Chairman's Summary—Section 6

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In his paper, Mr Featherstone locates the vast bulk of South African manganese-ore deposits in the Kuruman—Postmasburg area of the north-west Cape, and gives the estimated reserves of the three types discussed by him as being Hotazel 3 x 10^6 t, Wessels 50 x 10^6 t, and Mamatwan 50 x 10^6 t proven, but 200 x 10^6 t probable plus a possible further 400 x 10^6 t.

Typical analyses of the three types of South African ore are presented, together with analyses of other classified types for comparison. The major interest is centred on the Mamatwan ore because of its vast reserves. Mineralogically it is composed chiefly of braunite, with smaller amounts of manganite, hausmanite, and hematite. The gangue consists mostly of calcium and magnesium carbonates, with an absence of MnO_2. From the chemical analyses of the three ores and the assumption that Hotazel and Wessels ores evolved geologically from Mamatwan without the formation of new minerals, an approximate mineralogical composition is calculated for the three ores.

Although smelting with Wessels ore had not yet been carried out, the similarity in chemical analyses to Hotazel suggested that its characteristics would be very similar. Taking the three South African ores two at a time and basing calculations on purely theoretical smelting-balance considerations, six graphical representations are given of metal weight, % Mn in metal, and slag-to-metal ratio against the ore-mix compositions employed. From these, it is immediately evident that Mamatwan ore is *not* a suitable source of Mn for the production of high-grade 40 per cent MnO slag, while, even for 20 per cent MnO slag, maximum production is favoured by minimum amount of this ore in the mix. Furthermore, the CaO+MgO content of Mamatwan is ill suited to the production of silicomanganese. It is suitable as a refining agent for the production of low- and medium-carbon ferromanganese, but this application consumes only small amounts of ore. Owing to the enormous reserves of Mamatwan ore, it is important to establish whether it can be processed to a form suitable as a feed to electric furnaces for the production of high-carbon ferromanganese or whether any process can be found whereby the ore can be utilized successfully in its raw form.

In spite of adverse reports from Australia and Japan on trials with sintered Mamatwan ore as a primary feed to a furnace producing high-carbon ferromanganese, a trial was duly conducted at Metalloys, Meyerton, on the ore sintered at Iscor Vanderbijl Works. The test is described in detail and compared with operation with an ore burden. The operation with a sinter burden was unsatisfactory, the differences, compared with operation on ore, corresponding closely to those reported on similar trials in Australia.

Mr Featherstone suggests that the very properties that render Mamatwan ore unsuitable for processing in the electric furnace are desirable for its processing in a blast furnace under South African conditions: these are the highly basic CaO+MgO content, which will render the burden self-fluxing, and the absence of MnO_2, which will give a lower temperature of the off-gas. Mamatwan ore has, in fact, been smelted successfully for many years in Iscor's No. 2 blast furnace at Newcastle, in Natal.

Research is required to improve blast-furnace practice in the production of ferromanganese and to evaluate the use of form coke and anthracite as a substitute for metallurgical coke, reserves of which are very limited. The volume and temperature of the top gas can be reduced by oxygen-blowing, and, at the same time, production is increased and the coke rate reduced.

In electric-furnace ferromanganese, silicon is usually below 0,2 per cent, whereas in blast-furnace metal it is about 0,7 per cent. However, with increased heat reserve afforded by oxygen injection and employing a higher basicity, silicon contents below 0,2 per cent in blast-furnace metal are a distinct possibility.

To date, only old pig-iron furnaces have been used for the blast-furnace smelting of manganese ore. In a blast furnace designed specifically for ferromanganese, the stack height can be substantially reduced to perhaps 10 metres when Mamatwan ore and oxygen blowing are used – this resulting in added capital savings in the ancillary equipment. Metal could well be produced at twice the present rate and for half the cost, which is surely sufficient incentive to develop and bring such a process to economic viability.

