of final rolled products per ton of molten steel, ensures the uniformity of the chemical analysis of the metal and radically improves the conditions of work when casting steel. There appears a possibility of complete mechanization and automation of the whole process of casting steel. Billets of various cross-sections can be cast at the continuous casting plants. Squares, rectangles, flats, rounds can be cast of a very wide range of grades of steel, including carbon, low-alloy and alloy steels, to produce plate, sheet and bar section.

The works may specialize in producing plate and sheet or bar section in accordance with the demand of the country in certain types of rolled products.

When constructing the first iron and steel works in the country or in the region, it is sometimes expedient to construct a works on the universal program which envisages installation of both plate and sheet mills and bar section mills either simultaneously or in stages.

The establishment of production of hot-rolled sheet and plate is economically unjustified at the works with a capacity of up to 0.2 million tons of steel a year, if modern technology is used. The fact is that a semi-continuous or even a reversing strip mill will be loaded insufficiently.

The establishment of specialized production of sheet and plate meets with certain difficulties when it is done at the works with an annual production of 0.5 - 1.0 million tons of steel, if modern technology is used. The difficulties arise in particular when it is necessary to produce strip and sheet of a 1,500 - 1,700 mm width. In this case the mills are insufficiently loaded, which lowers down the technical and economic characteristic of their work.

When it is necessary to produce hot-rolled strip and sheet of a 1,000 mm width, it is possible to install a semi-continuous strip mill having 1,200 mm rolls. Even such mills, however, have a capacity of up to one million tons per year and they will not be sufficiently loaded at small-capacity works either.

When a large works is specialized in sheet and plate production, it is necessary to install continuous wide strip mills with 1,700 - 2,000 mm rolls which can produce 3.0 - 6.0 million tons per year and to construct shops for cold-rolling where 1.5 - 2.5 million tons can be rolled annually. Such sheet and plate rolling shops ensure the production of hot- and cold-rolled strip, sheet and plate the thickness of which approximately ranges from 0.15 to 12.0 mm and the width, from 500 to 1,800 mm.

Single-stand reversing mills may be installed in the cold-rolling shops, and if the shop produces more than 250 - 300 thousand tons of steel annually, then four- or six-stand continuous cold-rolling mills may be installed, the choice depending on the assortment and the volume of cold-rolled products.

The production of cold-rolled sheet and plate with various coatings can be established

on a small scale by installing one or two 4-high reversing mills to process hot-rolled coils brought to the works.

To manufacture medium and small-sized sections and rod at the works producing 0.2 million tons per year it is possible to install one semi-continuous combined mill with a cogging stand which will process cast blooms.

To manufacture a wide range of shapes at the works producing 0.5 - 1.0 million tons per year one designs rolling shops consisting of finishing mills, for example, such as a heavy section mill with rolls of a 650 mm diameter and a 350/250 combined semi-continuous section mill. The mills mentioned above provide for the production of heavy and medium structural sections, viz. beams, channels, angles and so on, narrow gauge rails, sections and wire rod.

The heavy section mill rolls all the cast blooms and produces heavy sections and billets for the other mill.

To manufacture sections at the works of a 3-6 million ton annual capacity the equipment of the rolling shops includes a continuous billet mill and several finishing mills, such as heavy section mills, medium section mills, jobbing mills, rod mills. The annual production of each of them amounts to 0.4 - 0.7 million tons and even more depending on the assortment of the products.

It is possible to include shops for further processing the rolled products into the structure of the iron and steel works. They may be pipe- and tube making shops, shops for manufacturing hardware, shops to produce formed sections, shops for applying metal and non-metal coatings and so on.

If at the works there is shop to produce sheet and plate, it is possible to construct a shop for manufacturing electro-welded pipes and tubes. The units to be installed are to be chosen on the basis of the required assortment of pipes and tubes. It is possible to install units to produce pipes and tubes the diameter of which ranges from 6 to 1,400 mm and which are intended for different purposes, such as for main and distributing pipelines to transport oil, water and so on, structural pipes for mechanical engineering, etc. The units can weld from 20 to 800 thousand tons of pipes and tubes annually, depending on the assortment.

