included fluid-dynamic characterization by means of a time-dependent input technique to evaluate the effects of interference level between feed zone and reaction zone. The effects of agitation level on fluid-dynamic parameters were also investigated. Mathematical models for simulating the electrochemical reactor in steady-state conditions are presented. Characteristic parameters were determined by comparison of experimental profiles with the results of fluid-dynamic and electrochemical studies carried out by the same authors.

97/04072 Operation of blast furnaces with coke

Kasai, A. *et al.* Jpn. Kokai Tokkyo Koho JP 09,111,322 [97,111,322] (Cl. C21B5/00), 28 Apr 1997, Appl. 95/268,748, 17 Oct 1995, 4 pp. (In Japanese)
Coke having reaction ratio 30–45% is fed to the furnaces in the operation of the blast furnaces. Alternatively, the above process is carried out for fine-grained powder blowing process. The process prevents deterioration of tuyere raceway parts and pulverization of coke.

97/04073 Petroleum coke wastes as the fuel for iron-ore smelting in a melter-gasifier furnace

Greenwalt, R. B. U.S. US 5,630,862 (Cl. 75-445; C21B13/14), 20 May 1997, WO Appl. 93/US8,648, 14 Sep 1993, 17 pp.
Sulfur- and heavy metal-containing petroleum coke wastes were combusted as a fuel along with a sub-bituminous coal in a melter-gasifier furnace for the smelting of Fe-ore feed to obtain molten pig iron and slag for steelmaking. The smelting process provides a disposal of the environmentally undesirable petroleum coke and the associated S and heavy metal impurities, typically as a fuel mixture containing 30–65% of the sub-bituminous coal. The coke particles are partially combusted in a fluidized bed by blowing with O_2-containing gas, and the resulting CO-H_2 type hot gas is used for Fe-ore feed reduction at nominally 850°C. The melter-gasifier furnace is typically operated at 1100°C to obtain molten pig iron and slag for tapping. The S from petroleum coke is preferably removed by the molten basic slag based on CaO and Al_2O_3. The heavy metals from petroleum coke are collected in molten pig iron.

97/04074 Powder entrapment in a multi-phase flow packed bed

Pinson, D. *et al.* *Process. Handl. Powders Dusts, Proc. Int. Symp.*, 1997, 257–267. Edited by Battle, T. P., Henein, Hani. Minerals, Metals & Materials Society, Warrendale, PA.
Many industrial applications employ multiphase flow in packed beds, for example, granular filters for (hot) gas cleaning and the flow of unburnt coal in an ironmaking blast furnace. Understanding the mechanisms governing powder entrapment in packed beds and relevant issues such as powder hold-up and bed permeability is an important step towards the modelling of such a flow system. A study of powder entrapment and its effect on gas pressure drop in a gas-powder two-phase flow bed with and without liquid hold-up. It is found that the contact point between particles plays an important role in the capture of powder and the presence of a liquid-phase in the packing may significantly increase the powder hold-up and gas pressure drop. The effects of variables relevant to blast furnace conditions are subjected to experimental examination.

97/04075 Predictions of particulate formation, oxidation and distribution in a three-dimensional oil-fired furnace

Yuan, J. *et al.* *J. of Institute of Energy*, June 1997, 70, 57–70.
The paper describes the prediction of a three-dimensional oil-fired industrial type furnace. The gas phase combustion-related properties are calculated by means of time averaged Eulerian conservation equations in addition to the k–ε turbulence mode. The droplets and cenospheres balance equations are solved in Lagrangian fashion, with a stochastic approach for turbulent dispersion. The different phases are coupled through mass, momentum and energy exchange processes, assuming negligible influence of local discontinuities induced by the non-gaseous phase. The turbulent-diffusion flame is modelled by means of a clipped-Gaussian pdf to account for fluctuations of scalar properties. Chemistry is assumed to be fast. Radiation is modelled by the discrete transfer method. Oil combustion particulate, namely soot formed during gas-phase reactions, and cenospheres formed by the liquid-phase pyrolysis, may contribute to fouling, heat-transfer and emissions. Soot was modelled by solution of its Eulerian transport equation. In this work a Lagrangian model to predict formation, oxidation and spatial distribution of cenospheres is used. Soot is found to form in the fuel-rich edges of the flame; because of its fast oxidation, it contributes significantly to radiation only. On the other hand cenospheres, due to their structure and size, contribute significantly to fouling and emissions.

97/04076 Prevention of slag foaming in refining of molten pig iron

Hosohara, S. *et al.* Jpn. Kokai Tokkyo Koho JP 09 87,719 [97 87,719] (Cl. C21C1/06), 31 Mar 1997, Appl. 95/247,145, 26 Sep 1995, 5 pp. (In Japanese)
This method comprises inserting a top blowing lance near the interface between the metal and the slag, and a foaming-preventing agent (e.g., coke, coal) is blown through the lance.