Dr Clark has given us a detailed and comprehensive report on the production of ferrosilicon—chromium by the single-stage process on two 17,5 MVA furnaces at Rhodesian Alloys in Gwelo. A technical description is also given of the furnaces.

The alloy is an intermediate product for the manufacture of low-carbon ferrochromium by the Perrin process, and is also sold direct for use in stainless-steel production. The alloy typically contains 36 to 38 per cent chromium or over 39 per cent chromium, with silicon in the range 40 to 46 per cent and carbon below 0,05 per cent.

The raw materials – chromium ore, quartz, and coke – are sized to 25 to 150 mm, 20 to 150 mm, and 15 to 40 mm, respectively, and are used undried as received. All raw materials are of exceptionally high quality: the chromite contains Cr_2O_3 in the range 46 to 50 per cent with Cr/Fe ratios of 2,26 to 3,71; the quartz consists of 98.7 per cent SiO_2; and the coke contains only 12,0 per cent ash.

The raw materials and recycled revert material are weighed out to an accuracy of ±1 per cent and fed to the furnace in electric charging machines, which are also used to spread the charge and poke when necessary. Smelting is carried out at a load of 15 MW, with secondary electrode voltages in the range 160 to 175 V and current about 62 kA. Tapping is carried out every 2 h 40 min with a steel drill and steel bar to open the hole. Oxygen-lancing is employed only in case of difficulty. Metal and slag are tapped into firebrick-lined ladles, and the slag overflows into a slag ladle. The metal plus some slag is then poured

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into another ladle, from which the metal is teemed through a fireclay nozzle set in the bottom of the ladle side. The alloy is collected in cast-iron moulds via a tilting tundish, which enables the last material, which is contaminated with carbides, to be rejected for eventual recirculation to the furnaces.

Dr Clark gives the bases on which charge calculations are made, the material and power consumptions per tonne of alloy, and a host of other useful information. The low power consumption in the range 6700 to 6750 kWh per tonne of alloy reflects the advantage of using optimum-sized, high-quality raw materials in an operation that is evidently carried out in a well-managed and efficient manner.

In conclusion, Dr Clark gives intriguing information on the value of comparative thermodynamic calculations in determining the quantitative expected effect of a number of operating variables. He cites four examples, viz, the separate effects of varying Cr and Si contents in the alloy on power consumption and daily production rate, and the effect, on the latter two parameters, of minimizing alloy losses by entrainment in the slag and silicon losses by evaporation from the furnace. He has drawn attention to a field in which further attention may well yield unexpected dividends.

In his interesting and informative paper, Dr Way has carried out a detailed analysis from statistical data of Western World production of stainless steel and chromite ore, capacity and production of ferrochromium, and prices of high- and low-carbon and charge chromium, and he has used the data to forecast trends up to 1980 and 1985. In summarizing his paper, it is not possible for me to more than touch upon some of the salient points.

The U.S. Bureau of Mines lists 15 varieties of ferrochromium under high-carbon (including charge chromium), medium-carbon, ferrosilicon—chromium, and low-carbon. In the U.S.A. in 1971, about 65 per cent of chromite ore consumed went to the metallurgical industry, and the percentage of high- and low-carbon ferrochromium consumed in the manufacture of stainless steel was also 65 per cent.

In 1971, world production of chromite was 6,3 million tonnes, the U.S.S.R. and South Africa being the major producers – but South African ore is unfortunately low-grade at 44 per cent Cr_2O_3 and Cr/Fe of about 1,5, resulting in much research being carried out to beneficiate the ore or to develop a metallurgical process suitable for its direct use.

The price commanded by low-carbon ferrochromium of 55 per cent Cr on the basis of new pence per kg of contained Cr is virtually the same as that of the 68 to 70 per cent Cr variety owing to the lower melting-point of the former, which renders it suitable for melting in the induction furnace. But the price of low-carbon (0,03 per cent C) ferrochromium is approximately twice that of the cheapest variety, viz, charge chromium at 55 per cent Cr and 4 to 8 per cent carbon.

