Separation of FeO and P₂O₅ from Steelmaking Slag Utilizing Capillary Action

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The recoverability of FeO and P resources from steelmaking slag was investigated using a novel mechanical approach involving capillary action. After determining the phase relationship of the CaO–FeO–SiO₂–P₂O₅ system with the coexisting 2CaO·SiO₂ and MgO phases, it was found that P₂O₅ was concentrated in the 2CaO·SiO₂ phase and was also distributed in the liquid phase. Due to the density difference of the FeO rich liquid phase and P₂O₅ containing 2CaO·SiO₂ phase, the P₂O₅ concentration in the upper part of the sample was 2.2–3.6 times higher than that of the lower part. Also, the FeO concentration in the upper part of the sample was nearly half of that in the lower part. To improve the efficiency of the separation of the solid 2CaO·SiO₂ phase and FeO rich liquid phase in steelmaking, capillary action was used to facilitate penetration into sintered CaO. Once the liquid phase had penetrated the CaO sinter, it was found that the solid 2CaO·SiO₂ phase and FeO rich phase could be effectively separated. When a sintered CaO sphere was added to a mixture of the solid 2CaO·SiO₂ phase and FeO rich liquid phase, it was possible to recover 87% of the P₂O₅ and 90% of the FeO from steelmaking slag. The recovered CaO sinter, which includes a FeO rich liquid phase, may be used as Fe source or a dephosphorization agent, and the 2CaO·SiO₂ phase, which includes P₂O₅, may be used as P source.

KEY WORDS: phase diagram; phosphorus; iron; distribution; equilibrium.

1. Introduction

The amount of global crude steel production increased from 837 million tons at year in 2000 to 1 510 million metric tons in 2012.¹⁾ Steelmaking slag is an inevitable by-product of steel, with 12.8 million tons produced in Japan alone in 2012.²⁾ Slag production will increase with growing global demand of steel. Steelmaking slag contains 20–30 mass%FeO and often more than 1 mass% of P₂O₅, but despite the value of these two components, it tends to be utilized as a road construction material, and in cement.³⁾ Since the quality of iron ore is degrading over time, the further recovery of FeO from slag will become increasingly important. Also, the annual amount of P₂O₅ included in steelmaking slag has been estimated to be roughly equivalent to the total annual imports of P₂O₅ into Japan.⁴⁾ Hence, if it is possible to separate P₂O₅ from slag, steelmaking slag will be an alternative resource of P₂O₅.

The composition of steelmaking slag varies considerably according to the type of process, and the conditions in the workshops, for instance. Even so, it can be safely assumed that the primary phase that precipitates during cooling is 2CaO·SiO₂, and that this phase will separate with the FeO rich liquid phase. It is known that the distribution of phosphorus in the 2CaO·SiO₂ phase is higher than in the liquid slag phase.^{5–14)}

If it is possible to separate the solid 2CaO·SiO₂ phase that includes P₂O₅ with the FeO rich liquid phase, it will be possible to use these phases as sources of phosphorus and iron. The phase relation of the CaO–FeO–SiO₂–P₂O₅ system as they coexist with the 2CaO·SiO₂ and MgO phases was determined in the present work and the degree of phase separation due to the density difference of the solid 2CaO·SiO₂ phase and FeO rich liquid phase was investigated.

Tanaka *et al.*¹⁵⁾ reported that FeO slag containing P₂O₅ penetrates the CaO sinter and that P₂O₅ is fixed as 4CaO·P₂O₅. The liquid FeO rich phase is absorbed into the CaO sinter. In this work, capillary action into sintered CaO was used to enhance the separation of the solid 2CaO·SiO₂ phase and liquid phase.

