SORELMETAL

TECHNOLOGY DEPARTMENT

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Thermodynamic Evaluation of Boron Removal from Ductile Iron Melts

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1.0 INTRODUCTION

The contamination of Ductile Iron melts by boron has been reported more and more frequently in the last few years. Boron was reported to offset the pearlite promoting effect of copper and, as a result, the manufacture of fully pearlitic castings was made more difficult in presence of boron. As little as 0.002% boron was reported to be detrimental.

It was recently proposed by Dr R. Naro that sodium could be a good candidate for removing boron from Ductile Iron melts, and an experimental program was proposed to DIS. Prior to perform the tests, Rio Tinto offered to carry out thermodynamic simulations to verify if the reaction of sodium compounds with boron is theoretically possible. The results are presented below.

2.0 TETS PARAMETERS

The thermodynamic calculations were run using the FACTSAGE data base of École Polytechnique de Montréal. Note that this simulation is purely thermodynamic and does not include kinetics factors that may influence the reactions under production conditions.

The chemical composition of the iron is listed in Table 1; a boron concentration of 0.002% was taken as the reference level. The different mixtures injected in the liquid iron are listed in Table 2. Simulations were run at 1400 and 1550 ^{o}C.

Table 1 Chemical Composition of the Liquid Iron

Elements	Weight %
Fe	94.07
C	3.70
Si	2.00
Mn	0.20
P	0.02
S	0.01
B	0.002

Table 2 Mixtures Injected

Test #	CaO	SiO_2	Na_2O	Na_2CO_3	kg/t
1	50 %	50 %	0	0	20
2	40 % min	40 % min	Up to 20 %	0	Up to 40
3	0	0	0	100 %	Up to 100

3.0 RESULTS

3.1 Injection of SiO_2 + CaO

At the selected test temperatures, this mixture forms pseudo-wollastonite and remains solid; no reaction with boron is predicted by the model.

3.2 Injection of SiO_2+CaO+Na_2O

Adding Na_2O reduces the melting point of SiO_2+ CaO and the resulting slag can then absorb B_2O_3.

The effect of injecting up to 20% Na_2O in the CaO-SiO_2 mix is shown in Figure 1. Boron removal is significantly more efficient at 1400 ^oC and a minimum concentration of about 0.0011% B is reached with a mix containing 5% Na_2O. Increasing the Na_2O content above 5% does not improve boron removal.

When injected at 1550 ^oC, sodium tends to vaporize as elemental sodium or as NaO.BO. It creates a deficit in sodium that reduces the amount of liquid slag at equilibrium and its ability to absorb boron.

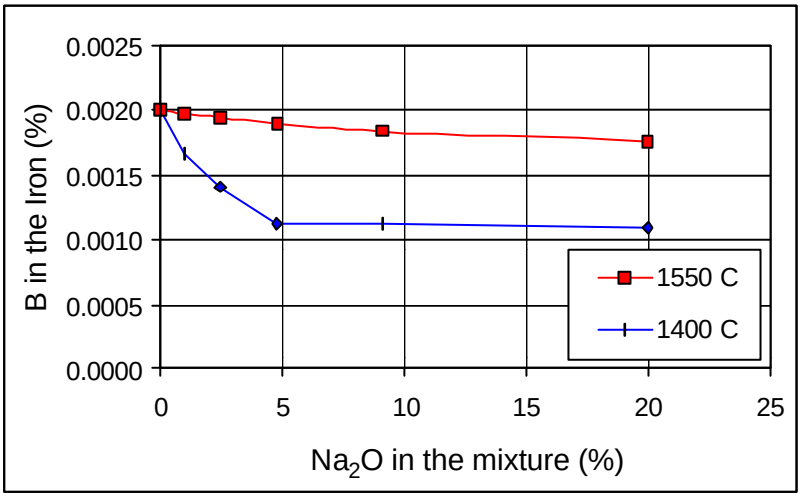

Figure 1 Boron Removal by Injection of SiO_2-CaO-Na_2O (20 kg/t)

The effect of slag basicity (%CaO/%SiO_2) was verified for a mix containing 20% Na_2O. Increasing the basicity (increasing the amount of CaO) decreases the boron removal efficiency by reducing the solubility of boron in the slag. The effect is seen at both test temperatures.

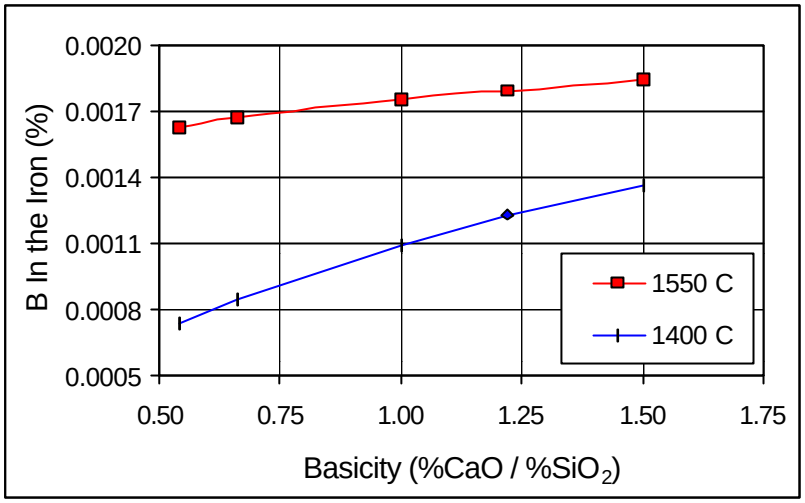

Figure 2: Effect of Injection Mixture Basicity on Boron Removal (20 kg/t, mix containing 20% Na_2O)

