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United Nations Industrial Development Organization

Third Interregional Symposium
on the Iron and Steel Industry

Brasilia, Brazil, 14 - 21 October [illegible]

Agenda item 3

OBSERVATIONS ON MINI-MILLS[1]

by

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In spite of the generally accepted axiom that steelmaking and rolling costs decrease with the increasing size of the producing unit, mini-mills, producing mostly from scrap using electric furnaces, continuous casting, and hot-rolling comparatively small tonnages of 80,000 to 400,000/[illegible] tons per year, not only succeed in meeting the competition of large-scale bulk producers, but also even constantly grow in numbers wherever particularly favourable conditions exist and certain essential basic principles are observed.

In the author's opinion the further growth of mini-mills - particularly in developing countries - depends mainly on raw materials and power. Anticipating a tightening of scrap supplies in the future and taking into account the high economic minimum level of the direct-reduction processes already operating, his company, jointly with a consortium of mini-mill operators, has perfected and is starting up a direct-reduction process of a modular type suitable for outputs as low as 30,000 tons/year.

Another development described is a novel fume-collection system with an efficiency of more than 90%.

Based on experience gained by participation in the building or reconstruction of more than a hundred mini-mills, the author expresses his confidence in the future of this formula so long as it is realised that a mini-mill is not just a scaled-down large steelworks but is governed by specific economic, technical, organizational, and operational characteristics.

[illegible]
the future [illegible] [illegible], but since the first astronaut put his foot on the moon, the scale of our world has made an enormous leap forward, from the scale of our planet to the light years of the universe. In practical terms, our concept of dimension is undergoing fundamental changes in almost every field. Economic frontiers between nations disappear to give place to larger and larger super-states or federal unions, the small manufacturer is replaced by industrial combines employing mechanical mass-production equipment and methods, and in the world of steel an annual production of 250,000 tons, considered quite substantial 50 years ago, is dwarfed by today's concept of the 15 million tpy unit.

The bigger dimensions grow, the less can their development be left to chance, the more necessary it becomes to plan, compute, design, and project the world to come.

However, history and economic development does not always follow a script like a movie, but quite often just happens. In the world of steel one such "unscripted happening" is the emergence of small steelwork units - not at all conforming to the prevailing concept of a minimum size of millions of tons - which not only seem to fulfill a very important function under specific circumstances, but also frequently appear to be far more economically successful than their big "planned" brother.

These somewhat "out of norm" steel enterprises are mostly called MINISTEEL WORKS or MINIMILLS, expressions which have been in use for a few years, like "mini budgets", "mini wars", or "mini skirts".

We believe that the writers originally using this expression had [illegible] steel works in mind. However, the expression is used in so many varied ways that in order to avoid any confusion we think a clearer definition is necessary and therefore propose the following description:

A MINIMILL IS A PLANT PRODUCING STEEL FROM SCRAP, PIG IRON, AND/OR PREREDUCED PELLETS OR SPONGE IRON BY THE HIGH-POWERED ELECTRIC ARC FURNACE AND CONTINUOUS-CASTING PROCESS AND SUBSEQUENT ROLLING INTO RODS, SMALL AND MEDIUM BARS AND SECTIONS, AND NARROW STRIP AT ANNUAL OUTPUT RATES BETWEEN 80,000 TO 400,000/500,000 TONS.

Although the size still remains a major criterion, we believe that there exists a second essential element which gives minimills a specific identity and distinguishes them from the small first phase of a works eventually to become large.

In our experience and opinion, minimills have a definite function - and are usually successful - under conditions which are temporarily or permanently unsuitable for a large steel combine.

One example of such conditions has been Italy after the second world war. Owing to a number of particular circumstances, the country had tremendous possibilities of development and has, in fact, one of the most impressive European progress records of the last decade.

However, one of the most essential materials for this development was steel and the Italian steel industry existing after the war did not have by far the necessary capacity to provide the quantities of steel needed. Certainly, plans were made for the development of a large-scale Italian steel industry, and works like those at Taranto are among the most spectacular achievements of large-scale steel units of the last decade.

The financial organization of the considerable capital needed for the creation of large steelworks, their design, planning, building, and putting into operation takes many years and the progress of Italy would have been much slower if the industry had been made to wait for the steel of Taranto or the other long-term development projects of the big companies.

The consequently existing need for the quick availability of steel products motivated small- and medium-size enterprises all over the country to establish small steelworks, built at comparatively low cost in an unusually short time, to fill the existing demand for steel products - in brief, to set up ministeel works, of which about 50 exist in Italy today.

