SPOTLIGHT
on an excursion to Southern Cross Steel

by P. N. HARRIS*

On 23rd November, 1982, a party of 80 members of The South African Institute of Mining and Metallurgy left the Wanderers Club grounds at 07h00, and were driven in two luxury coaches to the stainless-steel mill of Southern Cross at Middelburg. Southern Cross is a trade name adopted by MS & A (Middelburg Steel and Alloys), who operate two Alloy Divisions (at Middelburg and Krugersdorp) and one Steel Division (at Middelburg). Although the tour groups were too large to permit an in-depth study of the equipment and processes, a valuable impression of the country's stainless-steel industry was gained.

Stainless-steel Mill

The initial Southern Cross stainless-steel mill was built in Middelburg at a cost of 12 million rands in 1965–1966. This mill was based on ingots that were hot-rolled on a 3-Hi hot mill to produce 19 000 t of 'hot rolled' plate and up to 4000 t of cold-rolled sheet per annum.

The new Southern Cross stainless-steel mill of MS & A, which cost 150 million rands, has an annual melting and slab-casting capacity of 200 000 t, and is geared at present to produce about 40 000 t of hot plate and 24 000 t of cold-rolled sheet and coil per annum. This plant incorporates sophisticated, modern process equipment. The stainless-steel production facilities at Middelburg feature full thyristor control of d.c. drives, full computerization, and automated line control. The equipment of the hot-rolling mill is the first of its kind designed with a single-stand reversing Steckel mill with coilers on either side. Since these coilers are enclosed in reheating furnaces, long lengths of coil can be rolled from continuous cast slabs of up to 16 t in mass down to gauges suitable for subsequent continuous cold rolling. The cold-rolling and pickling section incorporates a novel sodium sulphate electrolytic pickling process. Pollution control is achieved by sophisticated air-purification systems. The meltshop practice is illustrated in Fig. 1.

Whereas in the past ingots provided the feed stock to the hot-rolling section, the new practice is to use large continuous cast slabs, which not only give a high yield but also permit the production of large continuous coils of cold-rolled material. Fig. 2 illustrates slab grinding, walking-beam furnace heating, and the rougher Steckel mill. The product from the hot mill is either plate or hot band. The latter is likely eventually to be a cost-effective feed stock for overseas stainless-steel mills. For the steel to be brought to the correct metallurgical condition, it has to be annealed after rolling. Owing to the film of oxide that forms on the surface of the metal, this steel

