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EFFICIENCY AND EFFECT OF Na_2O ADDITION TO CaO-BASED SLAGS FOR HOT METAL DEPHOSPHORIZATION

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SYNOPSIS : The effect of soda-ash addition to CaO-based slags for hot metal dephosphorization on the phosphorus, vanadium and manganese distribution ratios between slags and hot metal were determined. The efficiency of soda-ash addition was also investigated.

The reduction-loss of sodium in CaO-based slags by silicon in hot metel was completely restrained under the condition of log(B.O.S.)≧2.8 . The equivalents of (CaO) molar fraction to (Na_2O) are, respectively, 1.9 on C_P and 0.9 on C_V.

KEY WORDS : hot metal dephosphorization, soda-ash, CaO-based slag, phosphorus distribution ratio

1. INTRODUCTION : In steelmaking process, selective removal of alloying elements is desired for the purpose of both cutting cost and upgrading of steel. The effect of soda-ash addition to CaO-based slags for hot metal dephosphorization on the phosphorus, vanadium and manganese distribution ratios between slags and hot metal were determined. The efficiency of soda-ash addition was also investigated.

2. EXPERIMENTAL PROCEDURES :
The experiments were carried out at the hot matal dephosphorization station in Fukuyama works[1].
Experimental conditions are shown in Table 1 and 2.

Table 1 Hot Metal Conditions

	Composition(%)						Temper-ature	Heat Size
	[C]	[Si]	[Mn]	[P]	[S]	[V]		
Initial	4.7	.14 ~.24	.16 ~.24	.105 ~.120	.002	.06 ~.07	1290 ~1330 °C	140 ton
Final	4.0	tr.	.14 ~.21	.005 ~.013	.002	.02 ~.03	1290 ~1320 °C	

Table 2 Experimental Treatment Pattern

Material	Unit Consumption	Feeding Method	Feeding Pattern and Feeding Rate 0 5 10 15 20 25 30 (min.)
FeO	24~34 kg/ton	Top Feeding	2.1~3.4 kg/min/ton
Oxygen Gas	4.4~6.5 Nm3/ton	Top Blowing	0.3 0.2 0.3 Nm³/min/ton
CaF2	2.0 kg/ton	Top Feeding	1.0 kg/min/ton
Soda Ash	0~2.5 kg/ton	Top Feeding	1.0 kg/min/ton
CaO	14~17 kg/ton	Injection	0.7 kg/min/ton
Nitrogen	0.7 Nm3/ton	CaO Carrier	0.03 Nm³/min/ton

During the dephosphorization treatment, soda ash was fed in the various stages. Table 3 shows the condition of soda ash addition. Soda ash was fed at the rate of 150 kg/min. The total oxygen feeding rate during soda ash addition was varied between 30 and 100 Nm^3 /min.

Table 3 Experimental condition of soda ash addition

Pattern	Symbol in Fig. 1	Soda Ash Feeding Rate (kg/min)	Oxygen Flow Rate During Soda Ash Addition (Nm^3/min)		
			Gaseous	Solid	Total
A	■	150	30	70	100
B	□			25	55
C	×			0	30

The distribution ratios of phosphorus, vanadium and manganese were calculated by the compositions of the slag and the hot metal after treatment. The yield of soda ash was calculated by the sodium content of the slag and the volume of the slag which was estimated by the balance of phosphorus in the slag and the hot metal.

3. EXPERIMENTAL RESULTS:

A. EFFICIENCY OF SODA ASH ADDITION TO CaO-BASED SLAGS

To express the stage at which the soda ash addition was started, we define the relative oxygen comsumption "Vo" as follows ;

$$\mathrm{Vo}\ (Nm^3/\mathrm{ton}) = \int_{[\%Si]=0.24}^{[\%Si]} (dO/dSi)\,dSi \qquad (1)$$

$$\text{where}\quad dO/dSi\ (Nm^3/kg) = \begin{cases} 1.35 & ([\%Si]_{HM} \geqq 0.24\%) \\ 1.35/[\%Si]_{HM} & ([\%Si]_{HM} \leqq 0.24\%) \end{cases} \qquad (2)$$

$[\%Si]_{HM}$ is the silicon content of hot metal at the start of soda ash addition

Fig.1 shows the relationship between "Vo" and the yield of sodium. The loss of sodium increased as the oxygen flow rate during soda ash addition decreased from 100 Nm^3/min (pattern A) to 30 Nm^3/min (pattern C). In case of "pattern C", the loss of sodium increased as Vo decreased. These indicate that sodium cation in the slag was reduced by silicon in the hot metal and that the reduction of sodium cation by silicon conflicted with the reduction of oxygen.

