

論文 / 著書情報
Article / Book Information

題目(和文)	同時脱硫・脱りんによる製鋼スラグ使用量最小化に関する研究
Title(English)	Minimization of steelmaking slag consumption by simultaneous desulfurization and dephosphorization
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種別(和文)	論文要旨
Type(English)	Summary

論文要旨

THESIS SUMMARY

専攻： 材料工学 専攻
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申請学位(専攻分野)： 博士 (工学)
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要旨 (英文 800 語程度)
Thesis Summary (approx.800 English Words)

In the steelmaking process, a growing attention has been paid to the waste emission and consumption of natural resources for desulfurization and dephosphorization of molten steel under the restriction of CaF_2 utilization. Regarding the problem, the ideas of replacing CaF_2 by CaCl_2 to increase the reaction efficiency of CaO and utilization of high-MnO slags generated as by-product in the molten steel for desulfurization and dephosphorization have been proposed. Accordingly, the possibilities of simultaneous desulfurization and dephosphorization in hot metal pretreatment by using CaO-CaCl_2 based slags and in secondary refining by using MnO-SiO_2 based deoxidation slags have been researched.

To elucidate the effect of CaCl_2 as the substitute of CaF_2 , the CaO solubility and sulfide capacity of $\text{CaO-CaCl}_2\text{-CaF}_2$ slag were determined at temperatures from 1573 K to 1673 K by equilibrating molten slag and molten copper in a CaO crucible which was sealed in a nickel holder to suppress the severe evaporation of CaCl_2 . The CaO solubility increases by 4.5~5.5 mol pct and the sulfide capacity decreases by the factor of 1.5~1.8 times with an increase in CaCl_2 content from about 25 to 75 mol pct. The activity coefficient of CaS increases with a decrease in temperature and with the replacement of CaF_2 by CaCl_2 , which indicates that CaF_2 has stronger interaction with CaS than CaCl_2 . From the sulfide capacity obtained, the phosphate capacity of $\text{CaO-CaCl}_2\text{-CaF}_2$ slag saturated with CaO was estimated at temperatures from 1573 K to 1673 K by using the correlation between sulfide and phosphate capacities. An increase in content of CaCl_2 from about 25 to 75 mol pct in the slag, causes a decrease in phosphate capacity just by 2.3~3.3 times, indicating the replacement of CaF_2 by CaCl_2 would not significantly influence the dephosphorizing ability of $\text{CaO-CaCl}_2\text{-CaF}_2$ slags saturated with CaO . The influence of temperature on phosphate capacity is pronounced; more specifically, the phosphate capacity multiplies 66.8~81.1 times with decreasing temperature from 1673 to 1573 K. Based on the experimental results, the feasibility of using CaO-CaCl_2 slags for simultaneous desulfurization and dephosphorization in the hot metal pretreatment has been discussed. With an increase of temperature from 1573 to 1673 K, the phosphorous distribution ratio (L_P) and sulfur distribution ratio (L_S) between CaO-CaCl_2 slags and carbon-saturated iron melts decreases by 38.8 times and increases by 4.1 times, respectively, indicating the influence of temperature change on L_P is much bigger than that on L_S . A

successful simultaneous desulfurization and dephosphorization can be achieved within a big range of oxygen potential, about $10^{-14.3}$ to $10^{-12.5}$ atm at 1573 K and $10^{-12.9}$ to $10^{-11.1}$ atm at 1673 K, and the optimum condition for simultaneous desulfurization and dephosphorization corresponds to $P_{O_2} = 10^{-13.8}$ atm and $L_P = L_S \approx 500$ at 1573 K, and $P_{O_2} = 10^{-12.4}$ atm and $L_P = L_S \approx 500$ at 1673 K.

To make full utilization of the high-MnO slags generated as by-product in the molten steel, the effect of BaO and Na₂O addition and Al₂O₃ substitution for SiO₂ on the phosphate capacity of MnO-MgO_{stad.}-Fe_tO-SiO₂ deoxidation slags at 1843 and 1873K was investigated by equilibrating the molten slag and iron in a MgO crucible. The addition of BaO and Na₂O to the MnO-MgO_{stad.}-Fe_tO-SiO₂ system dramatically increases the activity coefficient of MnO and phosphate capacity and decreases the activity coefficient P₂O₅. The phosphate capacity increases nearly 85 times with an addition of 12 mass pct Na₂O, whose effect is significantly bigger than that of BaO. At 1843 K, the phosphate capacity of 9.5Na₂O-46.1MnO-7.7MgO_{stad.}-14.1Fe_tO-24.9SiO₂ slag is nearly same with that of 36.9CaO-11.6MgO_{stad.}-24.32Fe_tO-26.33SiO₂ slag, indicating the feasibility of MnO based slags with addition of Na₂O as a substitute for CaO based slag. By replacing SiO₂ by Al₂O₃, the basicity of slags increases, but in contrast the phosphate capacity decreases and activity coefficient P₂O₅ increases, which was researched to be caused by the increase of activity coefficient of phosphate ion. When the oxygen content in the molten steel exceeds about 800 ppm, the L_P estimated by the obtained phosphate capacity for the MnO-MgO_{stad.}-Fe_tO-SiO₂ slag with an addition of 12 mass pct Na₂O is large enough for an effective dephosphorization of steel. If 20 kg of above composition of slag per ton steel is added into the steel tapped from a basic oxygen furnace having 0.010 mass pct phosphorous and 0.10 mass pct oxygen at 1843 K, the equilibrium phosphorous content would be 26 ppm.

Based on the experimental results and discussion, the proposals of conducting simultaneous desulfurization and dephosphorization in hot metal pretreatment by using CaO-CaCl₂ based slags and in secondary refining, conducting dephosphorization by using MnO-Na₂O-SiO₂ based slags before deoxidation process and desulfurization by using MnO-SiO₂ based deoxidation slags after deoxidation process have been given.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note：Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1 copy of 800 Words (English).

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(博士課程)

Doctoral Program

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