Chairman's Summary — Section 1

by J.P. KEARNEY*

In his plenary lecture, Dr Juji Nasu gave an historical review of the development of the various methods of stainless-steel smelting with particular reference to the increasing use of charge chromium to provide the amounts of chromium in the stainless steel. He stated that in Japan the average usage of low-carbon ferrochromium is now only about 1 kg per tonne of stainless-steel ingot, implying that the usage of charge chromium is almost 200 times greater than that of low-carbon ferrochromium. Dr Nasu stressed one important difference between the VOD vacuum process and the AOD process, pointing out that sulphur removal in the former was extremely difficult and charge chromium of low sulphur content would be required. He stressed that sulphur removal in the AOD vessel was effected by adding silicochromium to form a reducing slag, followed by blowing with argon gas to cause stirring of the metal and slag.

Dr Nasu made a passing reference to the production of ferritic stainless steels in Japan by the use of molten iron direct from the blast furnace, which is desulphurized first in a ladle and then blown in an LD vessel for the elimination of carbon and phosphorus. This is followed by oxygen blowing in a second LD vessel after the addition of the required ferrochromium.

On several occasions Dr Nasu emphasized the need for low-sulphur ferrochromium, with particular reference to the AOD process.

The electric-power consumption per tonne of ferro-alloys in Japan brought out the interesting point that, in the production of high-carbon ferrochromium, the power consumption had fallen from 5500 kWh/t in 1955 to 3500 kWh/t in 1973. Of the 32 furnaces producing high-carbon ferrochromium in 1924, 20 have transformer capacity not exceeding 10 MVA, while 11 have transformer capacity not exceeding 5 MVA. It would be interesting to know what factors have contributed to this marked reduction in power consumption as obviously it has not been due to the use of fewer and larger furnaces. A figure of 3340 kWh/t of ferrochromium is quoted for a monthly period of 1973 using a 25 MVA furnace, but apparently no prereduction of the charge was involved.

In Japan, the air-pollution problem from ferro-alloy furnaces is regarded seriously, the national emission standard calling for not more than 600 mg/Nm^3 when producing alloys with more than 40 per cent silicon, and 400 mg/Nm^3 for alloys with less than 40 per cent silicon. Venturi scrubbers, Tyzen washes, and bag filters are now commonly employed, wet separators being used in closed-top furnaces and the bag filters for open furnaces, particularly those employed for the production of high-carbon ferromanganese.

Dr Nasu reported that glass-fibre bags are being employed in the gas-cleaning plants because of the higher gas temperatures.

*Amcor Ltd, South Africa.

In the papers by Y. Otani and K. Ichikawa, and by E. Lankes and W. Boehm, a horizontal rotary kiln is the heart of the process, while the new development from Simon Carves is a vertical kiln with annular discharge.

All three of these papers laid heavy emphasis on the increasing need to be able to treat fines as contrasted with lumpy ore, and are thus of particular interest in this country, where the chromite as mined contains such a high proportion of fines. There are two interesting aspects of these pelletizing techniques. On the one hand, if it is assumed that the fines must be ground to permit efficient pelletizing, then the idea of prereduction becomes highly attractive, provided the reductant can be satisfactorily incorporated in the pellets. High temperatures are required in the kiln to bring about reduction (possibly 1350 to 1450°C), but excessive metallization of the pellets cannot be tolerated owing to the marked changes in the electrical characteristics of the solid burden in the submerged-arc furnace.

Direct pelletizing of the ground fines can be effected with the addition of small amounts of binder, producing mechanically strong pellets that have probably been significantly oxidized during the burning. It is known that oxidation with the resulting breakdown of the spinel structure in the chromite ore yields a material that is much more chemically reactive and more easily reduced. Provided the burning temperature is sufficiently controlled to prevent the formation of significant quantities of liquid phase, the pellets may constitute a charge that will reduce more easily in the submerged-arc furnace and yet produce no marked changes in the electrical characteristics of the solid burden.