Seamless pipes and tubes which are intended for heavy duty in the petroleum industry and in mechanical engineering, for example for drilling, for pumps and compressors, for boilers, for ball-bearings are manufactured at the tube mills. The latter are usually installed at the works where there is a possibility to supply these mills with round billets having a diameter of 80 - 350 mm. Tubes having a diameter of 30 - 400 mm can be rolled at these tube mills. The capacity of the tube mills is from 100 to 400 thousand tons of seamless tubes a year.

Tube and pipe production can also be established at special tube and pipe manufacturing works which receive the necessary billets and skelps from other works.

At works where flat-rolled products are produced it is expedient to build shops to manufacture formed sections which may partly substitute rolled sections.

Special equipment may be installed at the works to manufacture wire, wire ropes, wire nets, nails, nuts, bolts and other hardware.

Giving preference to building integrated iron and steel works with coke and blast-furnaces shops in the years to come, one should not exclude the possibility of utilizing some other technological cycles for the production of ferrous metals.

The fact is that in many countries coking coals are unavailable while natural gas, liquid fuel and different types of non-coking coals are available. Under these conditions when the demand for metal is relatively small the countries have to give up the idea of constructing blast-furnaces and turn to erecting iron and steel works following the new, cokeless technological cycles.

Most of the known processes may be divided into two groups which differ in the type of the utilized fuel-reducer. One group is characterized by the utilization of natural gas and the products of its conversion with oxygen, steam or carbon dioxide. The other group is characterized by the utilization of various solid reducers.

The reduction of iron with gaseous fuel is mainly carried out in shaft furnaces or retorts, while the solid fuel is utilized in rotary furnaces as well as in low-shaft furnaces and electric furnaces.

The processes of the first group result in producing sponge iron which is in many cases melted in arc-furnaces. Sponge iron is also produced in rotary furnaces after subjecting the reduced product to magnetic separation. Iron is produced in electric furnaces.

At present shaft furnaces applying natural gas are undergoing pilot testing only. If compared to retorts, shaft furnaces can ensure higher productivity and a lower consumption of natural gas and the converting reagent, such as steam, oxygen. This fact predetermines their potential advantages and makes it possible to suppose that in the future they will be used on a larger scale in industry.

The production of sponge iron can be established when using solid fuel as a reducer. The process carried out in rotary furnaces may be considered to be best prepared to be used on an industrial scale.

Electric furnaces consume a great amount of electric power which equals to 2,000 - 2,800 kwhr per one ton of iron. Therefore in the course of the last years greater attention has been paid to constructing electric furnaces using pre-heated and pre-reduced charge. Such practice makes it possible to lower the consumption of electric energy down to 1,000 - 1,500 kwhr per one ton of iron depending on the degree of pre-reducing and the capacity of the furnace. When rotary furnaces are used for pre-heating and pre-reducing the charge, the efficiency of the electric furnaces almost doubles.

When solving the problem of the expediency to establish and develop the national or regional iron and steel industry, there arise certain difficulties in choosing the criteria to determine the economic profitability of constructing metallurgical works. It is usual to calculate the profitability of the works, to compare the specific capital investments with those in similar enterprises in other countries, to compare the expected cost of the local metal with the level of world prices, to calculate the expected savings in foreign currency and so on. If these calculations show that the capital investments in constructing metallurgical, ore- and coal-mining enterprises are quickly or relatively quickly justified by the economy in the cost price, then there is no doubt that the establishment of the national metallurgy is expedient from the economic point of view. In many cases, however, the calculated economic characteristics of constructing and operating metallurgical works do not show any advantages or show that the national production of ferrous metals can be established only when the costs exceed the prices of imports.

At first sight it seems that in the latter case the country which decides to construct an iron and steel works will suffer losses in comparison with importing metal. In this connection we should like to draw your attention to the following fact. The cost of the primary ferrous metals, i.e. without machining them and without the expenses on casting, comprises a relatively small share of the total cost of capital construction and machine-building. The experience of the USSR says, for example, that the cost of the primary ferrous metals amounts to 5-10 pct of the total cost of the products of the machine-building industry. It means that if the cost of metal becomes 20 pct higher than the level of world prices, the cost of the products of the machine-building industry increases but by 1 - 2 pct, all other factors remaining unchanged.

