coal will have been used for electricity production in association with 25 000 to 70 000 tons of uranium. The latter prediction is very vague because of the uncertainty of the course of reactor development during the 1990's. However, it is considered that domestic uranium requirements will tend towards the lower part of the quantity bracketed.

These figures are based on a multitude of inter-related variables none of which can be given a firm value. The results of the calculations can therefore be considered to be only a rough first approximation to the future fuel requirements, within this country, for the production of electricity. Nevertheless, they do serve as a basis for future estimates in as much as the predictions can be modified at a later date to take account of differences which may arise in the future pattern of industrial and technical development.

ACKNOWLEDGEMENT

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Note: This paper will be included in the 'Proceedings of the Tenth International Symposium on the Application of Computer Methods in the Mineral Industry', which will be published in due course.

The future development of the iron and steel industry in South Africa

J. P. COETZEE **Published in the Journal, March 1971**

DISCUSSION

Dr. K. Gebhard

In his excellent and comprehensive survey on the future development of the Iron and Steel Industry in South Africa, Mr. Coetzee has also mentioned the direct reduction processes as a possible method of converting iron ore to iron.

Mr. Coetzee has made it quite clear that at this stage one should not consider these processes as a 'magic formula' which herald a 'break through'. I agree entirely with this point of view. Once upon a time I held the opposite view, but in the meantime I have revised my views. To do so, I had 40 years at my disposal.

In 1930 I had the privilege of being connected with the first commercial sponge iron plant in Germany[1] — a plant which was capable of producing 40 tons of sponge iron a day. We were determined to prove that the blast furnace would become obsolete in the near future. We considered it as an unnecessary detour to convert iron ore first into an iron-carbon alloy, which contained further quite a number of undesirable elements, and to remove this carbon by an endothermic process. Direct iron-making seemed to be a logical short cut.

Unfortunately, we were not able to establish this 'short cut', but the life of our sponge iron plant was cut short. We had solved all technical but not the economic problems.

Basically the positon is still the same today — mainly economic and to a lesser degree technological aspects determine the rate at which sponge iron plants are installed. More has been said and written than done about direct reduction plants. I think that there are two main reasons for this stagnation in the introduction of direct reduction processes.

The first reason is that modern blast furnaces are just too good and too economic ever to be replaced by direct reduction processes on a large scale. This, of course, already limits the field of application for direct reduction plants.

The second reason is that sponge iron production and utilisation is based on technical considerations, which increase not only the production cost of sponge iron but also the conversion cost to steel to such an extent that under special conditions only are direct reduction plants an economic proposition. Are these technical considerations still as forceful and valid today as they were when 'direct steelmaking' was first contemplated? The development of sponge iron production as a method of direct steelmaking came under serious consideration approximately 50 years ago. At that time the Open-Hearth Process was the backbone of the Iron and Steel Industry. Naturally sponge iron was considered as a low carbon input material for Open Hearth furnaces. It soon became evident that sponge iron was far from being an ideal input material for such furnaces. It oxidises rapidly when exposed to an oxidising flame and its heat conductivity is so poor that practically no heat penetration into a layer of sponge iron can be achieved. Thus sponge iron became feedstock for electric furnaces and this has strongly influenced the development of the sponge iron technology.

