

understood. In this study, we focus on the change in precipitation behavior of MX type carbonitrides in model steels with different heat treatment conditions.

It is found that dominant precipitation behavior has been changed with cooling rate from normalization temperature before tempering and better creep properties have been obtained in the steel quenched rather than in the one air-cooled. It is confirmed that precipitation of $M_{23}C_6$ is suppressed and total fraction of MX is relatively increased by the quenching procedure. It is thought that better creep resistance is mainly due to fine distribution of MX that is achieved by suppressing typical co-precipitation of MX such as Nb(C,N)-VN during cooling after normalization and tempering.

(cf. *ISIJ Int.*, **42** (2002), 779)

Social and Environmental Engineering

Fluorine-containing mineral phases in ironmaking and steelmaking slags and their solubilities in aqueous solution

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The minerals containing fluorine in hot metal pre-

treatment, BOF and secondary refining slags are identified by using X-ray diffraction method and electron microprobe analysis. From the area fractions of these minerals on a polished cross-section estimated by using an image processor, it was found that a main mineral in hot metal pretreatment and BOF slags is $2CaO \cdot SiO_2$ containing fluorine and that in secondary refining slag is $11CaO \cdot 7Al_2O_3 \cdot CaF_2$ or $12CaO \cdot 7Al_2O_3$ containing fluorine. The CaF_2 phase is observed in hot metal pretreatment and BOF slags with the fluorine content above 2.3 mass%. The dissolution behavior of synthetic F-containing minerals such as CaF_2 , $Ca_3F(PO_4)_3$, $3CaO \cdot 2SiO_2 \cdot CaF_2$, $11CaO \cdot 7Al_2O_3 \cdot CaF_2$ and $2CaO \cdot SiO_2 - 1$ (or 2) mass% CaF_2 solid solution, has been investigated in shaking test and the solubilities of these minerals are studied as a function of pH value of aqueous solution.

(cf. *ISIJ Int.*, **42** (2002), 785)

Immobilization of fluorine in aqueous solution by calcium aluminum ferrite and the mixture of calcium aluminate and gypsum

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The immobilization of fluorine by calcium alu-

minium ferrites has been studied using 20 mass ppm F-containing aqueous solution. It is found that the rate of the F immobilization by $Ca_2(Al,Fe)_2O_5$ is initially slower than that by $3CaO \cdot Al_2O_3$ at the solid/liquid ratio of 1/200, but a similar immobilization degree is obtained at later stage. The hydration product contributed to the F immobilization is the $Ca_3(Al,Fe)_2(OH,F)_{12}$ phase, which is confirmed by the combination of XRD and electron microprobe analysis. For a ferrite phase of $Ca_2(Al_{0.68}Fe_{0.32})_2O_5$, the hydration product has a chemical composition of $Ca_3Al_{1.54}Fe_{0.46}[(OH)_{1-x}F_x]_{12}$ ($x=0-0.13$). The F immobilization by $2CaO \cdot Fe_2O_3$ does not occur to a significant extent, but the F immobilization by $12CaO \cdot 7Al_2O_3$ is accelerated with the addition of $2CaO \cdot Fe_2O_3$ due to the formation of the $Ca_3(Al,Fe)_2(OH,F)_{12}$ phase. It is also observed that F can be immobilized by the formation of ettringite ($3CaO \cdot Al_2O_3 \cdot CaSO_4 \cdot 32H_2O$, $3CaO \cdot Fe_2O_3 \cdot CaSO_4 \cdot 32H_2O$) through the substitution of F ion for the SO_4^{2-} site.

(cf. *ISIJ Int.*, **42** (2002), 794)