If one takes into consideration the fact that machine-building and metal-working are, as

a rule, highly profitable branches of national economy, one comes to the conclusion that even when the cost of ferrous metals rises very considerably, the economic profits gained in the machine industry may completely justify the extra expenses for the production of ferrous metals. These factors may determine that economic soundness of constructing domestic metallurgical works with relatively low economic characteristics.

Bearing this factor in mind, when proving the expediency of establishing metallurgical production, it is expedient to supplement the economic calculations for the metal producing branch of industry with the calculation of the expected profits gained by the main metal consuming branches of the industry of the country or the region. Such calculations and such a way of solving the question of the expediency of establishing ferrous metallurgy can be best realized when state firms and governmental bodies of the interested countries participate in it. It should be noted that iron and steel industry is rather a capital-consuming and material-consuming branch of industry and the industry demands comparatively not so many workmen. It is, however, possible to establish rather labour-consuming branches, in particular the machine industry, on the basis of the use of ferrous metals, which will lead to drawing large masses of the population of the country into industrial production.

Thus constructing integrated iron and steel works is most expedient when using the classical technological cycle which includes coke and blast-furnace shops. It may prove economically sound even when the cost of locally produced metal exceeds the level of world prices.

#### 4. Iron Ore Deposits and Current Production of Steel in the Developing Countries.

At the beginning of 1966 more than 1.5 milliard people, i.e. 46 pct of the total world population, lived in the developing countries which occupy 50.7 pct of the whole territory of the globe.<sup>1/</sup> This creates good prospects for a considerable growth of the demand of these countries in ferrous metals and of the market for the latter. In 1950 - 1966 the increase of the population of the developing countries amounted to 42 pct, while that of the world population was only 37 pct. In other words the rate of the growth of the population in these countries is higher than that in other countries. About half of the world resources of iron ore is concentrated in these countries and in many cases the quality of the ore there is better than that of the ore found in industrially developed countries. The distribution of the iron ore deposits and the scale of ore extraction are characterized by the following data<sup>2/</sup>:

R e g i o n s	Resources		Output of mining	
	x 10 <sup>9</sup> tons		x 10 <sup>6</sup> tons	
	total	proved	1950	1966
<b>The developing countries of:</b>				
Latin America	87	13	5	59
Asia and the Far East	27	11	4	37
The Middle East	1	...	...	1
Africa	18	5	6	35
<b>Total</b>	<b>133</b>	<b>29</b>	<b>15</b>	<b>132</b>
<b>World total</b>	<b>288</b>	<b>56</b>	<b>242</b>	<b>614</b>

1/ The USSR Central Statistical Board. The National Economy of the USSR in 1965., 1966, p.82.  
 2/ The Ministry of Geology of the USSR. The All-Union Geological Fund. Mineral Resources of the Countries of the Capitalist World (Capitalist and Developing Countries) at the Beginning of 1967, 1968, p. 52-55.  
 U.N.O. Quarterly Statistical Bulletin of the European Ferrous Metallurgy, Geneva, 1955, No. 3, p. 8. Ibid, 1967, No.3 p.A.



As seen from the above figures, in the course of the last 16 years the mining of iron ore in the developing countries grew more rapidly than that in the whole world. As a result the share of the iron ore mining in the developing countries increased from 6.4 pct of the world total in 1950 up to 21.5 pct in 1966.

The developing countries occupy the leading place in the world in respect of their resources of oil and natural gas. They possess 85 pct of the world total resources of oil and 48 pct of those of natural gas.<sup>1/</sup>

The use of natural gas, fuel oil and hydroelectric power enabled some developing countries to partially compensate for the shortage of coal. The resources of coal in the developing countries amount to about 3 pct of the world total and the quality of coal is, as a rule, relatively low.<sup>1/</sup>

It is necessary to note that the natural resources of developing countries are studied very badly and the resources may be considerably greater. But even with our poor prospecting of the natural resources of developing countries it is quite obvious that there are favourable preconditions for a considerable development of metallurgical production in the developing countries. The present level of the development of the iron and steel industry in these countries is, however, very low. Thus on the basis of the data available to the Steel Committee of the European Economic Commission of the United Nations Organization the following table of the production of steel can be compiled reflecting the share of the developing countries in the world total:<sup>2/</sup>

Steel Production, x 10 <sup>6</sup> tons			
	1950	1960	1965
The developing countries	2.8	9.3	17.0
The world total (minus the Chinese People's Republic)	190.9	328.0	444.0
The share of the developing countries, %	1.5	2.8	3.8

In the course of 15 years the amount of steel produced in the developing countries increased but by 14.2 million tons, while the world production of steel increased by 233.1 million tons for the same period of time. In 1965 the share of the developing countries in the world production of steel amounted only to 3.8 pct while the population of these countries comprised 46 pct of the whole population of the globe.

