INDUSTRIAL APPLICATION OF ALUMINIUM SLAG IN STEELMAKING PROCESS

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Introduction

In the production of aluminium, a lot of aluminium slags were generated. Many trials have been done all over the world to recycle aluminium slag in most economic ways. Waste aluminium slag was used as raw materials to make calcium aluminate cement "refractory cement" or to synthesise mullite materials, which belongs to the comprehensive utilisation of wastes with a great economic and environmental significance[1,2]. Aluminium slag contains a lot of Al_2O_3 and elemental aluminium inside which could be used to improve the properties of the refining slag in the steelmaking process. The elemental aluminium is used as deoxidiser, while Al_2O_3 can improve the fluidity of the refining slag. A large amount of steel was produced in China and a lot of refining slags were needed for steelmaking, especially for the production of high quality steel. So, large amounts of aluminium slags could be utilised with a great environmental significance. Aluminium slag can be added into the refining slag with CaO in the steelmaking process. Then the slag will have both a good fluidity and a good deoxidation ability which have great benefits for the production of clean steel.[3,4].

Experimental procedure

The element composition for the slag was analysed by x-ray fluorescence spectrometry (RIX, 3000X, Japan) and was represented by the CaO-Al_2O_3-SiO_2 ternary phase diagram according to the variations of slag types at different times. The steelmaking process of production for trials is Pre-treatment of hot metal → LD → LF refining → Calcium treatment → CC (continuous casting) as shown in Figure 1. In this steelmaking process, deoxidation was done by SiMn alloy after the LD process and deep desulphurisation (≤ 50ppm) and the alloying composition was adjusted in the LF refining. The protection of the casting was enhanced to prevent secondary oxidation. The process of calcium treatment was also used to control the morphology of inclusions.

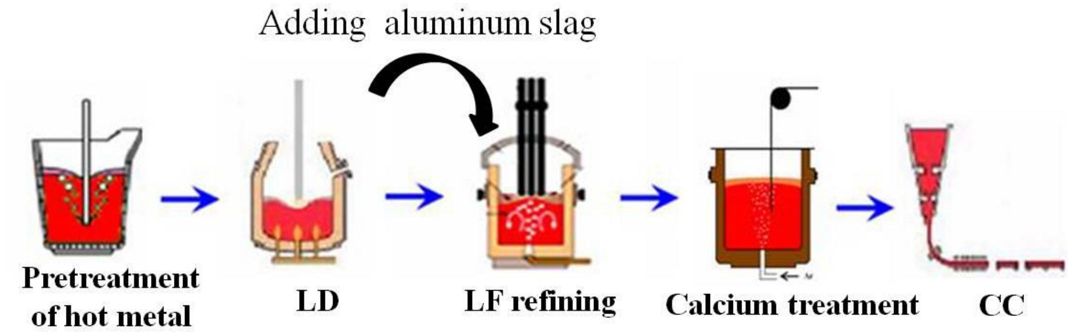

Figure 1: The steelmaking process of trials and position of adding aluminium slag

The aluminium slag was pressed into ball shape with a size of 40 mm in diameter and added into the ladle at the beginning of the LF refining process with CaO. The composition is shown in Table 1.

Table 1: The main composition of aluminium slag, wt%

Al	Al_2O_3	SiO_2
1-5	73-78	1-2

Results and Discussion

The composition of the slag in the steelmaking process is shown in Figure 2. BW, EW, BS and ES is at the beginning of LF refining for weak deoxidation (SiMn alloy as the deoxidiser), at the end of LF refining for weak deoxidation, at the beginning of LF refining for strong deoxidation and at the end of LF refining for strong deoxidation (Al alloy as the deoxidiser), respectively. According to the variations of slag types at different times, the composition of the slag changed a little in content of Al_2O_3 in the slag for the BS and ES process. But the change of the slag under weak deoxidation mode is obvious, mainly needing to improve the alkalinity of the slag and increase the Al_2O_3 content in the slag. It shows that under the weak deoxidation mode, the task of slagging is heavier, which prolongs the desulphurisation time.

The content of (FeO+MnO) is used to present the oxidising ability of the slag. The content of raw slag is 0.5-2% and 8-15% for strong deoxidation and weak deoxidation, respectively. The result for oxidising ability change of the slag is shown in Figure 3 for different deoxidisers after adding aluminium slag. For the weak deoxidation process, the oxidising ability is significantly reduced which has great benefits for the production of clean steel. The Al_2O_3 content is also significantly improved which can increase the fluidity of the slag and promote the absorption capacity of the inclusions.

