SPOTLIGHT

on the South African–German Seminar

by L.B. MCRAE*

The following papers were presented at a seminar that was organized by the SAIMM and held at Mintek during 1991. The occasion was a visit by 12 members of the Committee for Metallurgical Fundamentals of the Verein Deutscher Eisenhüttenleute.

Microstructural phenomena occurring during reduction of transition metal oxides by Professor W. Plushkell, Technical University, Clausthal

The early stages of reduction of transition metal oxides with hydrogen or carbon monoxide were investigated by hot-stage *in situ* microscopy. It was found that the growth of metal particles on the surface of oxides is governed by a linear growth law. Two reaction models were developed.

Measures to avoid sticking in fine ore reduction by Professor D. Neuschütz, Technical University, Aachen

The factors influencing the sticking behaviour or iron-ore fines during metallization were investigated. The influence of carbon deposited on ore particles from CO-containing gases on the sticking of the particles was investigated.

Overview of current pyrometallurgical research at the University of the Witwatersrand by Professor R.H. Eric, University of the Witwatersrand

Over the past decade a number of studies have been undertaken on the carbothermic reduction behaviour of chromite ores from the Bushveld Complex. The studies can be grouped according to the temperature at which the work was carried out. The first investigations were performed at relatively low temperatures (1250°C to 1400°C), and were aimed at improving the understanding of the pre-reduction behaviour of ores before smelting. Further investigations were carried out on prereduction in the presence of fluxes such as silica. These involved a higher temperature (1300°C to 1500°C), and it was found that the fluxed prereduction of chromite at 1500°C results in more than 90 per cent metallization. The third group of investigations were directed towards the refining of ferrochromium and the production of stainless steel.

Laboratory experiments on smelting–reduction according to processes occurring in smelter–gasifiers and iron-bath reactors by Professor K. Koch, Technical University, Clausthal

The reduction behaviour of iron oxide melts in alumina crucibles at 1550°C was investigated. Carbon monoxide was used as the reducing gas. The effects of top-blowing, bottom-blowing, and the injection of carbon monoxide, as well as the use of solid carbon, were studied. The formation of foaming slags was seen to hinder the reduction reactions. The use of solid carbon gave the highest reduction value.

Cokemaking technology for the future by Dr K. Wessiepe, Ruhrkole AG

Coke will be needed worldwide in the next decade for the ironmaking industry. The production routes must be environmentally compatible, preserve resources, and be cost-effective. To this end the German cokemaking industry has developed and has successfully applied the 'New Design'. A new future-orientated cokemaking system of 'Jumbo' coking reactors (GVR) designed to meet ever-increasing demands, especially safety, will be developed within the framework of the Europäische Entwicklungszentrum für Kokereitechnik, which was founded by Ruhrkole AG with the participation of various European companies.

The development of a coal-blending model for the optimization of coke properties used in the blast furnace by Mr W.H. van Niekerk, Iscor Ltd/University of Pretoria

The relationships between coal properties, the strength of coke, and the performance of a blast furnace were investigated by means of correlation studies, and a linear programming model was developed for the production of a coal blend based on these relationships. The unique feature of this approach is that it utilizes a knowledge of the minimum blast-furnace coke requirements, rather than the maximum attainable coke quality. The model predicts the least-expensive coal blend that will still comply with the minimum coke-quality requirements of a blast furnace. The study also confirmed the existence of a relationship between the rank and the caking parameters of coal, and the hot strength of coke.

Kinetic aspects of chromite ore reduction with coal by Professor D Neuschütz, Technical University, Aachen

Laboratory investigations were carried out on the reduction of chromite ores by coal at temperatures from 1200 to 1500°C. The reduction sequence of iron, chromium, and silicon was studied, as well as the formation of complex metallic, spinel, and slag phases. The role of silica addition in the reduction of chromite was also studied.

* Mintek, Private Bag X 3015, Randburg, 2125 Transvaal

Prereduction of chromite ore by Dr M.J. Niayesh, Mintek

The conventional route for the production of 'charge chrome' via submerged-arc smelting consumes approximately 4MWh per ton of alloy.

An alternative route for the production of ferrochromium was investigated involving the utilization of furnace off-gas for preheating and prereducing the chromite in an externally fired shaft kiln.

