（＊掲載記事題目及び掲載頁は変更になる場合があります。）

Fundamentals of High Temperature Processes

Prediction of furnace heat transfer and its influence on the steel slab heating and skid mark formation in a reheating furnace

J.H.JANG et al.

In this work, a mathematical heat transfer model of a walking-beam type reheating furnace has been developed. The model can predict the heat flux distribution within the furnace and the temperature distribution in the slab throughout the reheating furnace process by considering the heat exchange between the slab and its surroundings in the furnace, including the radiant heat transfer among the slabs, the skids, the hot gases and the furnace wall as well as the gas convection heat transfer in the furnace. The furnace filled with hot combustion gases such as H_2O, CO_2, O_2, and N_2 is modeled as radiating medium with spatially varying temperature. After the predictions of the present model were compared with the data from an in situ measurement in the furnace, the effect of the skids on the slab heating, the heat transfer characteristics and temperature behavior of the slab were investigated by changing such parameters as residence time and emissivities of the slab and the furnace wall.

(cf. *ISIJ Int.*, **48** (2008), 1325)

Manganese and chromium distribution between $CaO–SiO_2–MgO_{sat.}–CrO_{1.5}–MnO$ slags and Fe–Cr–Mn stainless steel

M.-A.VAN ENDE et al.

The Mn and Cr equilibria between a Mn rich stainless steelmaking slag ($CaO–SiO_2–MgO_{sat.}–MnO–CrO_{1.5}$) and Fe–Cr–Mn stainless steel were investigated in a temperature range from 1 823 to 1 873 K under Ar atmosphere. The partition ratios L_{Mn} and L_{Cr} between liquid slag and steel were determined as a function of slag composition and temperature. By combining the experimental results with thermodynamic calculations, it was found that, as basicity increases, L_{Mn} decreases, while L_{Cr} increases. The elevated basicity leads to a high MnO activity coefficient. On the other hand, the $CrO_{1.5}$ activity coefficient decreases with higher slag basicities. The influence of MnO and $CrO_{1.5}$ contents on the activity coefficients was also considered. It is concluded that in order to maximize Mn recovery during high Mn stainless steel production, a basic slag with a high MnO activity coefficient must be employed whereas high temperatures should be avoided.

(cf. *ISIJ Int.*, **48** (2008), 1331)

New EAF dust treatment process with the aid of strong magnetic field

S.ITOH et al.

A new EAF dust treatment process named as "Lime Addition and Magnetic Separation Process (LAMS Process)" has been proposed to recover zinc oxide from the dust and to use solid residue as a flux for steel refining. The LAMS Process consists of the reaction of EAF dust with CaO followed by the adequate crushing and high gradient magnetic separation. The basic principle of this process has been established by revealing the phase equilibria in the $CaO–Fe_2O_3–ZnO$ system where $Ca_2Fe_2O_5$ can be in equilibrium with pure ZnO rather than $ZnFe_2O_4$, which is the major component of EAF dust, at higher CaO region. The conversion of zinc ferrite in EAF dust to ZnO and $Ca_2Fe_2O_5$ has been experimentally demonstrated by heating the dust with double molar amount of CaO at 1 173 and 1 373 K. It has also been demonstrated that the formed ZnO and $Ca_2Fe_2O_5$ can be separated by the strong magnetic field. Therefore, it may be possible to recover ZnO from EAF dust without the carbothermic reduction like Waelz process.

(cf. *ISIJ Int.*, **48** (2008), 1339)

Evolution and distribution of the copper-rich phase during oxidation of an Iron–0.3wt%copper alloy at 1 150°C

B.A.WEBLER et al.

Residual copper contents in low carbon steels lead to a cracking phenomenon known as surface hot shortness. This phenomenon is caused by a copper-rich liquid layer that forms due to copper enrichment as iron oxidizes during casting, reheating and/or hot rolling. Evolution of the copper-rich liquid layer is dependent on the competing processes of enrichment due to iron oxidation and diffusion of copper back into the metal. This paper presents comparisons between experiments and calculations of a fixed grid finite difference model that predicts the evolution of the copper-rich region. Experiments involved oxidizing an iron–0.3wt%copper alloy in a gold-image furnace equipped with thermogravimetric balance. Samples were oxidized at 1 150°C in three atmospheres, dry air, wet air (15 vol% H_2O), and argon–15vol%H_2O. Model predictions agree with measured data for dry air oxidation at 1 150°C for 60, 300, 420, 600, 900, and 1 200 s. Agreement was also obtained for iron oxidized for 1 800 and 2 700 s in argon–15vol%water vapor. However, model predictions deviated for samples oxidized 3 600 s in dry air, 3 600 s in water vapor, and 600 s in wet air. The deviations arise due to grain boundary penetration and diffusion of copper. Results suggest a critical amount of separated copper is necessary for substantial grain boundary penetration to occur and the required amount decreases when the gas contains H_2O. The model was also used to estimate the evolution behavior of the liquid copper phase under industrially relevant conditions.