In 1950-1965 the annual rate of growth of the production of steel in the developing countries was 12.7 pct while that of the world amounted to 5.75 pct. In spite of the fact that the former is 2.2 times higher than the latter such a relatively slow tempo of outstripping the industrialized countries in the development of iron and steel industry can be hardly accepted as satisfactory.

The group of developing countries includes approximately 80 countries being at different stages of industrial development. These countries lie in the South-East Asia and the Far East, in the Middle East, in Africa and in Latin America. Only about 40 developing countries have iron and steel works.

<sup>1/</sup> EEC of UNO. Committee for Ferrous Metallurgy. World Trade in Steel and the Demand for Steel in Developing Countries. ch. VI, September 11, 1967, p.12.

<sup>2/</sup> *ibid*, p.7.

The level of development and the output of the metallurgical production in these countries vary very greatly. In most of the developing countries the iron and steel industry is represented by small non-integrated works with steelmaking and rolling or only rolling shops processing imported billets. It is only in nine developing countries that integrated iron and steel works have been constructed. Of the 23 integrated iron and steel works six are in India, six are in Brazil, four are in Mexico, two are in Argentina and the other five countries have one work each.<sup>1/</sup>

In 1965 of 17 million tons of steel produced in the developing countries 14.7 million tons, i.e. 85 pct, were produced in the following seven countries: India (6.4 million tons), Brazil (5.0 million tons), Mexico (2.5 million tons), Argentina (1.3 million tons), Venezuela (0.6 million tons), Chile (0.5 million tons), the U.A.R. (0.4 million tons).<sup>2/</sup> Consequently all the other 33 developing countries possessing iron and steel works produced as much as 2.3 million tons of steel, in other words only 0.5 pct of the world total. Each country produced on the average only 70 thousand tons of steel per year.

In 1965 the share of the developing countries in the total consumption of ferrous metals amounted to 7.2 pct. The per capita consumption of steel in the developing countries amounts to 20 kilograms a year, while in the industrially developed countries it is as high as 400-650 kilograms. In this respect the developing countries consume much less steel than even the mean figure for the whole world which equals 142 kilograms.<sup>3/</sup>

Thus in most of the developing countries there is no production of ferrous metals or this production is carried out on a very limited scale. It is only the first steps that are being taken to create and develop iron and steel industry. The last years are characterized by origination of numerous projects of constructing new iron and steel works or developing the existing ones.

In accordance with various calculations and forecasts by 1975 and 1980 a considerable growth of steel production is expected in the world including the developing countries.<sup>4/</sup>

Under these conditions it is very useful to study and to analyze all possible ways of development of the iron and steel industry in the developing countries. It is also useful to carry out technical and economic investigations, geological prospecting, designing and other preliminary work on a global, regional and national scale.

When analyzing the ways of development of the iron and steel industry in the developing countries on a national or a regional basis it is necessary that the principal pre-conditions be studied thoroughly and evaluated from the economic point of view. The advanced experience of and the technical and economic trends in the metallurgy of the world should also be taken into consideration.

##### 5. The Development of National Iron and Steel Industry.

When solving the questions connected with constructing metallurgical works one should proceed from the principle that the national iron and steel industry should have the priority in its establishment and development, as it is one of the most important conditions for the industrial development and economic independence of the developing countries.

It is recommended that the developing countries take all the possible measures for a speedy development of their national iron and steel industry if the countries expect that in

1/ *ibid*, p.5

2/ *ibid*, p.8

3/ Prager László. A fejlődő országok acéliparának helyzete. "Kulkerkedelem", 1967, p.11, 12, 370.

4/ IEC of UNO. Steel Committee. The World Market of Iron Ore. Appendix 3. The Output of Ferrous Metallurgy in 1975 and 1980., September 5, 1967, p.16, 18-19.

the future their national economy will require ferrous metals and if there are some resources of fuel and iron ore and some economic pre-conditions for it.