A mathematical model was developed to describe the reduction of composite pellets in the controlled atmosphere of the reduction chamber of an externally heated shaft kiln. Experimentally determined kinetic heat-transfer data were used, and the general equation for transient heat generation and transfer was approximated and solved numerically.

A bench-scale shaft furnace was developed, and the experimental results obtained with this unit were used to verify the results of the mathematical model. The experimental results were found to be in good agreement with the predictions based on the mathematical model, and it is accordingly believed that the technical feasibility of an externally heated shaft kiln has been demonstrated on bench scale.

Mintek's role in the development of plasma-arc technology based on a graphite electrode by Mr R.M. Denton, Mintek

The lack of a plasma torch of proven design capable of operating in the 20 to 60 kA range resulted in intensive research at Mintek. A number of pilot-plant furnaces have been built with power ratings ranging from 50 kVA to 3,2 MVA. All of these direct-current transferred plasma-arc furnaces use a graphite cathode. The development of this technology resulted in the installation of a 16 MVA d.c. transferred plasma-arc industrial facility for the smelting of ferrochromium. The fact that this furnace has recently been successfully uprated to 40 MVA justifies the use of a graphite cathode.

Theoretical study of electrically-based thermal processes for the treatment of steel-plant dusts by Mr L.R. Nelson, Mintek

Increasing environmental pressures are being placed on steel plants to treat their arisings of waste dust. Such treatment should ultimately render waste products innocuous and disposable, and, where possible, recover the valuable species in the dusts. In this paper, steel-plant dusts were classified into four broad categories. Ideal equilibrium calculations were carried out on each dust type to establish the most suitable processing conditions for its treatment by the available electrically-based thermal processes. From this study it became apparent that electrically-based thermal processes are the most suitable for the treatment of high-zinc (more than 15 per cent zinc) and alloy-steel dusts.

The application of electrochemical measuring techniques to the study of slag/metal systems at high temperature by Mr J.M.A. Geldenhuis, Iscor Ltd/University of Pretoria

Measurement of the P_e values of different types of solid-zirconia electrolytes, including commercial oxygen probes, were made to ensure that the oxygen potential is determined accurately when oxygen probes are used for these measurements. A crucible assembly was also developed, which permitted the measurement of the activity of chromium in an iron–chromium alloy in equilibrium with a Cr_2O_3-saturated liquid slag at 1600°C. The results obtained in this study were compared with those of previous workers, and it was found to be of the utmost importance that the P_e values of solid electrolytes used in oxygen sensors are known if reliable oxygen-activity measurements are to be made.

Hot desulphurization of coal gas by Professor K. Schwerdtfeger, Technical University, Clausthal

Present-day plants require the fuel for gas turbines to be cooled before the sulphur is removed. The desluphurizing of coal gas with lime at elevated temperatures was investigated. The problems of converting the consumed adsorber (calcium sulphide) to calcium sulphate by oxidation with air were discussed, as well as the acceleration of the oxidation at 900°C by catalysts.

The role of Iscor's research department in the commissioning of the world's first commercial COREX plant by Dr A. Morrison, Iscor Ltd

The COREX plant makes use of coal gas for the direct reduction of iron ore in a vertical shaft. In shaft reduction, optimum operation is obtained with a low pressure drop, which is affected, among other factors, by the extent of the low-temperature breakdown of the ore charge. It was found that the maximum breakdown occurred at 600°C when iron ores were heated under simulated plant conditions. Under reducing conditions, samples held at 500°C showed a higher level of breakdown than those heated to 800°C. A test procedure has also been developed for thermal shock-testing of coals for use in the COREX process. The fragmentation of coal and high heating rates also adversely affect the operation of the plant. This test procedure allows coals to be ranked on the basis of their resistance to thermal shock. Based on the results of the investigations, guidelines (aimed at avoiding high pressure drops) have been formulated for efficient shaft operation.

The problems facing the development of smelting–reduction by the liquid-bath approach by Mr J.P. Hoffman, Middelburg Steel & Alloys (Pty) Ltd

For such a process to be successful the optimum has to be found between the following elements of smelting–reduction: prereduction ratio (degree), post-combustion ratio, reaction kinetics, production rates, heat-transfer efficiency, cost of production, and environmental demands.