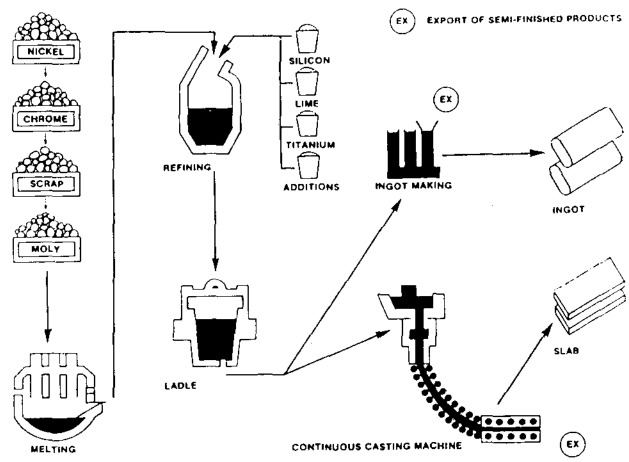

Fig. 1—Flowsheet of stainless-steel meltshop

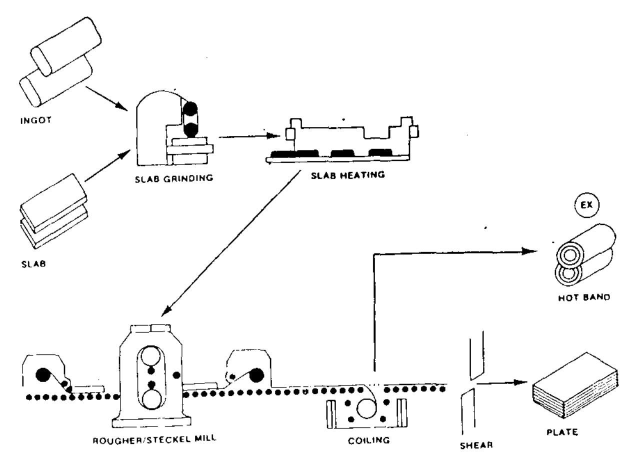

Fig. 2—Slab preparation and hot-mill rolling operation

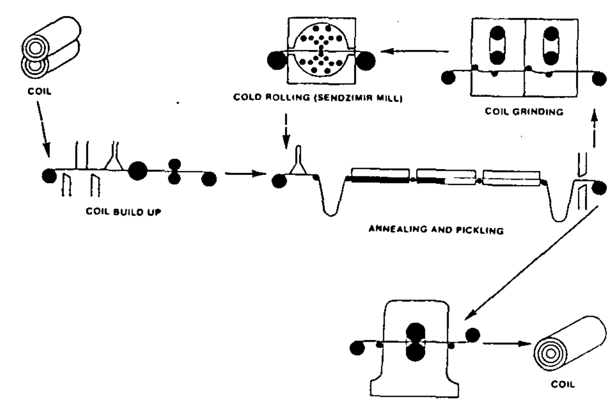

Fig. 3—Cold-rolling of stainless-steel mill

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has to be pickled, spot conditioned, and finally levelled in a stretcher–leveller machine before being sheared to the final plate size.

Fig. 3 illustrates the cold-rolling section of the mill, where coil is cold-rolled to size on a Sendzimir mill, which comprises a pair of small rolls backed up successively by a number of other pressure rolls. Annealing and pickling are undertaken in-line, and the final surface finish is given to the material by a skin-pass on a 2-high rolling mill before final coiling.

Ferrochromium

The world's largest reserves of chromium ore occur in the Bushveld Complex, which lies wholly within the Transvaal. This very large basin of igneous rock is estimated to contain 3100 Mt of chromium ore down to a depth of only 300 m, and represents more than 80 per cent of the total known world reserves.

In 1981 South Africa produced 2,87 Mt of chromium ore valued at 86,3 million rands, of which over 40 per cent by mass was exported in the raw state and earned approximately 53 million rands. However, chromium ore has a much greater significance for South Africa than merely as a raw material since it is the basis for a large and rapidly expanding ferrochromium industry capable of producing approximately 800 000 t of ferrochromium per annum valued at 570 million rands. Present sales are about 250 million rands per annum. Despite South Africa's large reserves of chromite, this material was formerly regarded as being suitable only for the production of chemical and refractory products, and was not considered suitable for the production of metallurgical-grade ferrochromium.

Transvaal chromium ores are available in very wide seams, up to approximately 2 m thick, as against the deep, narrow seams in Zimbabwe. However, Transvaal ores are of a friable nature, as opposed to the lumpy metallurgical grades mined elsewhere, and also have the disadvantage of low chromium-to-iron ratios. In the reduction of chromium ores, the iron content is reduced preferentially, which causes a problem in the production of low-carbon ferrochromium from low-grade chromite.

To ensure the correct metallurgical and corrosion-resistant properties in a stainless steel, it is essential that the final steel should have a low carbon content. Initially, low-carbon ferrochromium had to be used for the production of stainless steels. The introduction of the AOD (argon–oxygen decarburizing) process in the mid sixties provided a simple and cost-effective method of reducing the carbon content of ferrochromium alloys. In this process, the oxidation of much of the chromium metal to chromium oxide is prevented by a lowering of the partial oxygen pressure in the reacting vessel through the introduction of argon gas. The use of the AOD process has resulted in a marked decrease in the demand for low-carbon ferrochromium, and most ferrochromium producers in South Africa are now producing only high-carbon ferrochromium.

Manufacture of Ferrochromium

Basically, there are two processes for the production of high-carbon ferrochromium. In the conventional process used by the Middelburg Steel and Alloys Group, Samancor, and Tubatse, lumpy chromium and chromite fines, briquetted together with binders such as lime and molasses, are charged to a submerged-arc furnace. Reducing agents such as coke and coal are charged to the extent of approximately 15 per cent in stoichiometric excess. Slag-forming agents such as quartz and dolomite are added to the furnace, which operates at a temperature of approximately 1650 to 1700 °C. After smelting and reduction, the liquid ferrochromium is cast and subsequently crushed in jaw crushers to produce material having 50 to 54 per cent chromium, 3 to 7 per cent silicon, 6 to 8 per cent carbon, and less than 0,03 per cent phosphorus and sulphur. After sizing, this material is packed and sent to primary stainless-steel producers around the world. The power consumption in these processes is 3,7 MW per ton of alloy, which represents approximately 20 per cent of the total cost. The conversion yield per chromium unit is approximately 85 per cent.

The slag produced contains unreduced chromium oxide, together with about 2 per cent of the chromium metal (as prills that have not been separated from the slag). This slag has been approved as a building aggregate but, so far, has not been used in any quantity for this commercial application.