We are an Italian company and our own development over the last 20 years has been very much associated with the growth of the ministeel industry. The experience gained by the participation in the building and development of more than 100 minimills, by building or rebuilding about 150 rolling mills, more than 200 continuous-casting strands, and a wide range of ancillary machinery and equipment is the basis of the observations which we are offering as our contribution to the discussions of this meeting.

The situation underlying the growth of the Italian ministeel industry is only one example of particular conditions justifying the economic feasibility of the mini installation. Insufficient or very expensive means of transportation - especially in large developing countries - is another example, and need for vertical development as well as a variety of other circumstances can be other motives.

One aspect is common to most minimill operations: the particular conditions leading to their creation may be temporary only; therefore the more flexibility is provided in the concept of the original project, the better the possibilities to keep the initial investment usefully employed, if and when the conditions motivating the original scheme should change.

The main feature of a minimill is, of course, the product, the need for which is the motive for the creation of the works. In most cases minimills are producing small- and medium-size bars and sections - in some particular cases also flats and strip - but hardly ever other flat-rolled products like plates and sheets, as the equipment for their production is too expensive for a small output. The already mentioned flexibility as an essential criterion of the successful minimill applies particularly to the aspect of product. In many instances minimills operate very profitably next door to large-scale works, making the same products possibly at a lower cost, but the more flexible minimill can give better service and so compete successfully for a slice of the market.

During the last decade it was tried frequently to provide for maximum flexibility by universal-type rolling mills, which could be used for the production of the greatest possible variety of shapes and sizes.

This resulted in a comparatively low rate of plant utilization, i.e. capital investment, and, during the last few year , there has been a growing tendency to build minimills for highest possible plant utilization, i.e. a small range of products, but to provide in the layout for subsequent modification or enlargement of the plant in case changes in the market should make corresponding changes in the production programme and plant desirable or even necessary.

For instance, it is almost general practice today in the building of mini-bar mills to provide for a subsequent addition of a rod mill. It ought to be stressed, however, that these provisions for flexibility should neither entail any initially unutilized capital cost for future use nor compromise the compact layout essential for the economic minimill operation.

Another vital aspect of the planning and success of a minimill is the dimension. As mentioned in the foregoing, we maintain that particular conditions motivate the establishment and choice of product, and this applies also to the initial size of the works. However, the need for flexibility should also be taken into consideration in deciding the size of the establishment, and we believe that a voluntary limitation in this respect is a better safeguard for the continued economic success of a ministeel operation than the trend to aim at perpetual growth.

In many instances the success of mini operations depends on the lower transportation cost to a local market which is at a great distance from the nearest large scale producer. It is obvious that this advantage will exist only to the extent of the quantities which this local market can absorb, and any excess tonnages produced by the minimill will have to carry heavier transportation costs and to compete therefore with products of large works, which is not always easy.

It follows that the right dimension of a minimill depends primarily on the existing local conditions and might vary therefore greatly. A very recent variant of the species "ministeel works" reaching into the output level of 500,000 tpy and more seems to us rather a first stage of an eventual large-scale steelworks than a large form of a minimill.

In our opinion, the further growth of ministeel works - particularly in the so-called developing countries - depends on two factors: material and power.

In the definition of the minimill proposed by us at the outset, we quoted the electric arc furnace as the essential steelmaking unit. There are a number of other steelmaking methods that theoretically could be used for minimills: small blast furnaces with oxygen converters or cupolas melting down pig-iron or scrap for subsequent oxygen blowing and a variety of other processes. However, all these methods need additional materials [illegible] as coke [illegible] transform [illegible] raw [illegible] [illegible], they will need oxygen, the generation of which [illegible] absolute quantities of electric power. [illegible] availability of the required materials, we believe that the studies of projects of this kind so far have shown considerable disadvantages in terms of installation as well as of operating cost, as compared to the electric furnace alternative.

As steelworks are usually part of larger industrial complexes, it seems justified to assume that electric power is available. Ultra High Power arc furnaces in particular require a very large amount of electric power, the insufficiency of which creates problems for projects in various parts of the world, especially in countries with abundant resources of natural oil and gas.

A great deal of research has been carried out over the last decade to find steel-making processes which could make it possible to by-pass the transformation of natural fuel into electricity for subsequent electric steel-making, i.e. a method by which, for instance, iron ore could be transformed into steel directly, by using a natural fuel such as oil or gas. To the best of our knowledge no practicable process of this kind has emerged yet, and it seems to us that this system does not have the possibility to become of practical industrial use at least for the next decade.

The only process which might lead to a comparative independence from large electricity requirements, even for small operations, is the American developed S.N.R. process of magnetic separation of the iron particles in [illegible] for a combination of heat [illegible] by a powder metallurgical process. However, [illegible] pilot plant for the process has been in [illegible] 20 years, there still seem to be a great number of technical [illegible] to be overcome besides economic considerations.