(cf. *ISIJ Int.*, **48** (2008), 1345)

Ironmaking

Measurement of blast furnace refractory lining thickness with a 3D laser scanning device and image registration method

S.-K.KUO et al.

This paper presents a method for blast furnace lining thickness measurement with a 3D laser scanner and image registration method. A laser scanner is used to measure the inner profile through an opening on the upper part of the furnace. Two data point sets are obtained before and after the lining repairing process respectively, and data registration algorithm is employed to acquire rigid body transformation so as to compare the difference between both point clouds based on the same coordinate system. The difference represents thickness added to the initial lining. Furthermore, by comparing mechanical dimensions with the measured profile, residual lining thickness can be obtained.

(cf. *ISIJ Int.*, **48** (2008), 1354)

Influence of SiO_2 and/or MnO_2 on the reduction behaviour and structure changes of Fe_2O_3 compacts with CO gas

A.-H.A.EL-GEASSY et al.

Pure Fe_2O_3 and Fe_2O_3 doped with either 2.5–7.5 mass% SiO_2, 6.0 mass% MnO_2 and (6.0%MnO_2+7.5%SiO_2) compacts annealed at 1 473 K for 6 h were prepared. The different phases were identified by X-ray diffraction (XRD) and their structures were examined by optical and scanning electron microscopes. The magnetic properties were measured with Vibrating Sample Magnetometer (VSM). Total porosity and pore size distribution were determined and their external volume was also measured. Unlike in SiO_2 doped samples where no new phases were detected, manganese ferrite ($MnFe_2O_4$) was identified in MnO_2-containing samples. Annealed compacts were isothermally reduced with CO at 1 073–1 373 K and the O_2-weight loss was continuously recorded. It was found that the reduction rate of $SiO_2–Fe_2O_3$ samples increases at the early stages with SiO_2 mass% due to the increase in their original porosity. At final stages, the rate was retarded due to the formation of hardly reducible fayalite (Fe_2SiO_4). In MnO_2-containing samples, the reduction rate was retarded at initial stages due to the presence of manganese ferrite. At later stages, the formation of fayalite–manganoan [$(Fe,Mn)_2SiO_4$] greatly hindered the reduction process. A catastrophic swelling (ΔV= 405%) was recorded in 6%$MnO_2–Fe_2O_3$ compacts and was greatly diminished to 55.95% in presence of 7.5% SiO_2 due to the decrease in size and number of metallic iron whiskers and plates. The reduction mechanism of pure and doped samples was predicted from the correlations between reduction kinetics and the microscopic examinations of partially and completely reduced samples.

(cf. *ISIJ Int.*, **48** (2008), 1359)

Carburization degree of iron nugget produced by rapid heating of powdery iron, iron oxide in slag and carbon mixture

K.OHNO et al.

Iron nugget making process by rapid heating reduction of powdery iron ore and pulverized coal mixture is regarded as one of the novel iron-making processes. Iron carburization during smelting reduction is especially important reaction step from the viewpoint of saving energy in this process. If the rate and efficiency of carburization reaction are increased, energy consumption of the process will be reduced to large extent. The purpose of this study is to clarify the carburization degree of iron nugget during smelting reduction of the mixture.

The sample was prepared from graphite, electrolytic iron powder and synthetic slag containing iron oxide to simulate iron carburization phenomena during smelting reduction of the mixture in the present work. The sample was quenched immediately after the mixture changed into nugget shape in a rapid heating process. Laser microscope combined with infrared image furnace was used for sample heating and observation of carburization phenomena, and carbon content in the nugget was chemically analyzed after quenching.

From above-mentioned investigations, it was revealed that the occurrence of carburization during smelting reduction in the sample mixture is advantageous to obtain higher carbon contain iron nugget.

(cf. *ISIJ Int.*, **48** (2008), 1368)

Casting and Solidification

Refinement of as-cast austenite microstructure in S45C steel by titanium addition

M.OHNO et al.