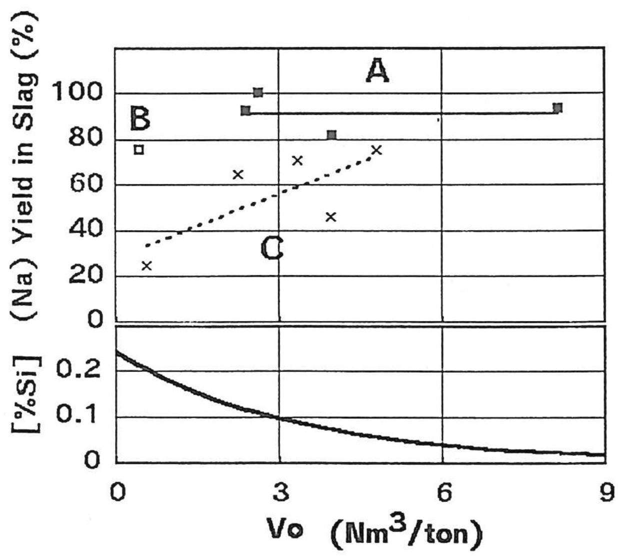

Fig.1 (Na) Yield in Dephosphorization

B. EFFECT OF SODA ASH ADDITION TO CaO-BASED SLAGS

The phosphorus and vanadium capacities are defined by equations (3), (4), (5)[2], (6)[3] and (7)[3] respectively.

$$Cp \equiv (\%P)/(fp \cdot [\%P] \cdot ao^{5/2}) \tag{3}$$

$$Cv \equiv (\%V)/(fv \cdot [\%V] \cdot ao^{5/2}) \tag{4}$$

$$\text{where} \quad ao = N_{FeO} \cdot 1.6 \cdot 10^{(-6030/T+2.5)} \tag{5}$$

$$\log fp = 0.13 \cdot [\%C] \tag{6}$$

$$\log fv = -0.34 \cdot [\%C] \tag{7}$$

Fig.2 shows the relationship among phosphorus, vanadium capacities (Cp, Cv) and sodium content in the slag at the end of treatment.

Phosphorus and vanadium capacities were, respectively, found to increase approximarely 60 % and 30 % as the content of sodium in the slag increased by 1%. These effects of sodium addition are 15~25% of the published results on equibrium[4], [5].

Cv and Cp were represented by using the molar fractions of CaO and Na_2O in the slag as follows ;

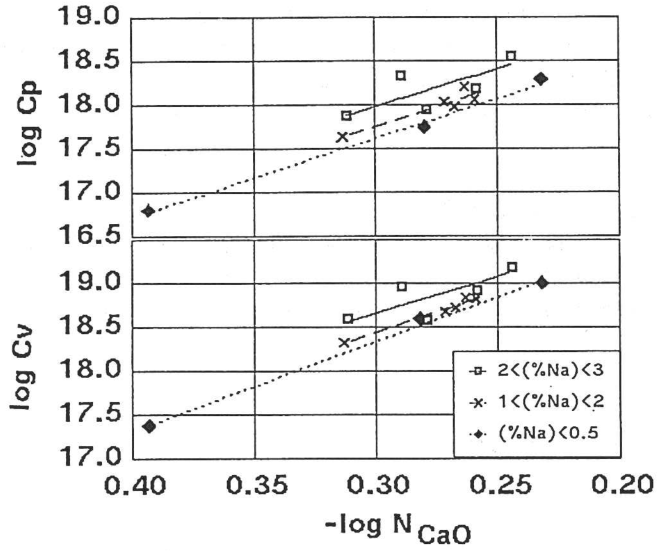

Fig.2 Dependence of Phosphate and Vanadate Capacities for NRP Slag on (Na) Content

$$\log Cp = 10 \cdot \log(N_{CaO} + 1.9 \cdot N_{Na_2O}) + 20.6 \tag{8}$$

$$\log Cv = 10 \cdot \log(N_{CaO} + 0.9 \cdot N_{Na_2O}) + 21.3 \tag{9}$$

Fig.3 shows the effect of sodium addition to the slag on the relationship between phosphorus and manganese distribution ratios. The manganese distribution ratio was found to decrease approximarely 40 % at a fixed phosphorus distribution ratio as the content of sodium in the slag increased by 1%.