2. Experimental

2.1. Sample Preparation

Reagent grade CaCO₃ was heated to 1 223 K to obtain CaO. The FeO was made by mixing an equivalent molar electrolytic Fe powder with reagent grade Fe₂O₃ powder and heating the mixture in a Fe crucible at 1 473 K under a purified Ar atmosphere for 6 h. Magnetic separation was used to remove metallic Fe and Fe₃O₄ from FeO after crushing.

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2.2. Experimental Procedure for Obtaining the Phase Relation of CaO–FeO–SiO₂–P₂O₅ System with Coexisting 2CaO·SiO₂ and MgO Phases

Prepared CaO and FeO were mixed with reagent grade SiO₂ and 3CaO·P₂O₅ to have composition of either a) 47.2 mass%CaO – 44.5 mass%FeO – 8.3 mass%SiO₂ or b) 45.8 mass%CaO – 43.1 mass%FeO – 8.1 mass%SiO₂ – 3.0 mass%P₂O₅. The melting temperature of the former composition was estimated at approximately 1 823 K and the primary phases were 2CaO·SiO₂ and 3CaO·SiO₂ according to the CaO–FeO–SiO₂ phase diagram.¹⁶⁾ The latter composition was chosen to examine the effect of the addition of 3.0 mass% P₂O₅ to the slag of the former composition. Mixed oxides were pressed into 15 mm ϕ tablets. A weighed 8 g tablet was placed in an MgO crucible (I.D. 14 mm, O.D. 18 mm, H 60 mm) and was heated under a purified Ar flowing atmosphere in a vertical electric resistance furnace with LaCrO₄ heating elements. The reaction tube was Al₂O₃, 60 mm in ID and 1 000 mm length. Samples were heated at 200 K/hour to 1 873 K and held for 1 hour to melt the sample oxide. Then the samples were cooled at 200 K/hour to 1 673, 1 623, 1 573 or 1 523 K and held for 4 hours. The sample was quickly pulled out of the furnace and was quenched by impinging He gas. The chemical composition of each phases were determined by SEM-EDS. Analysis was conducted after calibration with standard samples and ZAF correction method was used in this study. At least six points were analyzed for determination of phase composition for all samples. Analytical fluctuation with in same phase was less than $\pm 5\%$.

2.3. Experimental Procedure for Separation of Solid 2CaO·SiO₂ Phase and FeO Rich Liquid Phase by Capillary Action of Sintered CaO

The sintered CaO for capillary separation was prepared as follows. Prepared CaO powder was pressed into 15 mm ϕ tablets and sintered in a Pt crucible under air at 1 773 K for 12 h. The average CaO powder size was 12 μ m and the apparent density of CaO sinter was 2.75 g/cm³. The density of CaO¹⁷⁾ is 3.34 g/cm³, hence, the porosity was estimated as 18%. The prepared sintered CaO was ground by hand into a crucible shape or a spherical shape.

Two methods were used to separate the solid 2CaO·SiO₂ phase and FeO rich liquid phase by capillary action. The first method was to heat the premelted slag in a CaO sintered crucible. This premelted slag was obtained from experiment explained in 2.2 by heating P₂O₅ containing slag at 1 623 K for one hour. Weighed 0.680 g or 0.165 g premelted slag was put in a CaO crucible. The weight of the CaO crucible was 1.58 g (diameter 11 mm, height 7 mm). This CaO crucible was set in an MgO crucible and was heated in a purified Ar flowing atmosphere. The sample was heated at 200 K/hour to 1 823 K and held for 1 hour. Then the sample was cooled at 200 K/hour to room temperature.

The second method was to add CaO sintered sphere when the solid 2CaO·SiO₂ phase and FeO rich liquid phase were in coexistence. A weighed 0.15 g of 45.8 mass%CaO – 43.1 mass%FeO – 8.1 mass%SiO₂ – 3.0 mass%P₂O₅ tablet was placed in an MgO crucible. Premelted sample was not used in this experiment. The sample was heated at 200 K/hour to 1 823 K and was held for 1 hour. Then the sample was cooled at 200 K/hour to 1 773 K and held for 1 hour. A

weighed 0.74 g CaO sphere (diameter 8 mm) was added from the top of the furnace and then the sample was cooled at 200 K/hour to room temperature. Experiment was conducted in a purified Ar flowing atmosphere.

