SESSION II

April 24, 1989

Chairmen: B.P. Watson, The Ferroalloys Association - USA
M. Sciarone, The Ferroalloy Producers Association - South Africa

Introductory Address:
"Perspective on the Special-Metals Industry" - R. Walsh, Senior Vice President, Allegheny Ludlum Corporation - United States.

*1. **"Pre-Reduction of Fluxed Chromite Ore Pellets Under Oxidizing Conditions"** - N.A. Barcza, Council for Mineral Technology - South Africa.

*2. **"The Production of Ferrochrome by the Smelting Reduction with Top and Bottom Blowing Converter"** - M. Fujita, Japan Metals & Chemicals Co., Ltd - Japan.

*3. **"The Reduction of Chromite Spinels by Solid Carbon and by Carbon Dissolved in Liquid Alloys"** - R.H. Eric, University of the Witwatersrand South - Africa.

*4. **"DC Technology for Smelting Furnaces"** - S.E. Stenkvist, ABB Metallurgy AB - Sweden.

*5. **"Open-Bath Production of Ferrochromium in a DC Plasma Furnace"** - H.J. Kammeyer, Middelburg Steel and Alloys, Ltd. - South Africa.

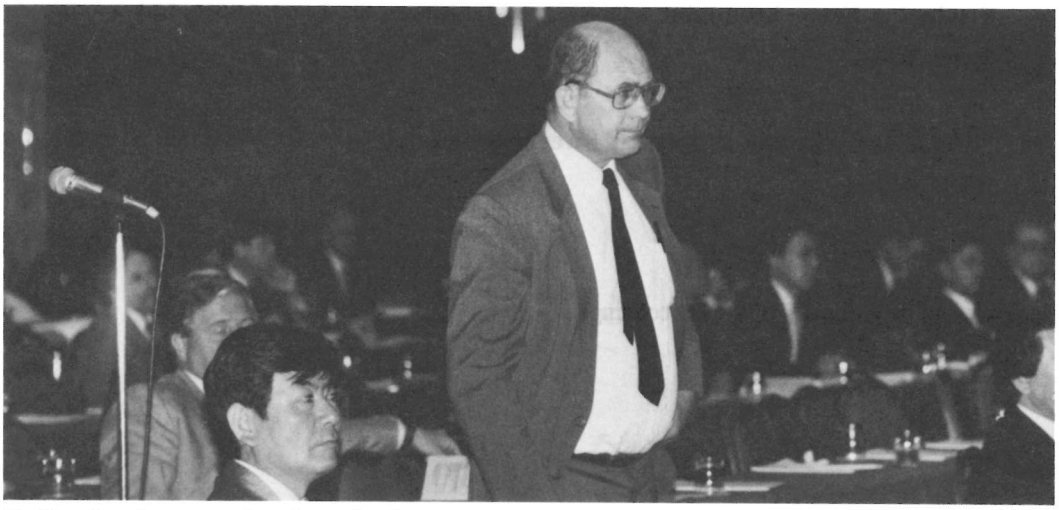
*6. **"Reactions and Phase Relationships in a 16 MVA DC Arc Plasma Furnace Producing Ferrochromium"** - D. Slatter, Middelburg Steel and Alloys, Ltd. - South Africa.

*8. **"The Plasmachrome Process at SwedeChrome AB"** - A.B. Wikander, SwedeChrome AB - Sweden.

*Papers are found in Volume I of the Proceedings

Session II *Speakers (left to right) are B.P. Watson (Chairman), R. Walsh, N.A. Barcza, M. Fujita, R.H. Eric, and M. Soiarone (Co- Chairman).*

Lunch on the first day of technical sessions.



D. Kozak asks a question from the floor.

SESSION II - DISCUSSION

"PERSPECTIVE ON THE SPECIAL-METALS INDUSTRY"

Q. B.P. Watson. Does Allegheny Ludlum have a program with their ferroalloy suppliers to improve quality, etc.?

A. R. Walsh. There is a vendor quality control group within our quality control organization. It reports to me. They work hand-in-glove with the purchasing department, and they are in fact charged with quality programs working with our suppliers. The people who work in production and in the technical department on process metallurgy jointly form teams, which is a common way of doing things in Allegheny Ludlum, also to work with suppliers. That is partly how that complex computerized control system was able to be built. I would add one other thing, we are now receiving specifications from our customers where I occasionally see something that is down in the parts per billion. We have not been unaccustomed to reading about parts per million and dealing with that, so it is not getting any easier for any of us fellows. Somehow, together, we have to learn to cope with that.

Q. J. Hall, Highveld Steel - South Africa. Mr. Walsh mentioned that 94% of the steel at Allegheny was continuously cast. The 6% that isn't, is that because of logistics or is it because of technical product reasons?

A. R. Walsh. The answer to that is yes. Some part of it is due to logistic reasons, if for no other reason occasionally you do have to take a casting shop down for maintenance. That being like real estate, the first three rules of a successful caster are maintenance, maintenance and maintenance, just like location, location and location works for real estate. The other honest half of that answer is there are some of those strange grades we make that we simply don't know how to cast yet, but we are working on it.