In this respect the positive experience of India should be noted. In India the national iron and steel industry is mainly developed by constructing state-owned large iron and steel works utilizing the domestic resources of raw materials and fuel. Iron and Steel combines have been constructed and put in operation in the towns of Bhilai, Durgapur, Rurkel. Work is being carried out to ensure a further considerable increase of the output of these combines. Another large iron and steel combine is under construction in the town of Bokaro.

In Mexico iron and steel industry is also being developed on the basis of utilizing the local resources of raw materials and fuel. The largest iron and steel works in Mexico belongs to the state-owned company of AISMA. Measures are being taken to considerably increase the output of this works.

The construction of a state-owned integrated iron and steel works has been started in the town of Isfahan in Iran. The local deposits of iron ore and coking coals will be utilized there.

In a number of developing countries it is economically sound to develop the national iron and steel industry even if some principal pre-conditions are not available in the country. Thus a large complex of metallurgical enterprises is being created in the town of Heluan in the U.A.R. on the basis of local deposits of iron ore although there are no fields of coking coals in the country.

The same situation is in Algeria where a state-owned iron and steel works is being constructed in the town of Annaba. The iron and steel industry of Argentina is completely based on the local iron ore and imported coking coals. In Brazil 60 pct of her iron and steel industry depends on the import of coking coals while utilizing the local iron ore.

In order to increase the economic profitability of the national iron and steel industry it is necessary to take into account business relations with foreign countries. Thus, for example, it is more expedient to import some specific types of rolled products into certain countries. Here we mean such rolled products as wheels, tyres, rolled axles, H-beams, some types of sections and flat products which, under the conditions of specialization, it is not expedient to produce at the local works due to a very limited demand for them.

In connection with working out plans for the development of the national iron and steel industry in the developing countries it is interesting to cite the experience of economic, scientific and technical cooperation of the countries which are members of the Board of Mutual Economic Assistance and participants in the work of its standing committee for ferrous metallurgy. This committee has been contributing to the development of the iron and steel industry in the member-countries of the Board of Mutual Economic Assistance for longer than a decade.

The European countries of People's Democracy inherited from capitalism a poorly developed and partially destroyed iron and steel industry. In Bulgaria there was practically no iron and steel industry.

It was necessary to restore the industry of the member-countries of the Board of Mutual Economic Assistance which was destroyed during the war. Then it was necessary to effect socialist changes in the national economy of these countries. These factors made a rapid development of the iron and steel industry one of the primary tasks. If each country has tried to solve the problem independently, it would have taken more time and a considerable amount of funds.

The task of establishing and developing the national iron and steel industry has been solved through economic cooperation. The Statute of the Board of Mutual Economic Assistance defines that "economic, scientific and technical cooperation of the member-countries of the Board is carried out in accordance with the principles of full equality, of respect of the sovereignty and the national interests, of mutual profitability and of comradely mutual as-

assistance". These principles as well as the main principles of the international socialist division of labour adopted by the Board of Mutual Economic Assistance are the guiding principles in the work carried out by the bodies of the Board of Mutual Economic Assistance concerned with ferrous metallurgy.

The economic, scientific and technical cooperation of the member-countries of the Board of Mutual Economic Assistance in the field of ferrous metallurgy is carried out on the basis of multilateral and bi-lateral agreements in a great number of ways. They include granting credits, mutual assistance in designing, constructing and reconstructing metallurgical enterprises, supplying metallurgical equipment and assistance in its installation, setting up and mastering, supplying metallurgical raw materials, coke and coking coals, mutual supply of rolled products, pipes, hardware and other types of metallurgical products; mutual exchange of experience on a wide scale, free information about the latest achievements of science and technique; joint performance of scientific and technique investigations; training personnel and so on.

The Soviet Union has helped the member-countries of the Board of Mutual Economic Assistance to develop their own iron ore deposits. And besides that every year the USSR considerably increased the deliveries of iron ore to these countries. This fact made it possible for some socialist countries which have not rich deposits of iron ore to cut down the capital investments in building expensive mines and beneficiation enterprises at small dispersed deposits. The Soviet Union also increases the deliveries of manganese ore, iron and ferro-alloys to the member-countries of the Board of Mutual Economic Assistance. Poland, Czechoslovakia and the Soviet Union supply coking coal and coke to Bulgaria, Hungary, the German Democratic Republic and Rumania. The member-countries of the Board of Mutual Economic Assistance asks considerable reciprocal deliveries of rolled products, steel pipes and tubes and hardware.