The former method simulates the reheating of steelmaking slag to separate FeO and P₂O₅ and the latter represents the FeO and P₂O₅ separation during slag discharge after the steelmaking process. The chemical composition of each of the phases was determined by SEM-EDS.

3. Results and Discussion

3.1. The Phase Relation of the CaO–FeO–SiO₂–P₂O₅ System with Coexisting 2CaO·SiO₂ and MgO Phases

Figure 1 shows the SEM image of samples held at 1 623 K.

Fig. 1. SEM successive image of slag sample held at 1 623 K (Left 0 mass% P₂O₅, Right 5 mass% P₂O₅).

The image on the left is a slag sample without P_2O_5 and the one on the right is that with P_2O_5 . The samples were vertically cut, and the MgO crucible can be seen in the lower portion of the image. It can be seen that both samples consist of various phases and are not uniform. Also, the morphology of the samples differs considerably. **Figure 2** shows the enlarged SEM image of samples held at 1 623 K. Four phases were observed for all samples investigated in the present work. These phases were CaO, (Mg, Fe)O, $2CaO \cdot SiO_2$ and the liquid phase. From the CaO–FeO– SiO_2 phase diagram,¹⁶⁾ $2CaO \cdot SiO_2$, $3CaO \cdot SiO_2$ and the liquid phase can coexist at temperatures above 1 573 K. However, the absence of a $3CaO \cdot SiO_2$ phase in the results suggests that CaO and $2CaO \cdot SiO_2$ can coexist with the (Mg, Fe)O phase.

When P_2O_5 was included in the slag, the $2CaO \cdot SiO_2$ phase was smaller and it had a smoother shape. The composition analysis of each of the phases, done at the upper, middle and lower part of the sample, revealed no composition difference between each of the phases. The composition of each of the phases is tabulated in **Table 1**, and is indicated in **Fig. 3** in the CaO–FeO– SiO_2 phase diagram.¹⁶⁾ Only small composition differences of CaO, $2CaO \cdot SiO_2$ and liquid phases between the experiments were found.

The MgO and SiO_2 contents in the liquid and CaO phase were lower than 2.5 mass% and 3.6 mass%, respectively.

Fig. 2. SEM image of slag sample held at 1 623 K (Left 0 mass% P_2O_5 , Right 5 mass% P_2O_5).

Fig. 3. Composition of CaO, $2CaO \cdot SiO_2$ and liquid phases after the procedure shown on CaO–FeO– SiO_2 phase diagram.

Hence, the liquid and CaO phase can be approximately expressed by the CaO–FeO binary system. The compositions of the liquid and CaO phase are shown in the CaO–FeO phase diagram¹⁸⁾ in **Fig. 4**. It is clear that the composition of the liquid and CaO phase is in good agreement with that when the liquid phase and CaO coexist.

Also, the FeO activity of the liquid phase can be estimated from the composition of (Mg, Fe)O. Jacob and Iyengar¹⁹⁾ assessed the thermodynamic properties of the (Mg, Fe)O solid solution. From the (Mg, Fe)O composition, the FeO activity was calculated. The result is shown in **Fig. 5** with the reported activity curve of FeO for the CaO–FeO binary system.²⁰⁾ The determined FeO activity agrees very well

Fig. 4. Composition of the CaO and liquid phase shown on the CaO–FeO phase diagram.

Fig. 5. Calculated FeO activity in the CaO–FeO binary system.

Table 1. Composition of phases and area after the procedure.