The Western World capacity for ferrochromium output was about 2,3 x 10^6 t per annum at the end of 1972, but production was only 66 per cent of this at 1,5 x 10^6 t. South Africa's capacity constituted only 12,6 per cent of the total, and actual production comprised only 55 per cent of this capacity. Of the total ferrochromium output in 1971, it was estimated that it was split roughly 50:50 between high- and low-carbon ferrochromium.

There is a strong correlation between U.S. consumption of ferrochromium and production of stainless steel, the correlation coefficient being better than 98 per cent for the years 1955 to 1972. Dr Way compares the estimated figures for the whole Western World, at the same time differentiating between high- and low-carbon in the consumption of ferrochromium. He concluded that, although a warning was sounded in 1962 that, owing to the introduction of oxygen blowing, etc., in steel-making, there would be a swing from low- to high-carbon ferrochromium, it had in fact taken a decade for this trend to become apparent. This was due to the time required to perfect the new metallurgical processes and to the reluctance of manufacturers to scrap existing plants until their large capital cost had been amortized or their operation had become inefficient.

In 1971, the estimated consumption of ferrochromium in the Western World was 868 000 t, of which Japan used the most, at 32,5 per cent, followed by the U.S.A., at 26,4 per cent.

For the period 1960 to 1970, the growth rate of total ferrochromium consumption in the Western World was 10,9 per cent. While U.S. authorities are predicting a growth rate beyond 1975 for ferrochromium consumption of 15 per cent per annum, Dr Way prudently suggests that a growth rate of 12,1 to 12,5 per cent should be used, corresponding to a growth rate of 10,4 per cent per annum for stainless-steel production. In 1971 to 1972, the ratio of high- to low-carbon ferrochromium consumed increased from 1 to 1,56. A Japanese authority has forecast that this ratio will tend towards 10:1, and, assuming that this is reached by 1980, Dr Way presents graphs of the calculated demand for low-carbon ferrochromium for varying rates of increase up to the maximum. He concludes, however, that the initial fall in the demand of low-carbon ferrochromium, which will bottom in 1978, will tend to recover towards the end of the 80s and then increase.

In analysing the prices commanded by low- and high-carbon ferrochromium, it is found that the price differential between them and charge chromium is 12,8 pence (69 per cent more) and 14 pence (81 per cent more), respectively. In spite of the swing to high-carbon ferrochromium, the demand for low-carbon ferrochromium remains brisk, and every fall in its price has also been reflected by a fall in the price of high-carbon.

Dr Way forecasts an increase in demand for ferrochromium from 1,1 x 10^6 t in 1972 to 1,5 x 10^6 t in 1975 and 2,7 x 10^6 t in 1980. He points out, however, that there is at present a gap of about 50 per cent between production and capacity, and, unless this gap is allowed to narrow, producers may find themselves in an unenviable position by the 1980s.

In South Africa, the annual production of ferrochromium in 1972 was 173 300 t, amounting to 60 per cent of the estimated capacity of 290 600 t. The annual growth rate of production from 1964 to 1972 was 7,9 per cent. Of the 1972 production, 20 000 t was used internally at Southern Cross, Middelburg, while the 152 000 t exported constituted 14 per cent of the Western World's consumption of 1,1 x 10^6 t in that year. The estimated capacity for ferrochromium production in South Africa and Rhodesia together was 491 000 t per annum at 1973, which constituted about 21 per cent of the total Western World capacity.

In conclusion, it is noted that prices increased sharply in the U.S.A. in mid-1973, including the low-carbon grade, owing to a shortage of ferrochromium in the face of strong demand. This was ascribed to the change-over to argon—oxygen decarburization in the manufacture of stainless steel not taking place as rapidly as expected.