"PRE-REDUCTION OF FLUXED CHROMITE ORE PELLETS UNDER OXIDIZING CONDITIONS"

Q. C.N. Harman, Ferro Alloys Corporation - India. I should like to know what is the quantity of ferrochromium required for coating the pellets?

A. N.A. Barcza, Council for Mineral Technology - South Africa. Of the order of 10% is the mass of the coating on the pellet.

Q. C.N. Harman. Does it mean 100 kilograms per ton?

A. N.A. Barcza. Yes

Q. C.N. Harman. How would that come out in the cost?

A. N.A. Barcza. Ferrochromium is recycled to processes anyway, because during the handling of ferrochromium during the crushing, fines of the order of 10% to 15% are normally generated. Instead of recycling these fines back to the conventional submerged arc furnace, or melting them in the plasma furnace one can use them to coat the chromite pellet itself. Therefore, in fact, it is only a recycling operation. You are not actually having to pay for the ferrochromium. It is rendering a useful function, perhaps more useful, than just recirculating back to the furnace.

Q. B.P. Watson. Have you projected cost benefits for this process?

A. N.A. Barcza. Although we did mention the fuel energy savings of the order of fifty U.S. dollars per ton of ferrochrome, the fact that you are attaining a much higher level of metallization than conventional processes achieved to date implies a far greater output of metal product. We are getting from the order of 60% of metallization up to 80% of metallization, and therefore, this is about a 25% increase in output. This in fact has a very major cost benefit to the over-all production cost of ferrochromium. The costs we have conducted, of course, are confidential, but I can assure you that the benefits are very materially there.

"THE PRODUCTION OF FERROCHROME BY THE SMELTING REDUCTION WITH TOP AND BOTTOM BLOWING CONVERTER"

Q. J.M. Knegt, Metalur Mecanica SA - Brazil. Was consideration given to the slag viscosity?

A. M. Fujita, Japan Metals & Chemicals Co., Ltd. - Japan. In answer to your question, he says that viscosity was best about 1.0. Viscosity ratio is expressed by the ratio of CaO to SiO_2. The best result was at that ratio.

Q. K.S. Chopra, Elkem Metals Company - USA. Some slides showed the transmission mode; what is the source he used? Was it petrographic or electron microscopic technique?

A. M. Fujita. In order to take those pictures, he prepared very thin layer of around 5 microns. It was polished and then placed on the microscope with light from the bottom and took the picture from the top.

"THE REDUCTION OF CHROMITE SPINELS BY SOLID CARBON AND BY CARBON DISSOLVED IN LIQUID ALLOYS"

Q. J.H. Downing, Elkem Metals Company - USA. In a regular furnace what percentage of the chromium is reduced in the solid state, and what is reduced in liquid?

A. R.H. Eric, University of the Witwatersrand - South Africa. The mechanism of the completely solid state reaction can only be applied to the pre-reduction that we do in the rotary kilns.

Q. J.H. Downing. Why couldn't that happen in the shaft of a furnace?

A. R.H. Eric. The liquid state mechanism is interesting because it happens at 1600°C. It starts with reduction in the liquid state, but it turns into a solid state reaction. It is very difficult at this stage to say what percentage would be in the liquid state and what percentage would be in the solid state. It appears that the liquid state reduction process switches into solid state within a very short period of time. Up to 40% reduction occurs in the liquid state and the rest in the solid state at 1600°C. We have never reached reductions greater than 70% to 75% in this case.

Q. D. Slatter, Middelburg Steel and Alloys - South Africa. Would you comment on the fact that the carbide is determined as being M_7C_3 at a carbon level of 6%? Because at 6% at equilibrium it should rather be the $M_{23}C_6$ carbide.

A. R.H. Eric. That is what we expected initially. First we more or less proved that it is M_7C_3 carbide simply because we have the peaks from the x-ray defraction, and second the electron probe microanalysis done at Mintek showed that the carbon content corresponds to the M_7C_3 carbide. So there is something strange going on through-out this production process. We are contradicting the iron-chromium-carbon phase diagram, but definitely we have seen M_7C_3 on the x-ray as a dominate phase, and the microprobe analysis proves it.

Q. B.P. Watson. Does this advancement result in a better chrome process?

A. R.H. Eric. It should in principle because we have now more or less understood and described the solid state reduction. We have the mathematical formulation which, although not 100% satisfactory, our collegues in industry perhaps could modify and make use of. So in principle it should result in a better process.

"DC TECHNOLOGY FOR SMELTING FURNACES"

"OPEN-BATH PRODUCTION OF FERROCHROMIUM IN A DC PLASMA FURNACE"

"REACTIONS AND PHASE RELATIONSHIPS IN A 16 MVA DC ARC PLASMA FURNACE PRODUCING FERROCHROMIUM"

Q. A. Saraf, Ferroalloys Corporation - India. What is the total power consumption required per ton ferrochrome in the DC Plasma Furnace?