Nevertheless, technical writers with an inclination towards science fiction believe this to be the steelmaking process of the future, and it may well be that a small-scale ministeel works might be the first practical productive application of this process which, in fact, would be a fundamental revolution in steelmaking since man started to make metal objects from metal-bearing minerals.

To some extent a first stage of fusionless metal segregation exists already with regard to the second central problem for the development of minimills, namely, the question of raw materials.

For all practical purposes most minimills existing at present are based on the use of steel scrap. Either they are placed in an industrial country with local scrap uprising or they import scrap from countries with an excess, but minimills are not the only users of scrap, and there are already very strong indications that within the next five to ten years there could be a severe shortage of steel scrap in relation to the then existing possible demand.

One of the reasons [illegible] steel industry, although scrap uprisings are, to a large extent, concentrated in industrial areas, big quantities arise in comparatively small batches spread over large areas. In view of the constantly increasing transportation costs, the collection of these dispersed uprisings becomes, therefore, extremely expensive, particularly with regard to scrap cars.

As a means of improving the efficiency of electric furnaces, the shredding of scrap - especially car bodies - preceded by their compression has been developed over the last decade, but the machines available so far for this purpose are profitable only for compressing large quantities, i.e. they are designed to operate in a fixed position, to which the scrap is brought for shredding or fragmentation.

In an attempt to facilitate collection and preparation of scrap, particularly for small operations, i.e. miniworks, we are working on the development of a mobile unit which can be moved from one to another small scrap-car depot to compress and shred small quantities at a cost which minimills can afford.

The second and, in our opinion, more important development with regard to the provision of inexpensive raw material for the ministeel works is sponge iron or pre-reduced pellets.

After being used on an industrial scale for more than 15 years in Mexico, it can be asserted today that direct reduction - electric furnace route is an established method of steelmaking, although there are other processes in use whose recorded performance cover too short a period of time to be judged as practical, while a great number of other published systems have not yet been put into practical use.

There are two aspects which still make the application of direct-reduced iron in ministeel works difficult. One of them is that the data published by works with more than experimental working results seem to indicate that for economic as well as technical reasons a furnace burden consisting entirely of sponge iron is not feasible but there must be a mixture of sponge and scrap.

The second point is that all direct-reduction processes which are operative at present have a comparatively high output level of economic feasibility of at least 150/200,000 tpy of sponge iron.

Taking these two points into account, it is evident that a ministeel works with, say, 150,000 tpy total steel production being able to use pellets only for part of the burden would not have the possibility of utilizing an independent direct-reduction plant and could therefore not afford to build one. Such works with small requirements have the possibility of purchasing reduced pellets from a pellet-making merchant plant, but their present prices are comparatively higher than scrap and, from the announced projects of planned merchant pellet plants, it does not seem likely that a considerable decrease of pellet prices can be anticipated in the near future. Consequently, it does not appear as if the use of purchased reduced pellets will be economically feasible for minimills for some time to come.

In some places, several ministeel works are investigating the possibility of joint ventures, but this, of course, is really feasible only if the minimills concerned are located fairly close to each other and are interested in different markets for their products. Companies who might have to compete with each other for the sale of their finished products are not the ideal partners for ventures of this kind.

Our close association with the ministeel industry over the last two decades and the resulting policy to respond - as far as it is feasible - to its particular needs has led to our co-operation with a consortium of Swiss and Italian ministeel companies in the development of a direct-reduction process particularly suitable for the small producer.

The plant for this continuous process comprises a number of shafts in which the iron ore is reduced into sponge iron by coal as the reducing agent under the effect of the heat generated in the heating chamber into which the shafts are set.

The system has enormous flexibility: the output capacity of one shaft is approximately 5,000 tpy and it is possible therefore not only to dimension the plant in accordance with actual requirements but also to provide for a subsequent gradual enlargement. The cost of the ancillary plant and the economics of the operation will probably impose an economically feasible minimum level - which we anticipate with approximately 30,000 tpy - i.e. six 5,000 ton modules - which can be built up at an almost standard pro rata cost once the minimill can absorb more sponge iron.

Like all direct-reduction processes, iron ore with a high Fe content is required, but contrary [illegible] the mine" ore within a certain [illegible], [illegible] fines, can be used and, being a primary [illegible] no prior treatment, has a lower cost than, for instance, green pellets, although the latter are also usable.

Contrary to expensive coking coal - as needed for blast furnaces - the process requires only a low, and therefore inexpensive, grade of coal and it is planned to investigate in the future the possibility of substituting coal with other reducing agents.