The effect of Ti addition on as-cast austenite (γ) structure of S45C steel has been investigated. The as-cast γ structure without the Ti addition consists of coarse columnar grains. The Ti addition leads to formation of equiaxed γ-grains and also grain refinement of the γ structure. Fully equiaxed and very fine γ-grain structure forms in a limited range of Ti addition of 0.13 to 0.17 wt%. The thermodynamic calculation of phase diagram showed that Ti carbonitride crystallizes as a primary phase in this composition range. The formation of the very fine equiaxed γ-grain structure originates from the columnar-to-equiaxed transition (CET) in δ-dendrite solidification induced by the primary Ti carbonitride particles. These particles act as the nucleation sites of the equiaxed δ-dendrite. The experimental results are suggestive of existence of finer Ti carbonitride particles retarding the grain growth of γ-phase after the peritectic transformation, which leads to the refinement of the as-cast γ structure.

(cf. *ISIJ Int.*, **48** (2008), 1373)

Heat transfer in funnel-mould casting: Effect of plate thickness

B.SANTILLANA et al.

Plant measurements and three-dimensional models are used to develop an accurate and efficient model of heat transfer in a thin-slab continuous casting mould, interface, and solidifying shell. A finite-element model of the complex-shaped mould, developed using ABAQUS, is applied to find offset correction factors that enable the efficient CON1D model to accurately predict temperature at thermocouple locations. Model interface parameters are calibrated using an extensive database of plant data obtained from the Corus Direct Sheet Plant in IJmuiden, The Netherlands, including measurements of mould heat removal, mould temperature, oscillation mark shape, mould-powder consumption, and mould thickness. The validated CON1D model is applied to quantify the combined effects of casting speed and mould plate thickness on mould heat transfer. Increasing casting speed causes a thinner solidified steel shell, higher heat flux, higher mould hot face temperature, a thinner slag layer and lower solid slag layer velocity. Increasing mould plate thickness increases hot face temperature, lowers solid slag layer velocity, increases slag layer thickness, and lowers mould heat flux.

(cf. *ISIJ Int.*, **48** (2008), 1380)

Instrumentation, Control and System Engineering

Adequacy of cold rolling models to upgrade set-up generation systems

H.C.FERREIRA et al.

This paper presents two strategies for the upgrade of set-up generation systems for tandem cold mills. Even though these mills have been modernized mainly due to quality requests, their upgrades may be made intending to replace pre-calculated reference tables. In this case, Bryant and Osborn mill model without adaptive technique is proposed. As a more demanding modernization, Bland and Ford model including adaptation is recommended, although it requires a more complex computational hardware. Advantages and disadvantages of these two systems are compared and discussed and experimental results obtained from an industrial cold mill are shown.

(cf. *ISIJ Int.*, **48** (2008), 1389)

Chemical and Physical Analysis

An observation of micro-crack in transformation-induced plasticity-assisted multiphase steel

S.H.LEE et al.

In a transformation-induced plasticity (TRIP)-assisted multiphase steel, the phases around a micro-crack at the initial stage of cracking during wire drawing were observed by a focused ion beam (FIB), transmission electron microscopy (TEM) and energy dispersive spectroscopy (EDS). A novel FIB method, which is termed as "In-plane lift-out" technique, was applied to obtain an overall plan-view of the TEM specimen containing the micro-crack. The equilibrium concentration ratio of Mn in austenite and ferrite was calculated for the alloy and compared with the EDS line profile of Mn concentration across the micro-crack in the TEM specimen. The interface between the ferrite and martensite was identified as the crack initiation site during drawing of this multi-phase steel.

(cf. *ISIJ Int.*, **48** (2008), 1394)

Discovery of potassium chloride in the sintering dust by chemical and physical characterization

C.PENG et al.

Sintering plant dust arrested by electrostatic precipitator (ESP dust) in an integrated iron and steel company is perceived as a precious secondary material to steelmaking process, due to the presence of important elements to the industry such as, Fe and C with an attractive concentration. However, some hazardous elements such as, K, Na, Zn, Pb, seriously destroying normal working of the blast furnace, are enriched meanwhile. Therefore, it becomes very important to know how to separate these elements from Fe and C before reusing the dust. The aim of this work is to carry out a chemical, physical, structural and morphological characterization of the sintering dust. The dust was subjected to granulometry analysis, chemical analysis, scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy *via* SEM (EDS), X-ray mapping analysis *via* SEM and X-ray diffraction. With the help of these analysis ways and some comparison made between characterization of the dust before and after water leaching, an encouraging conclusion was drawn: KCl was identified in the sintering dust with a content percentage up to 30%. Considering serious lack of potassium fertilizer in China, it is necessary to recover KCl from the sintering dust. In addition, endanger of K to the steelmaking process is restricted at the same time.