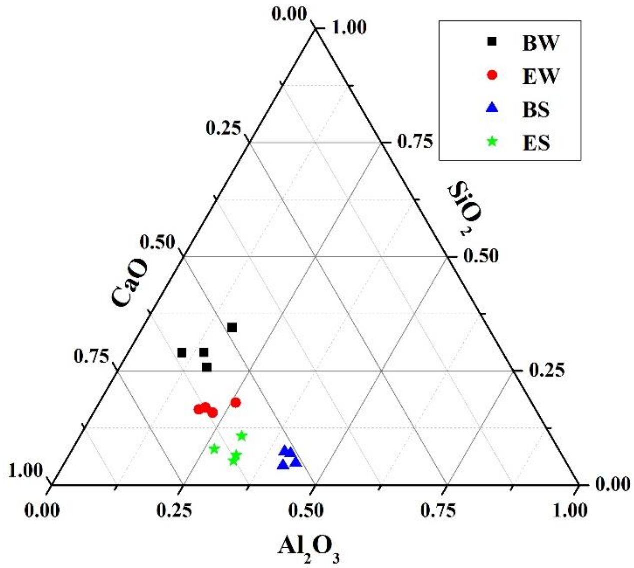

Figure 2: The composition of the slag at different times with different deoxidation agents

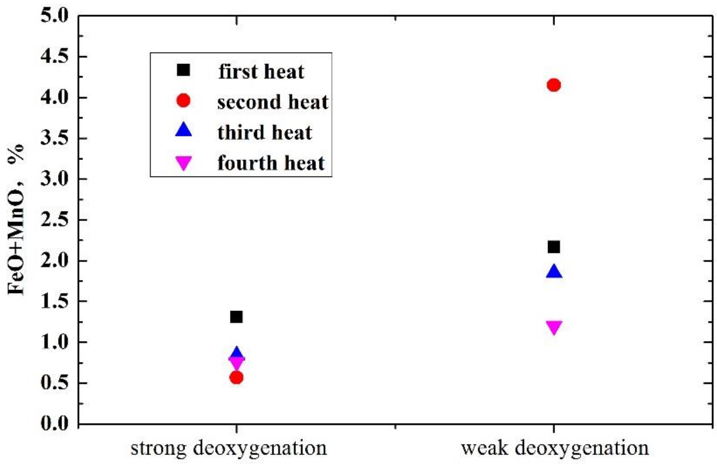

Figure 3: (FeO+MnO)% in the slag for different deoxidation agents

Figure 4 shows the effect of changing the temperature of the molten steel and the ratio (Al_2O_3)/(CaO) on the sulphur equilibrium distribution ratio(Ls) under the condition of CaO-Al_2O_3-8%MgO-7%SiO_2. It can be seen that Ls decreases as the (Al_2O_3)/(CaO) increases. Adding aluminium slag can increase the Al_2O_3 content to 20%-30% which has a large Ls. By increasing the Al_2O_3 content in the slag and increasing Ls among the slag and steel, not only the subsequent addition of Al content is reduced, but also the pre-desulphurisation has certain benefits, and the subsequent desulphurisation pressure is reduced. Another significant contribution to the increase in Al_2O_3 content is the reduction of the melting point of the slag. If the Al_2O_3 content of the slag is increased to 20%, the melting point of the slag will be reduced by an average of 117°C which has great benefits for improving the time of the slagging process. From the average result of the trials, weak deoxidised steel can shorten the time of the slagging process of 2-3 min.

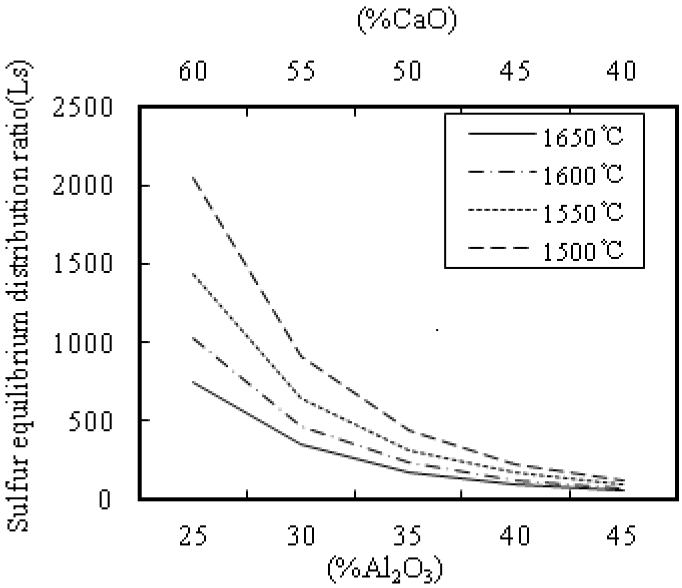

Figure 4: Sulphur equilibrium distribution ratio of different temperatures and different $(Al_2O_3)/(CaO)$

Conclusions

The effect of industrial application of aluminium slag is analysed in the steelmaking process. Aluminium slag as the industrial material could replace some natural deoxidation agents like Al. The following conclusions can be drawn:

1. For the weak deoxidation process, the oxidising ability is significantly reduced which has great benefits for the production of clean steel by adding aluminium slag.
2. Adding aluminium slag can increase the Al_2O_3 content to 20%-30% which has a large Ls which can reduce the subsequent addition of Al content and the subsequent desulphurisation pressure.
3. From the average result of the trials, weak deoxidised steel can shorten the time of the slagging process of 2-3 min by adding aluminium slag.

References

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