Versatility exists also with regard to the fuel used in the heating chamber for the generation of the heat needed for the reducing process. Fuel oil for natural gas can be used as well as coal or coke, although in the latter case the installation might need to become larger and also more cumbersome in operation.

The advantages of the system are obvious: its initial dimension can be adjusted to small works, the growth of which can be followed by easy enlargements; if suitable run-of-the-mine ore is available no ore preparation - pelletizing - is necessary, reducing agent is a cheap material, and the fuel can be adjusted to local conditions and availability.

An important aspect which is still in question, however, is the economics.

The process is not a new invention; it was already in industrial use for a period of time some years ago. However, [illegible] as well as operating practice have been rather [illegible] on account of the resulting high cost and the need to compete with comparatively low scrap prices this first operation was discontinued.

In order to establish realistic costs for plant as well as for operation under the use of various materials and at the same time to test the suitability of different burden, reduction, and fuel materials, we have built at our works at Hattrie a pilot plant comprising two shafts for a production of ca. 10,000 tpy of sponge iron and hope to have available by the end of this year a reasonable amount of operating and test data to be able to present proven information on feasible plant sizes, suitable materials, and capital as well as production cost.

The question of pellets brings us back to an aspect of the electric furnace which - although at present in its infancy - seems likely to become of extreme importance: the continuous feeding of the furnace burden.

One of the disadvantages of the minimill definition proposed at the outset is the cycle difference between the electric furnace and continuous casting and the resulting imbalance of plant and labour utilisation. Whereas it takes about one hour to cast a ladle of liquid steel into one or several strands of billets or slabs, the most efficient furnace still takes about two hours to produce the liquid steel, and the working of two furnaces in conjunction with one casting machine requires a very perfect fit of several factors which is not easily possible and avoided by most operators.

With regard to pellets, it must be taken into account, moreover, that they contain at least 7.5% non-metallic material and their use in the furnace burden normally causes a longer furnace cycle than for a 100% scrap burden.

Various ways have been found and are used to some extent to reduce the furnace cycle by preparation of the burden, such as compacting or shredding of scrap, preheating etc.; one of the most promising possibilities in this respect seems to be the continuous feeding of the burden, which eliminates not only the time lost by basket charging - which can be 15% of the total cycle time and possibly even more - but accelerates also the melting-down time in the furnace.

On account of the present high cost and limited availability of shredded scrap or reduced pellets, the continuous feeding practice is still in its infancy and very little experience data is available as yet. In addition, the presently predominant fume-cleaning systems using a fourth hole in the furnace roof cause a major difficulty, as it is neither practical to introduce the furnace feedstock against the stream of furnace fumes at high temperature and pressure nor is it considered feasible to put a fifth hole into the furnace roof.

This problem is not limited to ministeel works but is of particular importance to them, as optimum plant utilization and productivity are essential to their success. Our company has therefore devoted much attention to this question and we have developed a fume collection system which does not use the fourth hole of the furnace roof at all.

Through a manifold surrounding the furnace as well as the adjacent smoke-generating areas, a compressed-air curtain is projected towards the roof of the building which forces the fumes to a collecting hood from which they are evacuated through a suction head into a cleaning plant which can be of wet scrubber, dry bag, or any other type.

The principle of fume collection in a canopy in the roof of the building is not, of course new, but most methods proposing this system provide either collection of the fumes of the entire shop - which make them extremely expensive - or create very difficult working conditions.

As our system does not need expensive heat exchangers (essential for fourth-hole extraction), great attention has been given to the economy of its design; its cost compares favourably with that of other reputable fume-collection plant available at present.

The first catchment unit of this type patented in the USA, UK, and other countries has been working under conditions of industrial production since the beginning of 1973 around a 20 ton electric arc furnace and the results obtained over the first few months justify the anticipation that the system will be able to collect more than 90% of all fumes arising in a melting shop.

In almost all of our foregoing observations the question of economics has played some part, but we feel that, before concluding, something should be said about minimill economics in general.

We trust that quite a few authors will explain in great detail the rather absurd fact that the pro-rata capital cost and time of building of ministeel works can be half of that of a big conventional plant and that the economic welfare and prosperity of most minimills - even at times of depressed markets, when their greater brethren do not even manage to break even - seems to demonstrate their capability to produce and sell competitively.

A fundamental reason for the success of this type of steel enterprise is the realization that a minimill is not a scaled-down large steelworks but a type of its own, governed by its own specific technical, organizational, and operational characteristics.

An optimum plant utilisation, a rational layout providing for optimum handling conditions, and a compact management and labour force are some of them.

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