The iron and steel industry of all member-countries of the board of Mutual Economic Assistance and of Yugoslavia has scored great successes. In 1966 the amount of steel produced in the member-countries of the Board of Mutual Economic Assistance reached 127.4 million tons, in other words it was more than doubled in the course of the last decade.

Lately Yugoslavia has been taking an active part in the work of the Board of Mutual Economic Assistance in the field of iron and steel industry. Taking into account the output of steel in Yugoslavia the figure for 1966 exceeds 129 million tons. If in 1960 the share of the member-countries of the Board of Mutual Economic Assistance in the total world production of steel amounted to 18.7 pct, in 1965 it increased up to 26.1 pct.<sup>1/</sup> In 1966 the production of rolled products in the member-countries of the Board of Mutual Economic Assistance reached 87 million tons which comprises 25 pct of the total world production against 20 pct in 1965.<sup>2/</sup>

At present the member-countries of the Board of Mutual Economic Assistance on the whole meet their demand for rolled products by their domestic production. Since 1962 their export of rolled products to the third countries exceeds their import. Thus in 1966 their exports exceeded their import by about 2.5 billion tons.<sup>2/</sup>

Plans for the development of ferrous metallurgy up to 1970 as well as suggestions for the 1971-1975 period have been worked out by the member-countries of the Board of Mutual Economic Assistance and Yugoslavia.

1/ V.B. Khlebnikov. International Connections of the Soviet Ferrous Metallurgy and the Technological Progress of Ferrous Metallurgy in the member-countries of the Board of Mutual Economic Assistance, the "Stal" journal, 1967, No.10, p.875.

2/ Izolov, Deputy Chairman of the Council of Ministers of the People's Republic of Bulgaria, Chairman of the 34th session of the Executive Committee of the Board of Mutual Economic Assistance. Answers to a correspondent, Ekonomicheskaya Gazeta, May 1968, No.21, p.44.

It is also necessary to mention the "Intermetall" organization the experience of which may be useful for the developing countries. The members of the organization are Bulgaria, Hungary, the German Democratic Republic, Poland, the USSR and Czechoslovakia. The aim of "Intermetall" is to strengthen the cooperation of the member-countries of the Board of Mutual Economic Assistance in developing their production of rolled products.

Before setting-up this organization the exchange of rolled products between these countries was carried out on the basis of long-term trade agreements. It sometimes happened that some countries had a surplus of some types of rolled products while experiencing shortage of other types not envisaged in the agreement. "Intermetall" combines the long-term obligations with emergency deliveries over and above the plan and finds additional possibilities for the production and sale of rolled products.

The states participating in "Intermetall" carry out the deliveries of rolled products on the basis of the agreement for a quarterly exchange. Since 1965 wholesale exchanges are regularly established every three months and the volumes of deliveries of certain types of rolled products are agreed upon during these meetings.

The specialization of rolling mills and the development of cooperation between the iron and steel works of the member-countries of "Intermetall" make it possible to load the rolling mills more effectively. According to the calculations of Hungarian specialists the output of the mills in operation in Hungary, Poland and Czechoslovakia will increase as much as 3-7 pct and the cost price will decrease by 2-5 pct as a result of specialization.<sup>1/</sup>

#### 6. The Development of Iron and Steel Industry on a Regional Basis.

Among the developing countries there are many countries in which for some reason it is impossible to create the iron and steel industry on a national basis in the near future. In this connection it is necessary to take into account the low demand of the market and the relatively small population of many countries. Thus, for example, excluding India and the U.A.R. which have their national iron and steel industry and excluding Iraq, Algeria, Nigeria, the Philippines, Pakistan and Indonesia there are 52 more developing countries in Asia, the Middle East and Africa. About 320 million people live in these 52 countries or in other words the average for each country amounts to about 6 million people. At first light it seems there are difficulties connected with the transportation of raw materials and fuel over long distances. These, however, should not be in the way of realization of various projects of cooperation thanks to the modern development of means of transportation.