Temp		phase/area	mass%CaO	mass%FeO	mass%SiO ₂	mass%MgO	mass%P ₂ O ₅
1 523 K	sample without P ₂ O ₅	CaO	84.8	13.2	0.19	1.75	0
		2CaO·SiO ₂	67.5	3.84	27.7	0.96	0
		Liquid	31.8	66.1	1.25	0.94	0
		(Mg, Fe)O	3.83	56.8	0.17	39.2	0
		upper area	51.1	30.9	15.1	2.88	0
		lower area	42.6	44	9.31	4.14	0
1 573 K	sample without P ₂ O ₅	CaO	86.5	11.9	0.48	1.13	0
		2CaO·SiO ₂	67.8	3.35	28	0.85	0
		Liquid	34	36.2	1.61	1.20	0
		(Mg, Fe)O	1.28	31.6	0.18	67.0	0
		upper area	48.4	31.9	15.6	4.14	0
		lower area	38.4	50.7	6.04	4.87	0
1 623 K	sample without P ₂ O ₅	CaO	87.9	10.2	0.56	1.36	0
		2CaO·SiO ₂	67.2	5.72	26.1	0.90	0
		Liquid	34.9	62.2	1.66	1.20	0
		(Mg, Fe)O	1.61	29.5	0.18	68.7	0
		upper area	50.1	30.1	15.1	4.74	0
		lower area	43.3	42.4	9.92	4.40	0
1 673 K	sample without P ₂ O ₅	CaO	84.2	14.0	0.22	1.60	0
		2CaO·SiO ₂	67.9	3.05	28.0	1.08	0
		Liquid	38.1	57.2	3.60	1.08	0
		(Mg, Fe)O	1.92	33.1	0.10	64.90	0
		upper area	46.4	32.9	16.1	4.63	0
		lower area	36.8	51.5	6.91	4.78	0
1 523 K	sample with P ₂ O ₅ addition	CaO	85.3	13.0	0.16	1.50	0.00
		2CaO·SiO ₂	60.3	1.81	28.4	0.42	9.16
		Liquid	31.8	65.3	1.58	1.05	0.27
		(Mg, Fe)O	3.30	57.0	0.12	39.6	0.00
		upper area	48.0	32.3	12.9	3.06	3.82
		lower area	38.4	48.0	7.73	4.28	1.63
1 573 K	sample with P ₂ O ₅ addition	CaO	90.3	7.89	0.37	1.43	0.04
		2CaO·SiO ₂	60.4	242	28.3	0.16	8.76
		Liquid	32.7	64.7	1.15	1.12	0.36
		(Mg, Fe)O	1.50	37.9	0.18	60.3	0.14
		upper area	49.0	29.5	13.2	3.66	4.65
		lower area	39.6	48.1	7.22	3.84	1.27
1 623 K	sample with P ₂ O ₅ addition	CaO	88.5	10.1	0.17	1.18	0.00
		2CaO·SiO ₂	59.7	3.23	27.9	0.12	9.08
		Liquid	34.7	62.7	1.00	1.32	0.32
		(Mg, Fe)O	1.31	28.5	0.08	70.1	0.03
		upper area	47.4	28.9	15.6	3.72	4.37
		lower area	38.5	50.8	4.87	4.52	1.30
1 673 K	sample with P ₂ O ₅ addition	CaO	87	9.93	0.51	2.49	0.06
		2CaO·SiO ₂	60.0	1.99	29.1	0.08	8.80
		Liquid	36.1	61.9	1.07	0.65	0.28
		(Mg, Fe)O	1.83	32.1	0.10	65.8	0.14
		upper area	46.9	31.6	133.6	4.00	3.92
		lower area	37.5	50.9	6.16	3.60	1.81

with the extrapolation of the reported FeO activity at 1 673 K. The present results are consistent with previous reports and it was confirmed that the equilibrium state was attained in the present work.