(cf. *ISIJ Int.*, **48** (2008), 1398)

Chemical state of chromium in $CaO–SiO_2$ base oxides annealed under different conditions

K.SHINODA et al.

In order to understand the formation mechanism of Cr(VI) in chromium-containing steel slag, X-ray diffractiometry (XRD), X-ray absorption spectroscopy (XAS) in the region of X-ray absorption near edge structure (XANES), and X-ray photoelectron spectroscopy (XPS) measurements were performed for analyzing the chromium contained in the model slag of $CaO–SiO_2$ base. The model slag was annealed under different temperatures and atmospheres to change the chemical state of chromium. XRD results showed that a diffraction peak that can be assigned to $CaCrO_4$ comprising of Cr(VI) was detected in the model–slag sample annealed under a high partial pressure of oxygen (air). XANES results showed that the Cr(VI) concentration in the slag increased by annealing under a high partial pressure of oxygen, while it was very low in the slag sample annealed under a low partial pressure of oxygen. The XANES results were consistent with the XRD results. The formation conditions of Cr(VI) were discussed on the basis of the thermodynamic characteristics of a Ca–Cr–O system. The XPS results for the slag surface were dependent on the leaching tests performed on the slag, while the XANES results were insensitive to the leaching tests. This indicates that Cr(VI) dissolved from only a surface layer of the model slag. The chromium that dissolved from the slag in an aqueous solution by the leaching test was also analyzed and was found to be in the form of Cr(VI); further, its concentration depended on the annealing conditions of the slag.

(cf. *ISIJ Int.*, **48** (2008), 1404)

Forming Processing and Thermomechanical Treatment

Approximate model for predicting roll force and torque in plate rolling with peening effect considered

C.H.MOON et al.

An approximate model for predicting roll force

and torque in plate rolling is proposed. In this model, peening effect which unavoidably occurs in plate rolling due to a small ratio of work roll radius over mean thickness of slab (material) being deformed is considered. Besides, the proposed model does not need any iteration scheme to compute maximum reduction ratio per pass.

The proposed roll force model consists of three parts: i) an ideal roll force under homogeneous deformation condition and ii) geometrical factor depending on inhomogeneous deformation state in roll gap and roll radius, material width and thickness and finally iii) the ratio of work roll radius increased by flattening over original roll radius. Multiplication of these three parts gives roll force in a given pass. A similar procedure was taken for roll torque model. A lever arm ratio which plays a vital role in computing roll torque was modified so that inhomogeneous deformation state of material in roll gap is fully covered.

The validity of the proposed model is verified by applying it to No. 2 plate mill in POSCO. Results reveal that the predicted roll force and torque are in a good agreement with measured data, in comparison with conventional model being used. Accuracy of roll force is remarkably improved from 16.7 to 5.4% and that of roll torque is outstandingly enhanced from 26.0 to 6.3%.

(cf. *ISIJ Int.*, **48** (2008), 1409)

Austenitic grain growth behavior immediately after dynamic recrystallization in HSLA steels and austenitic stainless steel

N.Fujita et al.

Austenitic grain growth behavior after dynamic recrystallization in HSLA steels and the austenitic stainless steel of Type 316L was investigated focusing on grain growth during a very short holding time period immediately after hot deformation. Hot compressed specimens were isothermally held at temperatures of 1 373 K, 1 423 K and 1 473 K for various time periods from 0.1 s to 1.8 ks. The grain size in all steels was coarsened by 1.5 to 2.5 times in a short holding time period of 20 s. Addition of 0.078%Zr or 0.018%Ti in HSLA steel could not prevent this rapid grain growth, which retarded grain growth in a longer holding time period over 60 s. The grain growth exponent of the n value was evaluated using a formulated grain growth kinetic equation, and two n values largely differing in the fine and coarse grain size regions were obtained in a respective temperature and alloy. The n value in the latter region ranged from 2.3 to 3.2, being almost consistent with values of various materials reported in the past studies. The very high n value over 7.7 was obtained in the fine grain size region for dynamic recrystallization in all steels, where n values for static recrystallization was relatively lower than those for dynamic recrystallization. The similar result of n values was obtained from grain growth data after dynamic recrystallization in pure nickel. The cause for very high n value and the difference of n values obtained from grain growth data after dynamic and static recrystallizations were discussed based on features of the microstructure and the grain boundary evolved by dynamic or static recrystallization and annealing.