A. H.J. Kammeyer, Middelburg Steel and Alloys, Ltd. - South Africa. These figures, of course, get very close to the cost of our production and we are not to keen to give them away, but I can indicate as the process is not utilizing the heat that is normally being utilized in preheating the burden in a submerged arc furnace, you can expect that the energy consumption will be higher, and it is in practice like that and energy consumption of over four megawatt hour per ton of alloy is at this point in time achieved.

Q. A. Saraf. Does it vary for the chromium content being 50% to 54% and from 60% to 65%?

A. H.J. Kammeyer. It does not vary significantly on the 50% to 54% chromium content, although the 50% to 54% content is affected by the silicon and carbon content of the metal, so the silicon reduction that takes place affects the energy consumption. We have not really got much experience on the higher Cr content metals.

Q. D. Butcher, Union Carbide Management Services - Zimbabwe. One of the authors indicated that the plasma type furnace should be 60% to 80% of the capital cost of a conventional furnace installation, and I would like to ask Mr. Kammeyer if he would comment on that, whether they found that in their experience?

A. H.J. Kammeyer. I am not in a position to give you a total answer on this question. Because with the up-grading of the furnace it was not a question of putting in totally new equipment. But our feeling is that the capital cost will be very much the same as for submerged arc furnace and DC Plasma furnace.

Q. M. Sciarone, The Ferroalloy Producers Association - South Africa. Mr. Stenkvist, you made the statement of 60% to 80%. You have an opportunity to comment also because of the difference.

A. S.E. Stenkvist, ABB Metallurgy AB - Sweden. On the equipment side, we are on the DC furnace, of course, faced with a cost savings in the area of the transformer because we are looking at the high voltage, low current situation in the case of the DC furnace. A high current installation costs a lot of money. Of course you have to add to the total picture the cost of the rectifiers, but again here you can operate this furnace with a higher power factor, and there is also savings because of this. You do not generate as much reactive power in such a furnace, and consequently the need for a reactive power compensation is much less in a DC furnace. So on the total picture I think furnace plus reactive power compensation should be this much less for the DC furnace.

Q. R.C. Urquhart, Fenco Lavalin - Canada. What is the electrode consumption for the DC furnace?

A. H.J. Kammeyer. A value of less than two kilograms per megawatt hour can be achieved on the furnace.

Q. R.C. Urquhart. What was the life of the refractory lining for the 16 MVA furnace before a complete lining rechange was required?

A. H.J. Kammeyer. The first lining that was installed failed after almost nine months of operation. It was then redesigned. The second lining stayed in for just over two years, about two years and four months. The third lining was taken out with the up-grading of the furnace after 18 months of operation. But we are confident that refractory life, which depends of course on the design of the furnace, of more than three years is possible on the furnace.

Q. R.C. Urquhart. What do you project with the 40 MVA furnace in terms of power consumption, lining life and electrode consumption?

A. H.J. Kammeyer. We have only operated now for four months. The life, of course you have got to express in terms of the production that you put through the furnace as well, and also the power that is going through the hearth. In the redesign of the furnace we have taken that factor into consideration. So we feel that the refractory hearth is exposed to the same power throughput as that of the old furnace, so hopefully that will not affect the refractory life. Going up in current, of course can increase electrode consumption. We are going over to higher grade electrode and we feel with a 550 millimeter electrode of the higher grade, electrode consumption of the order of two kilogram per megawatt hour is still possible.

D. Slatter. I want to comment further about the lining life. When we did that dig-out I referred to in February, 1987, we were somewhat concerned about an area of the lining near the taphole and we thought it would be an appropriate time to take it out and see what was happening inside that furnace. In fact, when we dug that furnace out, we found that the lining was actually in remarkably good condition, as you could see from that one cross section I showed. There had been some eating down into the wear lining part, but none into the back-up lining. In fact, we think that that progression into the wear lining probably happens fairly early on. You establish a stable equilibrium and then proceed beyond that.

Q. C.N. Harman, Ferro Alloys Corporation - India. Why do you have to use a graphite electrode why not Soderberg type?

A. H.J. Kammeyer. In the process with the closed furnace the open bath conditions to get your electrode baking to take place and also to feed all the material through the center of the electrode we have never really seriously considered the Soderberg. We think it is really essential for this operation to use graphite electrode.

C.N. Harman. But the hollow electrodes are used in calcium carbide operation where the feed of fines is done through the electrode.

Q. M. Sciarone. Mr. Stenkvist, I think you made the suggestion that one should use Soderberg electrodes. Would you like to comment on it?

S.E. Stenkvist. In my paper I mentioned the possibility of using Soderberg electrodes, but that refers only to the possibility of a submerged electrode operation. With a free burning arc I think we have to stay with the graphite electrodes. If for nothing else, for the heat gradient situation that you have in the electrode itself.

"THE PLASMA CHROME PROCESS AT SWEDECHROME AB"

Q. M. Sciarone. On a few occasions you charge iron ore. Is there any metallurgical reason for that, because the price is usually determined by chrome units you sell and not by iron unless you get some money for your iron?

A. A.B. Wikander, SwedeChrome AB - Sweden. Sweden has a boycott and we are not allowed to import South African ore. We have a contract for ferrochrome with 52% Cr charge chrome. We have also found that we have a very stable movement in the shaft by using iron ore.