In this case it is promising from the economic point of view to construct metallurgical enterprises on a regional basis, i.e. jointly by a group of countries of the given region which do not produce steel. The construction should be carried out under mutually advantageous conditions and be subject to the approval and participation of the governments of the interested countries.

Such a form of the international division of labour as economic integration will enable the developing countries to solve a number of problems. They will be able to speed up the process of their economic development either directly or indirectly; they will be able to a certain degree to widen their domestic market which is rather limited at present; they will be able to centralize their home capital resources and to use them more effectively; they will be able to coordinate the volume of industrial production and the trends of its development with the requirements of the development of the whole region which embraces several countries and with the needs of the population of the region. The developing countries are making the first steps in attempts to coordinate their efforts in the field of industrial

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<sup>1/</sup> A. Zubkov, Master of economic sciences, "To-day of 'Intermetall'" . The "Kashdumrod-saya Zhizn" journal, 1967, No. 7, pp. 146-147.

development. They try to join their resources for constructing separate large enterprises which none of the states would be able to construct alone. Establishment of economic communities offers great possibilities for a stable and well-balanced economic development of the member-countries.

The successful construction and operation of the "Druжба" (Friendship) oil pipe-line can be cited as an example of regional cooperation which may be useful for the developing countries. The pipe-line was constructed and is operated by the member-countries of the Board of Mutual Economic Assistance, viz. the USSR, Hungary, Czechoslovakia, Poland and the German Democratic Republic.

At present in most of the developing countries the integration processes in the field of iron and steel industry are at the initial stage of investigations to establish the expediency of constructing iron and steel works in certain regions from the economic point of view. In this case it is possible to evaluate various projects of the volume of the output of the iron and steel works, of its composition, specialization and location. Thus, it is possible to construct an integrated iron and steel works in one of the member-countries of the community. There may be another version when only the main metallurgical shops, i.e. those for the production of iron and casting steel slabs and billets, are located in one country which has raw materials and a good system of transportation. Then the shops for rolling sections and flat products, for further processing and for manufacturing hardware are constructed in those countries where the consumption of certain types of rolled products is the highest. The question of how to establish the production of rolled products may be solved in a number of ways depending on the specialization of the shops which can produce flats and/or sections.

The concentration of the production of sections allows for lowering the cost of metal and at the same time it is possible to build rolling shops in a number of countries because section mills can work economically profitable even if their capacity is relatively small; certainly, at a larger works their characteristics would be better. In this case there appears a possibility to establish metallurgical production in several member-countries of the community.

As it has been noted it is more difficult to solve the question of the specialized production of strip, sheet and plate. Modern continuous hot-strip mills have a very high capacity and considerable economic advantages over reversing strip mills. There are also various ways of solving the problem of building cold-rolling shops, different shops for protective coating and shops for rolling narrow strip.

The process of integration is very difficult. It is necessary to overcome, in particular, the difficulties which may arise as a result of differences in the levels of economic development of the various countries intending to form a community.

All these and other questions should be solved in the course of detailed investigations with due consideration to the local conditions.

At the same time one should not exclude the possibility of constructing iron and steel works in the countries lying on the shores of seas and oceans, although sufficient resources of iron ore and coking coal may not be available in these countries. If they have convenient sea ports and if it is possible to ship raw materials and fuel from other regions at low freight charges, then constructing iron and steel works in these countries may prove justified from the economic point of view. The experience of Japan and Italy is very instructive in this respect. In the course of the last years they have greatly developed their iron and steel industry using imported iron ore, scrap and coking coal. One cannot but mention the fact that the development of sea transport and its relative cheapness allow the USA and Western Europe to make up the deficit of raw materials to a considerable degree by importing high-grade iron ore. At the same time they either have ceased developing their own iron-ore mining industry or slowed down its tempo.

Thus, the choice of correct and economically justified ways of developing the iron and steel industry in the developing countries depends on the proper solution of problems which are of both national and regional and even global character. It is this factor that explains, in particular, the attempts of the specialised agencies of U.N.O. to establish special groups of expert metallurgists to study not only the ways of developing the national iron and steel industry of the developing countries, but also the possibilities for cooperation of a number of developing countries in the field of metallurgical production.