It was found that the P_2O_5 content in the CaO and (Mg, Fe)O phases was very small. P_2O_5 was concentrated in the $2CaO \cdot SiO_2$ phase and also distributed in the liquid phase. The phosphorus distribution ratio between the $2CaO \cdot SiO_2$ and liquid phase, L_P , is shown in Fig. 6. The distribution ratio was lower than the results reported by Ito *et al.*⁵⁾ Also, the phosphorus distribution ratio was shown to have little dependence on temperature in the present work, as was also reported by Ito *et al.*⁵⁾

Due to the density difference of the FeO rich liquid phase and the P_2O_5 containing $2CaO \cdot SiO_2$ phase, FeO and P_2O_5 may be separated. The average composition of slag positioning in the upper quarter and lower quarter were analyzed by area analysis by SEM-EDS. The results are given in Table 1. The P_2O_5 concentration of upper part was 2.2–3.6 times higher than in the lower part. Also, the FeO concentration of the upper part was nearly half that of the lower part, confirming that it is possible to separate FeO and P_2O_5 in slag by use of the density difference. However, the effect of temperature is unclear. Ono *et al.*²¹⁾ melted converter slag at 1 873 K and cooled the sample at the rate of 25 K/hour and reported P_2O_5 concentration of upper part was 3.3 times higher than in the lower part. While the heating and cooling procedure was different, nearly the same degree of P_2O_5

Fig. 6. Dependence of iron oxide concentration on phosphorus distribution ratio between the $2CaO \cdot SiO_2$ and liquid phase in the CaO–FeO– SiO_2 system.

concentration was observed. In order to improve the recoverability of P_2O_5 and FeO from steelmaking slag, further improvement of P_2O_5 and FeO separation is required.

3.2. Separation of the Solid $2CaO \cdot SiO_2$ Phase and FeO Rich Liquid Phase by the Capillary Action of Sintered CaO

The composition of the slag before and after the premelted slag was heated in the CaO sintered crucible is shown in Table 2. The average composition of slag positioning was analyzed by area analysis by SEM-EDS. Also, an image of the sample after the experiment is shown in Fig. 7. It was confirmed that the FeO rich liquid phase penetrates the voids of the CaO sinter. When 0.680 g of slag was put in a CaO crucible, the crucible was black and the CaO sintered crucible was not capable of fully absorbing the FeO rich liquid phase during the experiment. When 0.165 g of slag was put in a CaO crucible, the crucible was still white and able to absorb more of the liquid phase. In this case, the remaining slag and crucible could easily be separated and the weight of CaO crucible increased from 1.58 g to 1.69 g, while the slag sample decreased in weight from 0.165 g to 0.055 g. During the experiment, 0.11 g of the liquid phase was absorbed in the CaO crucible. It was confirmed that

Fig. 7. Image of sample after heating the premelted slag in a CaO sintered crucible. (A) Image after the procedure (slag amount 0.680 g), (B) Image the procedure (slag amount 0.165 g), (C) SEM image of the CaO sintered crucible the procedure (slag amount 0.165 g), (D) SEM image of slag the procedure (slag amount 0.165 g).

Table 2. Initial and final slag composition after the procedure heating premelted slag in CaO sintered crucible.

		mass%CaO	mass%FeO	mass%SiO ₂	mass%MgO	mass%P ₂ O ₅
Slag 0.680 g	initial	45.9	36.0	11.6	3.65	3.04
	final	51.8	18.3	19.2	5.23	5.49
Slag 0.156 g	initial	44.5	36.6	11.2	4.77	2.99
	final	56.2	8.34	23.3	5.66	6.54

Table 3. Slag composition before and after the procedure.

	mass%CaO	mass%FeO	mass%SiO ₂	mass%MgO	mass%P ₂ O ₅
initial slag	45.8	43.1	8.10	0.00	3.00
final slag	56.7	10.1	25.1	1.70	6.40