(cf. *ISIJ Int.*, **48** (2008), 1419)

Welding and Joining

Thermal modeling of friction welding

M.Maalekian

Modeling of the friction welding process depends entirely on the accurate frictional heat generation term. In the present work it is demonstrated that the inverse heat conduction approach best represents the actual heat flow. Unlike other existing thermal models, this proposed model does not require the friction coefficient, the shear yield stress, nor the interface temperature data.

(cf. *ISIJ Int.*, **48** (2008), 1429)

Surface Treatment and Corrosion

$(Fe, Cr)_3O_4$ spinel layer as the key to solving the accelerated oxidation of high Cr iron alloy in high-temperature steam

Y.Murata et al.

The amount of hydrogen dissolved into oxide layers on Fe–10Cr alloy after exposure to steam at 750°C was measured with thermal desorption spectroscopy (TDS). It was found that the dissolved hydrogen existed mainly in $(Fe, Cr)_3O_4$ spinel layer formed on the alloy surface. This result is related closely to the fact that oxidation of high Cr ferritic steels is accelerated remarkably by the existence of steam at elevated temperatures. Using a diffusion system of $(Fe, Cr)_3O_4$/CoO, cation diffusivity was investigated at 750°C in argon atmosphere or in steam. As a result, the diffusivity of Fe ion in $(Fe, Cr)_3O_4$ became larger in steam than that in argon atmosphere, indicating that hydrogen (proton) promotes Fe ion outer diffusion from Fe–10Cr alloy. This is direct evidence that high temperature steam accelerates oxidation of Cr containing steels.

(cf. *ISIJ Int.*, **48** (2008), 1434)

Medium carbon steel surface hardening by vacuum arc cleaning of oxide layers

Y.Arai et al.

In vacuum arc cleaning (VAC) treatment of an oxide layer on a metal surface, the oxide layer is removed evaporatively by movement of high-energy-density cathode spots on it. The action of the cathode spots not only quickly removes the oxide layer on the metal surface; it also causes a rapid temperature variation on the metal surface, which might indicate a change in surface physical features and impart new additional functions. Changes of metal surfaces that had undergone VAC treatment for the oxide layer are investigated using S45C plate. A simple model is suggested and the experiment result is analyzed theoretically.

(cf. *ISIJ Int.*, **48** (2008), 1438)

Transformations and Microstructures

Effect of processing schedule on the microstructure and texture of 0.78 wt% Cr extra-low-carbon steel

E.V.Pereloma et al.

An extra-low-carbon steel was alloyed with 0.78 wt% Cr and subjected to three different processing schedules involving: (i) warm rolling to 65% reduction at 640°C, (ii) warm rolling to 80% reduction at 580°C and (iii) warm rolling to 65% reduction at 640°C followed by cold rolling to 40% reduction. Increasing the severity of the deformation resulted in an increase in the number of grains containing in-grain shear bands. X-ray bulk texture analysis indicates that the γ-fibre intensity was slightly higher in the steel warm rolled at 580°C than at 640°C and after cold rolling. Transmission electron microscopy and atom probe tomography revealed that Cr carbides were formed after all processing schedules. Carbon segregation to dislocations was also observed. Although the addition of 0.78 wt% Cr produced a volume fraction of carbides that was three orders of magnitude higher than those previously observed in 0.48 wt% Cr steels, a significant amount of solute Cr remained confined in the matrix and did not lead to any further depletion of the solute carbon.

(cf. *ISIJ Int.*, **48** (2008), 1443)

Microstructural refinement and precipitation behavior of low carbon steel produced by compact strip production

H.Wang et al.

Microstructure evolution and precipitation of low carbon steel produced by compact strip production (CSP) was investigated by means of scan electron microscope (SEM), transmission electron microscope (TEM) analysis and small angle X-ray scattering technique. It was found that the remarkable grain refinement can be attained by a large number of oxide and sulfide dispersive precipitates, and combining with the rapid solidification during continuous casting as well, which have dominant effect on strengthening. Consequently, the precipitation strengthening based on CSP process is also discussed in this paper.