#### 7. Difficulties in Establishing and Developing Iron and Steel Industry in Developing Countries and the Forms of Assistance of Industrially-Developed Countries

As it has been noted, in the developing countries there are favourable pre-conditions for establishing and developing the iron and steel industry both on a national and a regional basis. The process of establishing ferrous metallurgy, however, requires great efforts and mobilisation of resources. It takes a lot of time to prepare the sources of raw materials and fuel, to design and to build works and other projects, to train the workers, technicians and engineers, to overcome the limitations of the market and to make the latter wide enough, to develop the transport system and so on. It requires large capital investments as well. This process can be realized as an integral part of the general plan of industrialization, with the government bodies obligatorily taking part in it.

The development of the iron and steel industry in the developing countries is to a certain degree affected by the increasing competition for marketing the products of the iron and steel industry on the world market. This competition becomes especially severe during the periods of depression in the industrial production of the capitalist countries. In the industrially developed capitalist countries units of ferrous metallurgical enterprises systematically work under capacity. These factors affect the international market of ferrous metals. They affect not only the economics of the ferrous metallurgy in the capitalist countries, but also the processes of establishing and developing the iron and steel industry in the developing countries.

All these problems and difficulties in the development of the iron and steel industry must be solved and overcome for the sake of improving the welfare of the peoples and of ensuring a real economic independence of the developing countries. The questions of economic justification of constructing metallurgical works are extremely complex. This is especially true when it is necessary to analyze the assortment of products, the specialization of the works and the output of metallurgical production, the choice of the site for the works as well as the sources of supply of raw materials and fuel. Taking the above into consideration it is necessary to prepare the initial data on the sources of raw materials and fuel as well as on the expected metal consumption thoroughly and in detail. This work should be done before the beginning of the preparation of the initial reports on the project and the same so before the beginning of the preparation of technical designs of the metallurgical enterprises. If these data are not well-prepared, it may lead to expenditures unjustified from the economic point of view or even to mistakes in designing and constructing metallurgical enterprises.

Concrete recommendations on constructing new iron and steel works and developing the existing ones in the developing countries can be prepared as a result of performing special work and thorough investigations carried out in a separate country or in a group of countries of a certain region.

It should be noted here that the success of realization of any projects of either national or regional character is to a considerable degree dependent on the success of the mobilization of efforts and internal resources of the interested countries, on close scientific, technical and economic cooperation and mutual assistance of the countries.

At the same time the industrially developed countries should also play their positive role in some form. The USSR, for example, renders the developing countries of Asia and Africa economic and technical help in constructing iron and steel works in India (Bhilai, Bokaro, Asanama), in the U.A.R. (Helwan), in Algeria (Annaba), in Iran (Isfahan), in Ceylon, etc.

The approximate output of the iron and steel enterprises being constructed in the developing countries with the technique and economic assistance of the USSR is characterized by the following data, million tons a year:

Regions	Products	Iron		Steel		Rolled products	
		are to be built	are in operation	are to be built	are in operation	are to be built	are in operation
Asia		7.6	2.4	7.2	2.5	5.9	2.1
Africa		1.4	-	1.6	-	1.0	-
Total		9.0	2.4	8.8	2.5	6.9	2.1

The assistance rendered by the Soviet Union in constructing metallurgical enterprises in the developing countries embraces all the stages of capital construction. It includes preparation of technical and economic justification of constructing the enterprise, carrying out prospecting and designing work, delivery of a complete set of the equipment necessary for the project, sending Soviet specialists for rendering technical assistance in erecting the enterprise, installing and adjusting the equipment and operating the constructed units.

The Soviet Union renders technical assistance to the developing countries under the conditions of clearing, of long-term or commercial credits as well as with payment in hard or national currency.

In accordance with signed agreements and with established practice the foreign countries in most cases repay the credits granted by the Soviet Union with their traditional exports or with the industrial goods of their national enterprises.

This creates a guaranteed stable market for their products. The USSR does not demand that foreign countries should obligatory repay their credits in hard currency. This fact is of considerable importance.

The economic and technical cooperation of the Soviet Union with the developing countries is aimed at strengthening the independent national economy of the young nations.

This cooperation is based on the equality of the parties, on mutual respect for the national sovereignty, on non-interference in the internal affairs and takes into consideration the mutual interests of both the parties concerned. The Soviet Union does not strive to acquire property on the territory of the developing countries or to gain profits from them. All the projects which have been or are being constructed with the help of the Soviet Union remain the property of these countries.