CaO sinter can effectively absorb the FeO rich liquid phase, effectively separating it from the solid $2\text{CaO}\cdot\text{SiO}_2$ phase that includes P_2O_5 . The results indicated a decrease from 36.6 mass% to 8.3 mass% FeO in the remaining slag, while the P_2O_5 content increased from 3.0 mass% to 6.5 mass%. A mass balance calculation indicates that it is possible to recover 73% of the P_2O_5 in the initial slag from the remaining slag which contains the $2\text{CaO}\cdot\text{SiO}_2$ phase. As much as 92% of the FeO in the initial slag was recovered in the CaO sinter, which can be recycled without further treatment. Calculated P_2O_5 concentration in CaO sinter after slag absorption was 0.079 mass%.

In the process described above, it was confirmed that the FeO and P_2O_5 in steelmaking slag can be separated by reheating. It is, however, more convenient to separate on site during slag discharge after the steelmaking process. The possibility of recovering the FeO in the CaO sinter and P_2O_5 from the remaining slag by pouring steelmaking slag directly onto the CaO sinter was investigated. To simulate such an on-site separation method, a sintered CaO sphere was added to a mixture of solid $2\text{CaO}\cdot\text{SiO}_2$ phase and the FeO rich liquid phase. The composition of the slag before and after this process is shown in **Table 3**. The average composition was analyzed by area analysis by SEM-EDS. The image of the sample after this process in **Fig. 8** shows that the sinter was black after reheating. Inside the sinter, the CaO, liquid phase and $2\text{CaO}\cdot\text{SiO}_2$ phase can be observed, suggesting that the $2\text{CaO}\cdot\text{SiO}_2$ phase precipitated during cooling. The liquid phase and $2\text{CaO}\cdot\text{SiO}_2$ phase were found in the remaining slag, with a decreased FeO content from 43.1 mass% to 10.1 mass%, and an increased P_2O_5 content from 3.0 mass% to 6.4 mass%. The amount of in the FeO and P_2O_5 concentration after the removal of the liquid phase by CaO sphere addition to mixture of solid $2\text{CaO}\cdot\text{SiO}_2$ phase and the FeO rich liquid phase is approximately the same as that achieved by slag reheating, as was in the case in the first process.

No change in the composition of the liquid phase was observed with temperature, as can be seen in the results given in Table 1. As such, it can be assumed that the composition of the liquid phase absorbed in CaO sinter is the same as average composition of the liquid phase for sample with P_2O_5 addition shown in Table 1: 33.8 mass%CaO – 63.7 mass%FeO – 1.2 mass%SiO₂ – 1.0 mass%MgO – 1.2 mass%P₂O₅. From the composition difference of initial slag and final slag shown in Table 3, the amount of the liquid phase absorbed into the CaO sinter was estimated by calculating the mass balance of CaO, FeO, SiO₂ and P₂O₅. From the mass balance calculation of four oxides and taking the average value, it was indicated that 0.0885 g of the liquid phase was absorbed into the CaO sinter and 0.0615 g remained in the final slag. It was assumed that solid $2\text{CaO}\cdot\text{SiO}_2$ phase was not absorbed into CaO sinter and remained in the final slag with some amount of liquid phase. These calculations suggest that 90% of FeO can be recov-

Fig. 8. Image of sample after adding the CaO sphere into mixture of solid $2\text{CaO}\cdot\text{SiO}_2$ phase and FeO rich liquid phase. (A) Photo after the procedure, (B) SEM image of slag after the procedure, (C) SEM image of CaO sintered sphere after the procedure.

ered in the CaO sinter and 87% of P_2O_5 is collected in the remaining slag. Since the amount of initial slag was 0.15 g and that of CaO sinter was 0.74 g, it can be assumed that an approximately 5:1 ratio of CaO to slag is required to separate FeO and P_2O_5 in steelmaking slag. These results clearly show that the onsite separation of FeO and P_2O_5 in steelmaking slag is possible, as shown in **Fig. 9**. After separation, the CaO sinter including the FeO rich liquid phase may be used as an Fe source or dephosphorization agent, and the $2\text{CaO}\cdot\text{SiO}_2$ phase including P_2O_5 may be used as a P source.