The effect of the amount of injected material for a mix containing 5% Na_2O (optimum as seen in Figure 1) with a basicity of 1 was also verified. Very little effect is seen at 1550 ^oC; however, increasing the injected amount of material up to 40 kg/t at 1400 ^oC reduces the boron content to 0.0008%.

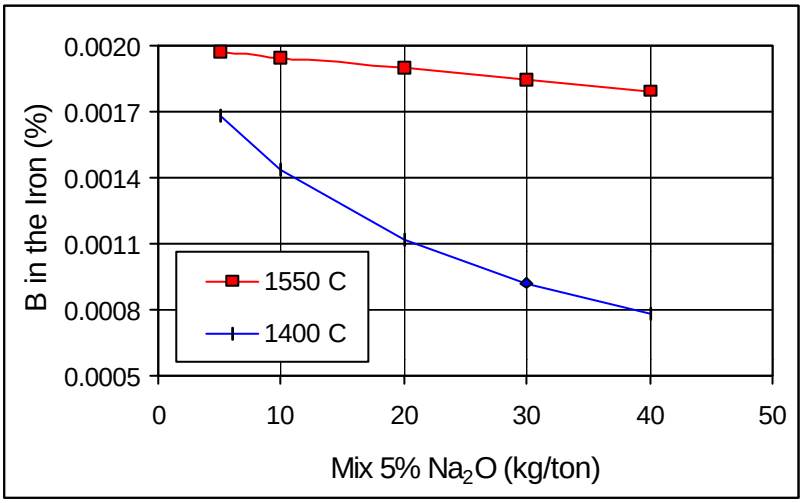

Figure 3. Effect of the Amount of Injected Mix (5% Na_2O) on Boron removal.

3.3 Injection of Na_2CO_3

Figure 4 presents the effect of Na_2CO_3 injection on boron removal at 1400 and 1550 ^oC. It shows that Na_2CO_3, when injected at a rate of 20 kg/t at 1400 ^oC, reduces the

boron concentration to 0.0004%; injecting 100 kg/t reduces it to 0. As the temperature is increased, the efficiency decreases. At 1550 °C, injecting about 60 kg/t is needed to reach 0.0004% B.

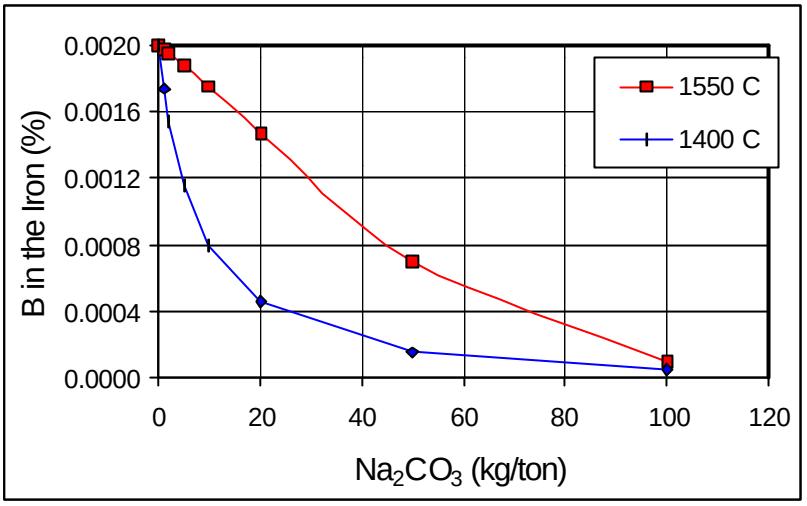

Figure 4. Effect of Na_2CO_3 Injection.

When injected, Na_2CO_3 decomposes to Na_2O and CO_2 and results in the formation of a $Na_2O - SiO_2$ slag (silicon in liquid iron is oxidized by CO_2). At high temperature, the efficiency is reduced due to the vaporization of sodium and other compounds.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Based on thermodynamic calculations for boron removal in Ductile Iron melts, the following conclusions can be drawn:

- Sodium compounds are efficient to remove boron from liquid iron.
- A mixture of $CaO-SiO_2$-5% Na_2O injected at a rate of 20 kg/t at 1400 °C allows to reduce the boron content from 0.002% to 0.0011%; increasing the amount injected to 40 kg/t allows to reach 0.0008%.
- Na_2CO_3 is very efficient to remove boron; when injected at a rate of 20 kg/t at 1400 °C, the boron content decreases from 0.002% to 0.0004%.
- In both cases, increasing the liquid metal temperature decreases the efficiency of the boron removal process.