97/04077 Procedure and apparatus for direct reduction of metal oxides

Pohl, U. and Ulrich, K. Ger. Offen. DE 19,543,074 (Cl. C21B11/08), 15 May 1997, Appl. 19,543,074, 13 Nov 1995, 6 pp. (In German)
A metal-containing material (e.g., metal oxide) is mixed with enough carbonaceous material for reduction, during preparation of a green charge. In additional, coal granules 0.2–1.5 mm diameter are added to the green charge prior to feeding into a hearth furnace, particularly a rotary hearth furnace. The green charge in the form of pellets and briquettes is shape-stable and does not disintegrate because its C content is low.

97/04078 Simplified smelting of nickel ore concentrates with melt refining for manufacture of ferronickel, iron–nickel alloy, or stainless steel

Blandy, C. W. D. PCT Int. Appl. WO 97 20,954 (Cl. C21B11/08C), 12 Jun 1997, AU Appl. 96/8,769, 19 Mar 1996, 31 pp.
In a smelter bath, Ni-containing ore concentrate and Fe source are added, followed by the formation of a slag layer containing a C source (especially coal) for reduction above the crude alloy melt layer, bubbling of O_2-containing gas into the molten slag, and O_2-gas feed above the bath for secondary combustion heating. The process is suitable for the smelting feed with Ni-sulfide ore concentrate as well as chromite, Fe-oxide ore, and/or laterite ore concentrate, using the slag melt heated at 1300–2000°C under low furnace-gas pressure. The oxygen-rich gas is injected into the molten slag and above the slag using two-level rows of tuyeres set in water-cooled Cu panels in the furnace wall. The smelting process is simplified for the ore-feed reduction to metal droplets in the upper slag layer, followed by periodic tapping. The refining and finishing of crude alloy melt is carried out in a decarburizing ladle and/or steelmaking converter with O_2-gas blowing.

97/04079 Sintered coal fines agglomerated for use in iron-ore smelting furnace

Jung, Y. C. *et al.* PCT Int. Appl. WO 97 24,414 (Cl. C10L9/08), 10 Jul 1997, KR Appl. 9,565,206, 29 Dec 1995, 14 pp.
The agglomeration of granular coal fines with particle size $\leq$8 mm is carried out by heating for $\geq$5 min at $\geq$600°C, especially after blending with $\leq$70% anthracite to decrease the swelling index. The resulting sintered coal has crush strength >5 kg/cm^2, and is suitable for use in smelting or direct-reduction furnace for Fe ores. The coal mixture is typically heated by hot spent gas from the reduction or smelting stage.

97/04080 Smelting of oxide ores using metalization and melting stages with carbon for reduction

Innes, J. A. and Dry, R. J. PCT Int. Appl. WO 97 17,473 (Cl. C21BS/00), 15 May 1997, AU Appl. 95/6,399, 3 Nov 1995, 29 pp.
A two-stage process for oxide ore reduction is presented. The first stage involves metalization of the powdered ore using a carbonaceous reductant injected into a furnace apparatus. The next stage comprises smelting of the pre-reduced ore feed injected with the carbonaceous residue into a furnace containing molten metal and slag layers. The intermediate products of the first-stage metalization include the ore reduced at $\geq$50% char from the coal and CO and H_2 gas residues from the pre-reduction. The process is suitable for the smelting of Fe-oxide ores, but may be applied to the chromite, Ni oxide, and similar ores with optional pre-reduction and metalization stages prior to smelting.

97/04081 Transient heat transfer analysis in vacuum furnaces heated by radiant tube burners

Mochida, A. *et al.* *Energy Convers. Mgmt*, 1997, 38, (10–13), 1169–1176.
An analysis method for transient characteristics of the combined radiative and conductive heat transfer in the industrial furnaces was developed using numerical analyses of heat transfer in vacuum furnaces. The vacuum furnace is heated by several radiant tube burners and enclosed with thermal insulation walls. Object materials are placed at the central region of the furnace. A three-dimensional computer program was developed to solve radiative heat transfer within enclosure including the transient conductive heat transfer within the insulation walls surrounding the system. The Monte Carlo method is used for the radiative heat exchange calculation. The results of the numerical simulation were compared with the results of experiment and good agreement was discovered, confirming the validity of the present simulation method.

97/04082 Vitrification of fly ash by swirling-flow furnace.

Ito, T. *Waste Manage.*, 1996 (Pub. 1997), 16, (5/6), 453–460.
The amendment of the Waste Disposal and Public Cleansing Law of 1992 states fly ash is regulated as 'Specially controlled waste'. Wide attention is now being paid to the melting and vitrification treatment of fly ash, which can reduce overall volume, detoxify and recover resources. Kobe Steel has demonstrated its operation using a swirling-flow furnace and has perfected a vitrification technique. The demonstration test has confirmed stable melting, high decomposition ratio of dioxins and the soundness of the slag. Kobe Steel has successfully developed a new technique for heightening slag quality and for heavy metals recovery from collected dust.