From the long-term technological viewpoint, great interest attaches to the Japanese paper on prereduced chromium-ore pellets, which reports the results obtained on pilot-scale tests using either a grate and rotary kiln or a shaft and rotary kiln capable of producing 6000 tonnes of pellets per month. No figures are given for the amount of reductant incorporated in the pellets, but it is stated that 30 per cent of the carbon in the pellets is lost by combustion during the firing. In addition, the degree of reduction is said to be controlled to less than 70 per cent. This is necessitated by the fact that a higher degree of reduction makes for difficulties in the operation of the submerged-arc type of furnace.

Power consumption is reduced to about one-half of that obtained in conventional smelting. In addition, it is claimed that the total equivalent fuel consumption in this process is lower than in the conventional smelting process.

Finally, the recovery of chromium from the ore into the alloy is stated to be up to 95 per cent. This is a remarkably good performance, and is probably a reflection of the greater ease with which the ground chromite in the pellets reacts and also dissolves in the slag. A significant proportion of the loss of chromium in the slag in normal operation is in the form of undissolved particles of ore.

In contrast with the use of prereduced pellets as described by Mr Otani, the paper by Messrs Lankes and Boehm dealt with the application of the LEPOL process for the production of burnt pellets made from finely ground chromite ore, bentonite being used as the binder. The LEPOL process consists essentially in a combination of travelling grate and rotary kiln, the green pellets from the disc being dried on the grate by the hot exit gases from the kiln and then being fed to the kiln.

The plant, erected at the Weisweiler factory of G.f.E., comprises a 'Double Rotator' grinding mill, preceded by a drying chamber. Ore containing up to 10 per cent moisture is dried and ground to plus 10 per cent on a 90 micron sieve. The authors report that a specific surface of 2000 to 2500 cm^2/g (Blaine Index) is required, and this involves a power expenditure of 14 kWh per tonne. Prior to entering the kiln, the pellets are relatively weak and, even when heated to between 700 and 800°C on the grate, have a compressive strength of 10 kg per pellet with a 1 per cent addition of bentonite. Maximum temperatures in the kiln are 1300 to 1500°C, and at the discharge the compressive strength of the pellets was 250 kg with a porosity of 30 to 35 per cent. The strength of the pellets at room temperature is critically dependent on the rate of cooling after discharge from the kiln, normal cooling in air reducing the strength by half.

In the plant, the pellets fall from the kiln into the cooler over a transfer chute, the cooler also consisting of a chain grate rotating in a casing.

Abrasion of the pellets in the kiln and on cooling must obviously play a highly significant role in the behaviour of the charge in the submerged-arc furnace, a figure of 4 per cent abrasion being quoted in the case of pellets burnt at 1350°C. The planned capacity of the plant is 250 tonnes per day, the dimensions of the kiln being 3,0 m in diameter by 18 m long.

The final paper in the session, presented by Mr R.F. Jennings, discussed the application of a vertical annular kiln to the firing of pellets made from chromite-ore fines. The main claim made for the vertical annular kiln is that it is ideally suited to capacities in the range 50 000 to 500 000 tonnes per year, kilns up to 10 m in diameter being in operation.

The base of the kiln is positively driven, the inner wall being either separately driven or free to rotate by friction with the pellet charge. The outer wall, which forms a rubbing seal with the base, is free to rotate, the centre of the rotation of the base being offset relative to the vertical walls and so facilitating discharge of the fired pellets.

The fired pellets are discharged through a cooler, which is used to preheat the air for combustion. The firing temperatures are about 1350°C, the top temperature being limited by the need to prevent slagging on the outer surface of the pellets.

As in all processes of this type, the quantities of fines produced are of first importance, the claim being made that, for pellets with a crushing strength of 40 kg, the total dust produced is less than 0,5 per cent, but to obtain this strength the ore fines must be ground to at least 60 per cent minus 200 mesh.

Heat requirements are stated to be 1,821 million kJ/t without any heat recuperation. With full heat recuperation, it is claimed that this could be reduced to 0,984 million kJ/t, final requirements being supplied by the combustion of the exit gases from closed-top smelting furnaces.