New Developments in Ferrochromium

So far, the largest-capacity furnaces used are 48 MVA furnaces, which deliver between 35 and 37 MVA of useful energy. In the mining of South African chromite, approximately 60 to 70 per cent of the chromite is produced as fines smaller than 2 mm, which are currently dumped, and only 30 to 40 per cent is considered as lumpy material having a size of 10 to 125 mm. Whereas both briquetting and pelletizing have enabled the industry to use the fine material, new developments in the use of fine chromium and fine coal are directed towards the use of d.c. plasma smelting. In this process, the chromite, coal, quartz, and dolomite can all be fine in size, since the basic principle of plasma smelting is to ionize the gases, which can then come into intimate contact with the burden and produce very high temperatures of up to 25 000°C.

Currently, MS & A is capable of producing 240 000 t of ferrochromium per annum, which is approximately 30 per cent of the South African production capacity of 800 000 t/a and approximately 15 per cent of the annual world production of 1,6 to 1,7 Mt of ferrochromium. MS & A plans to utilize plasma smelting as a means of increasing its production capacity in the future.

Stainless Steel

Stainless steel is not one alloy, but a family of over 56 commercial alloys, many of these being variations of certain basic types. In the broadest sense, it is a steel that has been rendered resistant to attack by environmental agencies and by a broad range of chemical media. Passivity to corrosive attack is achieved by the addition of chromium to the steel. A chromium content of 10 per cent confers a high degree of resistance to corrosive attack although, in more corrosive environments and at higher temperatures, greater chromium contents are necessary. This ability of suitable additions of chromium to render a steel 'stainless' is due to the ultra-rapid formation of a thin impervious layer of chromium oxide upon the surface of the metal. This film is similar to the hard protective oxide layer produced by the anodizing of aluminium but, unlike aluminium, is self-healing in the atmosphere. When the nature of the attacking medium is more corrosive, other elements have to be added to secure the desired degree of passivity, the major elements being molybdenum, nickel, and copper. Other elements such as nitrogen, aluminium, silicon, and titanium are added to the steel for various specific purposes.

3CR12 Steel

In organizing this tour, the Excursion Committee Chairman, Peter Harris, was prompted by the strong impact that MS & A's new 3CR12 steel has had on the mining and metallurgical industry, and this was borne out by the party's interest in the manufacture and uses of this exciting new product.

Whereas the prime value of 3CR12 to the mining industry lies in its corrosion-resistant properties, it has now found good applications in instances where wet abrasion is a problem. Tests conducted by the Chamber of Mines have shown that there is a marked difference in the performance of various metals under dry abrasive conditions and under wet abrasive conditions. Previously, abrasion had been perceived only in isolation, and the mines had used harder metals in an attempt to solve their abrasion problems. However, it is now realized that corrosion is also a dominant factor in wet abrasive wear, especially in the mines, where very aggressive acidic waters of low pH, and high chloride and sulphate contents, are prevalent.

In addition, recent experience in the South African mining industry has shown that the metal's resistance to corrosion enhances its slideability in ore-handling applications. This can often lead to an increase in payload.

The steel is not claimed to be a panacea for all the abrasive and corrosive ills usually encountered on the mines. However, it is felt that, in carefully chosen and proven applications, there are definite benefits to be gained from its use. The major breakthrough with 3CR12 is in terms of its excellent weldability. Other ferritic stainless steels have very poor properties after welding, but 3CR12 shows neither a loss of corrosion resistance nor a loss of toughness.

With 3CR12 steel, South Africa is now leading the world in the development of a range of corrosion-resistant chromium-containing steels aimed at replacing materials such as coated carbon steels in areas where corrosion or the combination of corrosion and abrasion leads to the rapid deterioration of carbon steel. It is believed that these developments will ultimately result in the exportation of large quantities of South African ferrochromium to overseas steel mills for final processing to plate and sheet. These developments are of particular importance to South Africa since they greatly increase the revenue that was formerly derived from the selling of chromium ore overseas. An important point to note is that, with the exportation of ferrochromium or of semis, South Africa is also exporting derived energy, which is favourably priced compared with the rest of the world.

