

Practice of Hot Metal Desulfurization Using Magnesium at Baosteel

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[Abstract] Desulfurization of hot metal using granulated magnesium at Baosteel is presented. Ultra low sulfur content of hot metal is achieved. Desulfurization using magnesium is proved to be cost efficient compared to the current lime/carbide technology.

Key words: hot metal; desulfurization; magnesium; cost efficient.

1 Introduction

There are two BOF shops and one EAF shop in operation at Baosteel with a productivity of 12 million tons crude steel which covers plate, pipe and wire products. The hot metal is partly desiliconized at blast furnace, and the whole hot metal is desulfurized in torpedo car with lime/ carbide. At No.2 BOF shop, dephosphorization is also performed to part of hot metal (Figure 1). After pretreatment, sulfur content can be reduced to 0.006% below and phosphorus to 0.030% below. In secondary refining, RH, LF, VD and WF are available. Due to customers' high demand on steel quality, ultra low sulfur content, which can hardly be achieved by conventional calcium based desulfurization reagent, is strictly required in part of our products, such as X-series pipeline steel, corrosion resistance steel etc. This requirement for lower steel sulfur levels has resulted in the introduction of magnesium desulfurization process. A new installation, which desulfurizes hot metal in transfer ladle using magnesium, was commissioned in 1998. This project enables us to produce steel with much lower sulfur content.

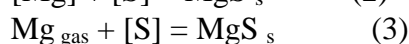
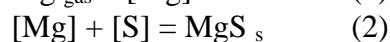
2 Magnesium injection process

The plant is installed at No.1 BOF shop (Figure 2). Hot metal is transported by torpedo car from BF. Torpedo cars are equipped with a skimmer plate to ensure as little as possible of the sulfur-rich slag is decanted from the torpedo car to transfer ladles. After hot metal being charged to transfer ladle and sampling, desulfurization is performed. The capacity of transfer ladle is 300 tons. The desulfurization reagents consist magnesium and carbide with a certain ratio. The injection lance is deeply submerged in hot metal to blow reagents. The injection duration is about 6~8 minutes. Before the treatment is finished, temperature is measured and sample is taken. And then hot metal is deslagged with a skimmer prior to being charged to converter. The final sulfur content is below 0.005% depending on steel grade to be produced (Figure 3). Ultra low sulfur content, lower than 10 ppm, can also be achieved. The magnesium consumption is 0.3~0.40 kg per ton. The temperature drop is about 8~15 °C. 1.5 million tons of hot metal can be treated annually.

3 Discussion

Compared to other desulfurization reagent like lime or carbide, magnesium is much more expensive. Therefore all the measures lowering magnesium consumption will contribute to cost reduction.

Due to its low vaporization point, magnesium granule vaporizes immediately as soon as its introduction to hot metal. Magnesium vapors float up and gradually dissolve (Reaction 1).



Because of high affinity of magnesium for sulfur, interaction takes place. Desulfurization reaction occurs simultaneously in two ways: the homogeneous reaction between magnesium dissolved in hot metal and sulfur (Reaction 2), and the heterogeneous reaction between the gaseous phase of magnesium and sulfur at the bubble interface (Reaction 3). The first way is the dominating one^[1]. So the dissolution of magnesium in hot metal is of vital importance, the degree of magnesium utilization depends mainly on the completeness of the dissolving of magnesium vapor in hot metal. Therefore, the more favorable the condition for dissolving of magnesium, the higher the degree of its utilization. The factors which promote the dissolution of magnesium vapor in hot metal, according to our practice, are: lowering hot metal temperature; enlarging reagent- carrier gas ratio to reduce the bubble sizes and increase the magnesium bubble interfaces in hot metal; increasing the residence time of reagent which is achieved by introducing magnesium into ladle at a greater depth; and increasing the partial pressure of magnesium in the bubble and static pressure in the area of magnesium introduction by adopting a slim shaped transfer ladle.

After magnesium is introduced into hot metal, vapor is formed and causes the stirring of hot metal, then magnesium vapor mostly dissolves in hot metal and magnesium mainly reacts with sulfur homogeneously. These properties distinguish magnesium as a desulfurization reagent from such material as lime and carbide which remain in the form of solid particles after being introduced into hot metal.

According to Reaction 3, $m = [\text{Mg}] \cdot [\text{S}]$ can be drawn. Coefficient m is only determined by temperature. Therefore in sulfur bearing hot metal, a certain magnesium content needs to be achieved before desulfurization reaction proceeds. The lower the final sulfur content, the higher the magnesium content should be satisfied, in other words, the more the portion of magnesium consumed in dissolution. According to our practice, when sulfur being removed from 0.012% to 0.002%, the final dissolving magnesium content is 0.0227% which is approximately 3 times as much as the magnesium used for decreasing sulfur.

Magnesium dissolved in hot metal is also capable, because of its high chemical affinity, of interacting with oxygen both dissolved in hot metal and present in form of oxide nonmetallic inclusions. Thus slag skimming is necessarily performed during hot metal being charged to transfer ladle from torpedo car. Otherwise low basicity BF slag will cause a significant drop of magnesium utilization of desulfurization.