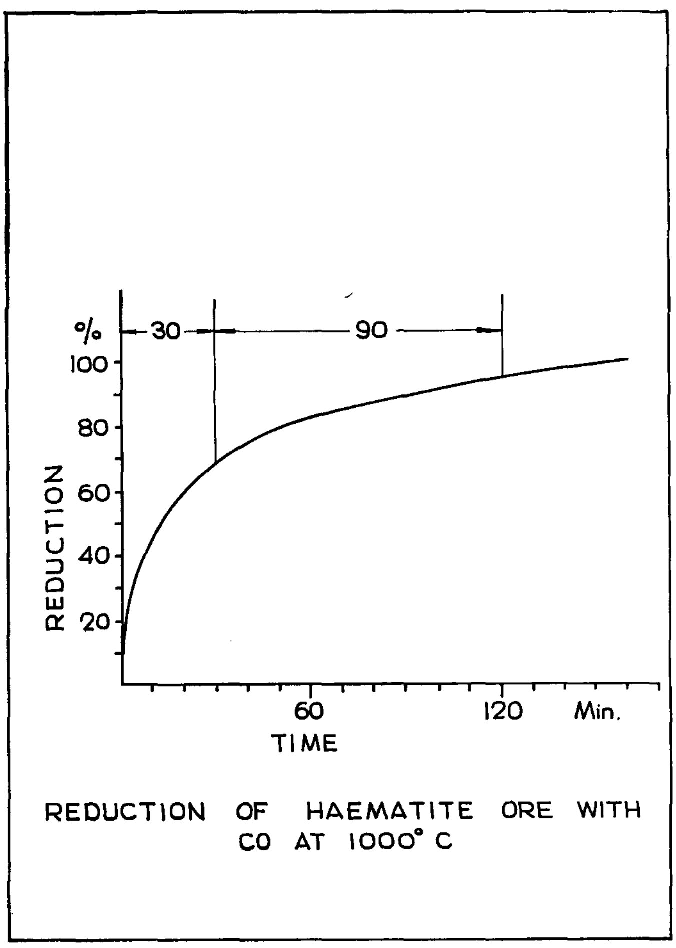

Fig. 1—Reduction of Haematite Ore with Co at 1 000°C

As an input for electric furnaces sponge iron has to comply with more stringent specifications than required for Open-Hearth operation. Their main aim is to keep the power consumption in the electric furnaces as low as possible. The iron content of the ore has to be as high as possible. It has been stated that the gangue content of the ore should not exceed, say 0,5 per cent. This, of course, increases the input cost to the sponge iron plant and excludes the use of lower grade cheaper ores. Further the degree of reduction has to be as high as possible, i.e. at least 95 per cent, otherwise the power consumption will increase unduly, because the final reduction has to be carried out in the electric furnace. If one looks at the correlation between the degree of reduction and reduction time of hematite ore — see Fig. 1 — it becomes quite clear that the degree of reduction has a strong economic impact on the production cost of sponge iron. Under the test conditions, the removal of the last 25 per cent of oxygen took three times as long as the removal of the first 70 per cent. The 'time scale' could be replaced by a 'cost scale'. Obviously the production rates and thereby the capital utilisation will increase substantially if one does not aim at a high degree of reduction. F. Meyer[2] of Krupps found that the production rates of a 110 m kiln would increase by 60 per cent and the coke rate decrease by 20 per cent provided the degree of reduction is lowered from 95 per cent to 80 per cent. The final reduction, if carried out at or above fusion temperature, will take only a fraction of the time which is required below fusion temperature.

To summarise, I have no doubt that great disadvantages for the case of sponge iron flow from the fact that sponge iron is made as a feedstock for electric furnaces. I feel that this can be avoided if we take the recent development in steelmaking, i.e. the oxygen refining processes into consideration. As is known, in oxygen refining processes, carbon is not an economic liability, but an asset. Bearing this in mind, I suggest an approach which differs basically from the hitherto accepted common concept. I suggest the production of high carbon sponge iron which after briquetting can be converted in a gas- or oil-fired hearth furnace into hot metal, i.e. into input material for an oxygen refining process. Thus the use of electric power can be completely eliminated and the conversion cost of sponge iron to steel will be drastically cut. If the final reduction does not require electric power, and if gas or oil can be used as a heat source and simultaneously the carbon content of the sponge iron can be used as a reducing agent and as fuel, then a lower degree of reduction can be tolerated. As outlined, this would result in a substantial decrease in the production cost of sponge iron.

The utilisation of ores with higher gangue contents would act in the same direction. The optimum values for the permissible degree of reduction and gangue content have to be determined for each set of circumstances.

It is well-known that economic disadvantages can arise from possible re-oxidation of sponge iron during transport and storage. The last 5 per cent to 10 per cent of reduction which is the most costly to achieve, can thus easily be lost. This can be avoided if the high carbon iron briquettes are further processed at the site of the sponge iron plant. Whether pigs should be shipped or conversion to steel and continuous casting be carried out next to the direct reduction plant, depends on local conditions. An attractive economic set-up could be a sponge iron plant coupled with steelmaking facilities and continuous casting near the source of raw materials whereby billets and/or slabs would be shipped to a rolling mill situated near the consumers' market.