The Visit

After touring the mill (Figs. 4 and 5), the party was entertained to a very well-prepared luncheon at the Middelburg Country Club. Various speakers from the Institute, after detailing points of interest in the tour of the mill, were unanimous in their thanks to Southern Cross for a well-planned and most illuminating tour. Our secretary,

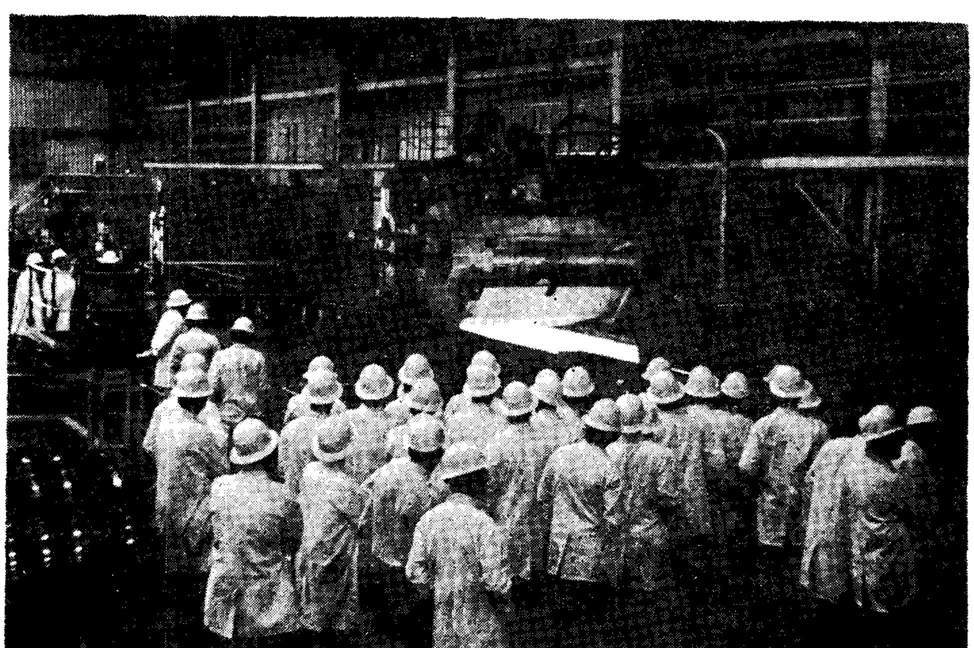

Fig. 4—Stainless steel emerging from the hot mill

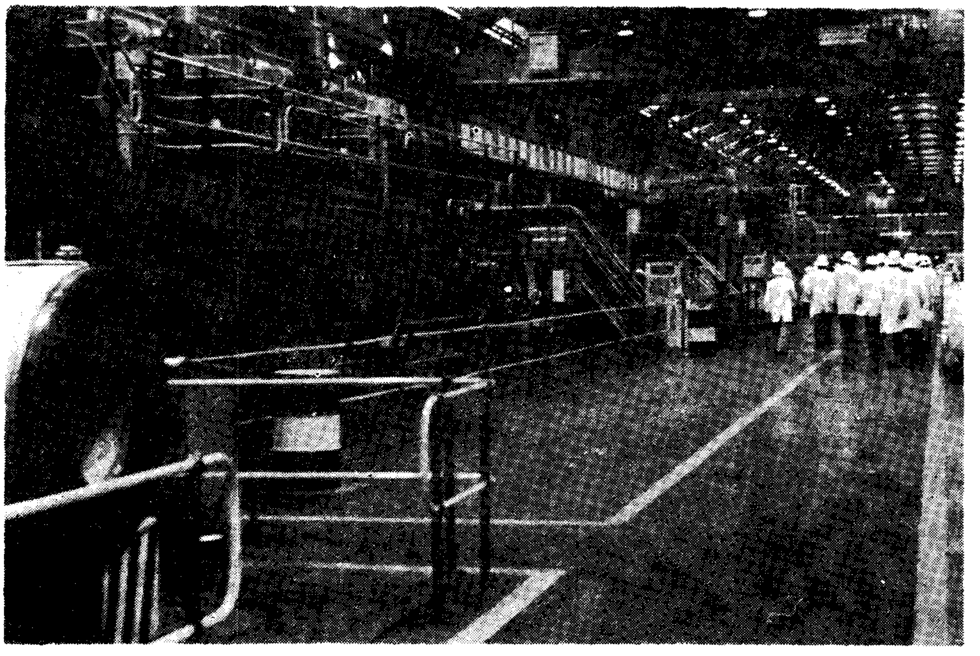

Fig. 5—Processing line (1 km in length) for stainless-steel coil

Judith Money, and Southern Cross P.R.O., Sue Muir, are to be congratulated on their excellent arrangements. A great deal of the success of the visit must be attributed to the ground work done by John Freer of the Excursion Committee, together with Don Maxwell, a director of MS & A, ably assisted by John Furze and Clive Thomas, who went out of their way to treat the party royally. Judging from comments on the bus, members all gained a valuable insight into the intricacies of special-steel manufacture, and a better appreciation of its importance to the country as a whole.