If FeO in steelmaking slag can be separated and used as a Fe source, the amount of steelmaking slag produced by the steelmaking industry will decrease. The effect of recycling FeO in steelmaking slag on the iron making process was considered. As much as 11.0 million ton of BOF slag was produced in Japan in 2012,²⁾ Considering that 24.6 million ton of BF slag was produced in year 2012, and that the CaO content in BF slag is 41.7 mass%,³⁾ the annual CaO input to the blast furnace can be estimated at 10.3 million ton. If 2 million ton of BOF slag is treated onsite to separate FeO and P_2O_5 using 10 million ton of CaO sinter, and if this CaO sinter is reused as BF input material, it would be possible to reduce the output of steelmaking slag by 18%. From the

Fig. 9. Idea of onsite separation of solid 2CaO·SiO₂ phase and FeO rich liquid phase in steelmaking slag.

recovery ratio of FeO determined in the present work (90%) and FeO content in BOF slag (22.4 mass%³⁾), it would be possible to recover 0.40 million ton of FeO (0.31 million ton of metallic Fe). Considering that the annual amount of pig iron produced in Japan in 2012 was 82.0 million ton,³⁾ 0.31 million ton metallic Fe recovery from BOF slag may be considered as not such a large contribution. However, the potential to decrease the amount of BOF slag emission and the possibility of effective phosphorus recovery from steelmaking slag suggest that the proposed method has the potential to have a significant impact on the steelmaking industry.

4. Conclusion

The phase relationship of the CaO–FeO–SiO₂–P₂O₅ system when coexisting with the 2CaO·SiO₂ and MgO phases was determined. Four phases, CaO, (Mg, Fe)O, 2CaO·SiO₂ and liquid phase, were observed for all samples in the present work. It is suggested that CaO and 2CaO·SiO₂ can coexist with the (Mg, Fe)O phase. The composition change of the CaO, 2CaO·SiO₂ and liquid phases with temperature was small. Composition of liquid and CaO phase was consistent with reported CaO–FeO phase diagram. The activity of FeO in the liquid phase estimated from the composition of the (Mg, Fe)O phase was shown to be in good agreement with the values reported in the literature. It was found out that P₂O₅ was concentrated in the 2CaO·SiO₂ phase and was also distributed in the liquid phase. The phosphorus distribution between the 2CaO·SiO₂ and liquid phase was in reasonable agreement with that indicated in previous reports. Due to the density difference of the FeO rich liquid phase and the P₂O₅ containing 2CaO·SiO₂ phase, the P₂O₅ concentration of the upper part was 2.2–3.6 times higher than in the lower part. Also, the FeO concentration of the upper part was nearly half that of the lower part.

The solid 2CaO·SiO₂ phase and FeO rich liquid phase in steelmaking was separated by capillary action into sintered CaO. The liquid phase penetrated the CaO sinter, making the further separation of the solid 2CaO·SiO₂ phase and FeO rich phase possible. By reheating slag in a CaO sintered crucible, it was possible to recover 73% of the P₂O₅ included in the initial slag as the 2CaO·SiO₂ phase. Also, 92% of the FeO in steelmaking slag was able to be recovered in the CaO sinter. The addition of, a sintered CaO sphere to the

mixture of the solid 2CaO·SiO₂ phase and the FeO rich liquid phase made it possible to recover 87% of P₂O₅ and 90% of FeO from steelmaking slag. It was evident that the onsite separation of FeO and P₂O₅ in steelmaking is possible. The recovered CaO sinter which includes the FeO rich liquid phase may be recycled directly as an Fe source or a dephosphorization agent and the 2CaO·SiO₂ phase including P₂O₅ may be used as a P source.

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