At the initial period after the commission, injection lance is regularly plugged due to injection pulsation resulting in standstill. After lance structure is modified and the fluidity of both magnesium and carbide are improved, the operation proceeds smoothly.

Based on nearly two years desulfurization practice, comparisons are made between the co-existing magnesium- carbide desulfurization in ladle and carbide and lime desulfurization in torpedo car (Figure 4). The overall cost covers reagent consumption, lance lining, carrier gas consumption and metal loss caused by deslagging. Taking into account of overall cost, temperature loss and injection duration, it can be concluded that magnesium desulfurization is more cost efficient than other technology.

4 Conclusion

Practice of hot metal desulfurization using magnesium is introduced. Cost comparisons are made based on production data and it can be concluded that the desulfurization of hot metal by magnesium is more cost efficient than other technology.

Reference

[1] I. A. Barannik, A. F. Shevchenko, Y. M. Riabukhin, Granulated magnesium and practice of using it for molten metal treatment, 51th IMA Proceedings, P.86, 1994

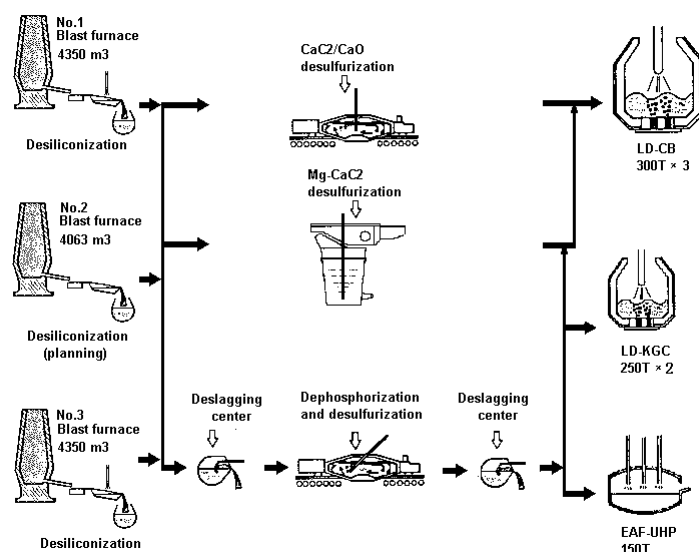


Fig. 1 The material flow of hot metal at Baosteel.

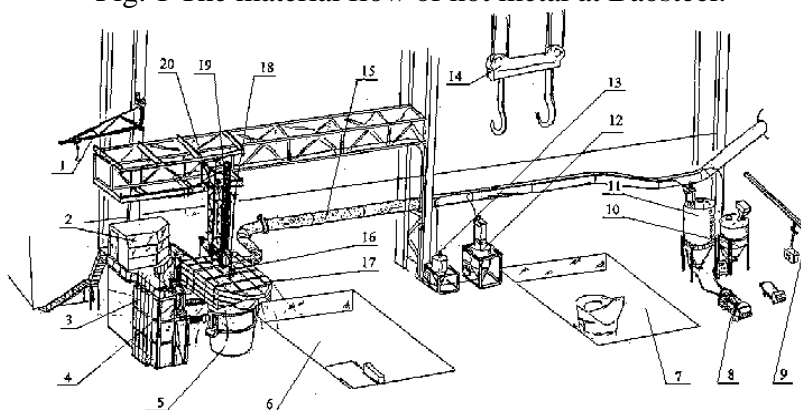


Fig. 2 Arrangement of hot metal desulfurization installation

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|----------------------|---|------------------------|---------------------|
| 1 hoist apparatus | 2 operation room | 3 lance for substitute | 4 probe replace |
| 9 crane | 5 hot metal ladle | 6,7 No.1&No.2 pit | 8 carbide tank |
| 13 Mg injector | 10 Mg silo | 11 carbide silo | 12 carbide injector |
| 17 hood | 14 430 tons crane | 15 flue | 16 injection lance |
| 19 injection guiding | 18 temperature measurement and sampling apparatus | | |

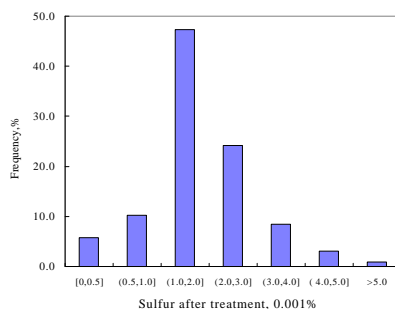


Fig. 3 Final sulfur content distribution

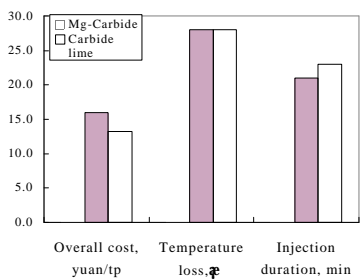


Fig.4 Comparison of different reagent desulfurization

Tab. 1 hot metal initial composition and temperature

Si, %	Mn, %	P, %	S, %	Temperature, jæ
<0.40	0.35~0.40	0.070~0.080	0.020~0.025	1360~1400