(cf. *ISIJ Int.*, **48** (2008), 1451)

Improved model of kinetics of strain induced precipitation and microstructure evolution of Nb microalloyed steels during multipass rolling

B.Pereda et al.

One of the main problems of empirical and semi-empirical models that are used to predict austenite microstructure evolution during hot rolling is their limited range of applicability regarding chemical compositions. This paper aims to improve a previous microstructural model paying special attention to the development of a more general equation for the prediction of the onset of strain induced precipitation in Nb microalloyed steels. This has been done with the help of new expressions describing the kinetics of strain induced precipitation as a function of the chemical composition. Moreover, the evolution of strain induced Nb precipitation was also modeled in order to determine the amount of Nb precipitated after each strain pass. The predictions obtained with the new model have been compared to results obtained in multipass laboratory tests using several Nb microalloyed steels. The model allows us to better understand the complex interactions occurring be-

tween Nb and microstructural softening depending on composition and process parameters.

(cf. *ISIJ Int.*, **48** (2008), 1457)

Mechanical Properties

Microstructure and mechanical property of copper bearing eutectoid steel

M.MURAKAMI et al.

Isothermal heat treatment was performed for austenitized Cu bearing eutectoid steels (Fe–0.8%C–Cu alloys). Microstructural observations revealed that the pearlite transformation is significantly retarded by the addition of Cu, but the morphology of pearlite, such as lamellar spacing and block size, are hardly influenced by the Cu addition. From the result of chemical analysis for cementite phase, it was found that the redistribution of Cu had occurred between ferrite and cementite through the interfacial diffusion during pearlite transformation and then the precipitation of Cu takes place simultaneously within ferrite phase. Furthermore, in the 2% Cu steel, age hardening behavior was found at the same temperature applied to the isothermal pearlite transformation. This means that the precipitation of Cu does not complete on pearlite transformation and the ferrite in pearlite structure is in the supersaturated state. Yield strength and tensile strength of the pearlite steels depend on not only lamellar spacing but also the dispersion of Cu particles within the ferrite phase. For example, 2% Cu addition increases yield strength and tensile strength by about 250 MPa without reducing ductility so much.

(cf. *ISIJ Int.*, **48** (2008), 1467)

New Materials and Processes

Microstructure and mechanical properties of 440C–TiC composite steels produced through powder metallurgy processing

T.-P.TANG et al.

This study sifted the commercial AISI 440C steel powders by using the matrix proposed previously with addition of TiC powder (25, 33 and 40 wt%) to produce a new composite steel with high hardness and strength after powder metallurgy, sintering and heat treatment. The mixing was done by ball milling, sintered at three different temperatures: 1 473 K, 1 573 K and 1 673 K, and followed by a series of heat treatments. The experimental results showed the highest TRS value at 1502.6 MPa, and porosity was decreased to 0.18% after 440C steel was added with 25 wt% TiC powders by sintering at 1 673 K. All of the specimens after sintering and conventional heat treatment did not show improvement on the hardness and TRS, instead showed decreases.

(cf. *ISIJ Int.*, **48** (2008), 1473)

Social and Environmental Engineering

Substance flow analysis of zinc associated with iron and steel cycle in Japan, and environmental assessment of EAF dust recycling process

K.NAKAJIMA et al.

Japanese zinc production in 2005 was 6.75×10^5 t, and domestic demand of zinc was 4.82×10^5 t. The main use of metallic zinc is in the surface coating of steel and the metal accounts for 62.8% of the domestic demand. The purposes of this study are as follows: (1) to identify the material flow of zinc associated with steel production, and (2) to estimate the environmental effects (energy consumption and CO_2 emission reduction) of some intermediate dust treatment processes.

The major conclusions are (a) in Japan, 6.16×10^6 t of blast furnace/converter dust was generated in 2000, and this product contained $2.20\times^{104}$ t-Zn. 0.433×10^6 t of EAF dust was generated and this dust contained 8.86×10^4 t-Zn, and (b) 9.57 MJ of energy is required for producing 1 kg of zinc oxide by the Waelz process using EAF dust, and the estimated amount of CO_2 emission in this process is 1.49 kg-CO_2. On the other hand, if the LAMS process proposed by the authors is employed, it is estimated that there will be a reduction of 1.70 MJ in energy consumption and a reduction of 0.14 kg-CO_2 in CO_2 emissions.

(cf. *ISIJ Int.*, **48** (2008), 1478)