Generally speaking, the suggested concept is a combination of steps well-known in the metallurgical industry. It follows the principle of the blast furnace process, where prereduction below fusion temperature in the shaft is followed by final reduction above fusion temperature in the hearth. It is, of course, an advantage of the blast furnace that these two steps are carried out in one unit, but the new concept has the advantage that refining to steel can be combined with the final reduction, which is carried out in a hearth furnace.

I am very pleased that Mr. Coetzee's paper has made it possible to make some comments on the subject of direct reduction. I shall be satisfied if I succeed by my remarks in paving the way for fruitful further discussions, which need not necessarily take place here and now. I think direct reduction, or to be more precise, sponge iron production for the direct production of steel by oxygen refining, is a topic which does not only fall in the domain of the Iron and Steel Industry of South Africa. I can see no reason why, by common and determined efforts, we should not succeed in making direct reduction plus oxygen steelmaking an economic proposition. Some of the vast resources of the country's raw material could then be used to greater advantage. Further, I should mention that exploratory discussions with parties outside South Africa revealed that such a development could also lead to the most desirable export of capital goods.

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AUTHOR'S REPLY

Mr. J. P. Coetzee

As I recollect, the various case studies on the application of direct reduction carried out at Iscor never gave a clear cut favourable answer and if I further take into account the fact that, despite numerous projects, only a few sponge iron plants are actually producing on a commercial scale, then I think that the new approach to the method of sponge iron production and its utilisation as suggested by Dr. Gebhard deserves our full attention.

Should it be possible by implementing his ideas not only to achieve a decrease in sponge iron production cost, but also to establish a cheaper method of converting sponge iron to steel, then a new approach to quite a number of problems would be possible. I have in mind problems in connection with existing Iron and Steel plants as well as with the establishment of new plants.

Not infrequently, integrated Iron and Steel plants are faced with an imbalance between the capacities of the various production units. Additional Fe-supply from a sponge iron plant at reasonable capital cost can play an important role here. The production and conversion cost of sponge iron will have to be considered for each set of specific circumstances.

Another interesting aspect, which was mentioned by Dr. Gebhard, is the possibility of deviating from the orthodox pattern of the fully integrated Iron and Steel plant, i.e. to locate sponge iron plus steel-making facilities on the one hand and rolling facilities on the other hand, on different sites. I am a strong supporter of this policy. In future the work will have to be brought to the main sources of labour. Ethnological grouping of people will play a prominent part in decisions to locate industries in certain areas. Bearing in mind the great impact transport cost has in South Africa on the production cost, one should try to optimise the relative location of the various units in regard to transport cost on raw materials, semis and finished products. I imagine that greater flexibility in this respect could flow from an approach as suggested. This could lead to a most desirable decentralisation of industry.

A review of the tenth international symosium of the application of computer methods in the mineral industry

G. H. Morton

The tenth international symposium on the application of computer methods in the mineral industry (APCOM) was held in Johannesburg in April; the first time it had taken place outside North America. In the technical sessions fifty-seven papers were presented, providing a review of current work and including some important original contributions. These papers and a full account of the discussion at the symposium will soon be published in a single volume.

The Technical Programme

The first session of the symposium included an opening address given by Mr J. W. Shilling, President of the Chamber of Mines of South Africa, and a keynote address by Mr K. F. Lane of the Rio Tinto Corporation Limited.

Mr Shilling spoke about the history of the South African mining industry and about some of the work of the Chamber of Mines. He stressed the importance of the symposium in familiarising those in mining with computer applications, and expressed his hope that it would stimulate and inspire scientists and engineers in the effort to develop safer and more economic methods of mining.

Mr Lane, talking about economic and financial modelling, gave a fascinating account of the experience of RTZ over the last twelve years. In a very honest appraisal of the substantial progress that had been made, he confessed some disappointment not only in the cost and