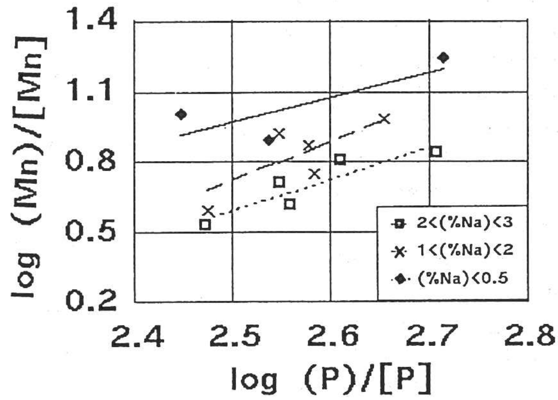

Fig.3 Relationship between (P)/[P] and (Mn)/[Mn]

4. DISCUSSION :

EFFICIENCY OF SODA ASH ADDITION TO CaO-BASED SLAGS

It was shown that sodium cation in the slag was reduced by silicon in hot metal and that the reduction of sodium cation by silicon conflicted with the reduction of oxygen.

So reduction loss of sodium cation can be expressed by using the balance of oxygen feeding rate and silicon transport rate on the boundary surface between slag and hot metal. B.O.S. (Balance of Oxygen and Silicon Feeding Rate) is defined as ;

$$\mathrm{B.O.S.} \equiv Q_{OX} \cdot \tau_{90} / W_M / [\%Si] \quad (10)$$

where Q_{OX} is the oxygen feeding rate (Nm³/min), τ_{90} is the 90% mixing time of the bath (sec.) and W_M is the weight of hot metal (ton). The 90% mixing time of the bath was measured by using copper as the tracer (Fig.4).

Fig.5 shows the relationship between B.O.S. and the yield of sodium. Reduction of sodium cation in the slag by silicon in the hot metal was restrained under the condition of ;

$$\mathrm{B.O.S.} \geqq 10^{2.8} \quad (11)$$

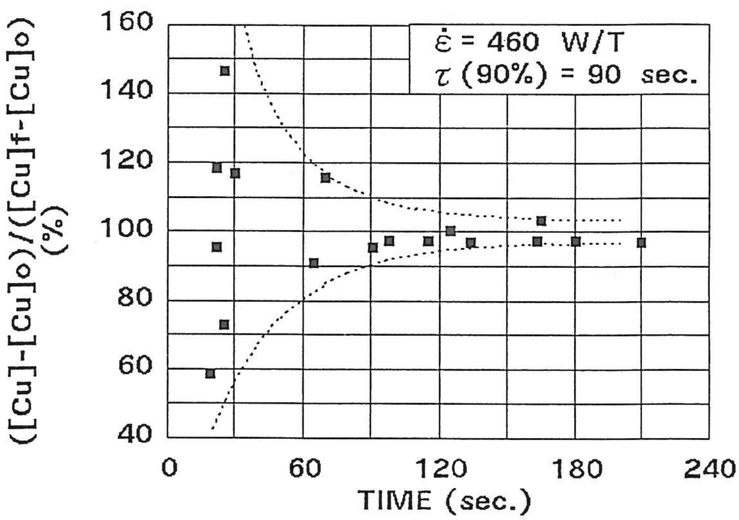

Fig.4 Mixing time during the treatment

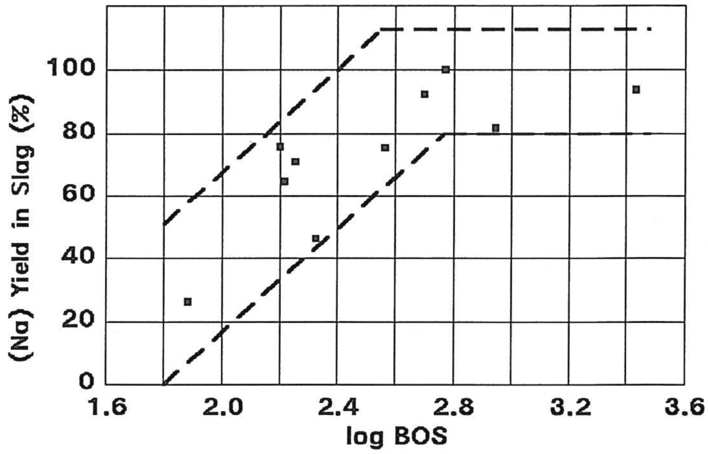

Fig.5 Relationship between B.O.S. and (Na) yield

5. CONCLUSIONS :

A. The reduction-loss of sodium cation in CaO-based slags by silicon in hot metel was completely restrained under the condition of
   log(B.O.S.) ≧ 2.8 .

B. The equivalents of (CaO) mole fraction to (Na_2O) are, respectively,
   1.9 on Cp and
   0.9 on Cv .

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