METAL '83

The International Precious Metals Institute has scheduled a seminar on the platinum-group metals for Williamsburg, U.S.A., on 10th to 13th April, 1983, and has announced its keynote speakers for each of the seminar's five sessions.

Mr Derek Dumenil, Johnson Matthey PLC, will present a global appraisal of PGM in the first keynote talk, followed by an expert from South Africa, who will discuss the extraction of PGM from primary and secondary sources.

On the second day of the seminar, Mr Edward D. Zysk of Engelhard Industries will discuss how the unique properties of PGM lead to unique uses. The keynote speaker for the fourth session, Dr G. J. K. Acres of Johnson Matthey PLC, will discuss PGM in catalysis.

The final session is devoted entirely to the economics of PGM. Mr John Treat of the New York Mercantile Exchange has entitled his keynote address 'Investment Trends in Platinum and Palladium'.

A field of international experts, who will represent an in-depth view of PGM in industry, is being assembled for the seminar. Each keynote address will be followed by several supporting talks and a question-and-answer period.

IPMI is an international association of miners, refiners, producers, users, research scientists, mercantilists, governments, and the general precious-metal community, formed to encourage the exchange of technology and information such as the publishing of data and statistics, to conduct educational meetings, and to continually seek the more efficient use of precious metals.

A complete programme of the seminar is available upon request. Interested persons can contact IPMI, 2254 Barrington Road, Bethlehem, PA 18018, U.S.A., for a programme and further information.

Metec '83

METEC – the International Exhibition for Metallurgical Technology and Equipment with Congress – which was to have been held in Dusseldorf from 14th to 20th May, 1983, has been cancelled, and will probably take place in *June 1984*.

Sampling

Sampling and sample preparation are crucial activities in many areas of chemical engineering, in the energy and food industries, in metallurgical processes, and in mining and mineral engineering.

Two new courses in the University of Leeds' Continuing Education programme, now available from the Department of Mining and Mineral Engineering, are designed specifically for those practitioners concerned with the taking and preparation of samples for analysis. By providing a variety of practical exercises all taken from real situations, the courses provide the essential information necessary for confident sampling techniques. The Course Tutor will be A. G. Royle, B.Sc., F.I.M.M., M.A.I.M.E.

Both courses present the mathematical content in the simplest terms and reduce the nomenclature to a minimum. Members will receive a full set of course notes but are advised to bring a pocket electronic calculator.

The Design of Sampling Programs

5th to 7th September, 1983

The object in the taking and preparation of samples is, after beginning with a mass of material weighing anything up to several hundred thousand tons, to end with a few grams of powder that have the same chemical composition as the original material.

The sampling process is never perfect, and errors occur at each stage of mass or size reduction. The objective of the course is to show how these errors can be calculated, so that safe sample-preparation procedures can be designed. Some of the nationally recommended sampling standards are examined, often with curious results. A section of the course is devoted to statistical considerations, particularly to the detection of bias.

The topics covered include:

- Sampling and precision
- Gy's sampling theory
- Ash in coal
- Sulphur in coal
- Iron ores
- Gold and precious-metal ores
- Coarse, free particles and alluvials
- Safety sampling
- Statistical tests
- Sample splitting
- Avoiding sample-preparation errors.

Sampling from Moving Streams

7th to 9th September, 1983

Sampling from a moving stream of material, e.g. solids on a conveyor belt or in suspension in a flowing pulp, is one of the safest ways of taking a sample if it is done properly.

The course first discusses correct procedures for the sampling of moving streams. It next moves on to show how much information can be obtained from the sample data, and how to quantify the errors made by assuming, for example, that the mean of the samples is the mean value of the material in the stream (it is usually not the standard error of the mean).

Sampling techniques such as random, regular, and random stratified sampling are considered and their effects quantified. Methods of examining fluctuations in flowrate and composition are studied in detail; the variogram is an indispensable tool for this purpose, and the whole system is put on a computerized basis – for which programs are made available.

The following areas will be explored:

- Correct sampling
- Correct and incorrect sampling devices
- Variations in quality and mass
- The variogram
- Types of variation
- Stationarity, non-stationarity, and periodicity
- Experimental determination of the variogram
- Modelling the variogram
- Regular, random stratified, and random sampling
- Determination of estimation errors
- Simultaneous variations in mass and quality
- Computer programs.

Further information on the two courses is obtainable from the Director of Continuing Education, Department of Adult and Continuing Education, The University, Leeds LS2 9JT, England.