The Production of Purified MnSi Alloy

Dong Ying Ye Yunfeng
Jilin Ferroalloys Corp.
Jilin 132002 China

ABSTRACT

This paper describes the production of silicon manganese with silicon content over 28% in 9000-20000KVA submerged arc furnace and specific measurements taken during the production. To reduce the impurities, the Mn-Si alloy with silicon content more than 25% reacts with a kind of basic slag, the phosphorous and carbon can be reduced to 0.05%, sulfur reduced to 0.005%. The dephosphorous rate, decarbon rate and desulfur rate can reach 50%.

1 INTRODUCTION

Typically, the production of high silicon Mn-Si is in 1000KVA furnace in China. The cost of products is much higher and can hardly make large-scale production. The measurements of producing high silicon MnSi in large submerged-arc furnaces is as follows: Chosing suitable

Manganese ore, selecting appropriate coke sizes, different furnaces adopting different slag types, that is the smaller size furnaces use high MgO slag while the larger one use high CaO slag, so the basicity, temperature and viscosity are suitable for the production of high silicon Mn-Si alloy. Although selecting good quality Mn ore or increasing silicon content in high Si MnSi production will decrease the impurity, there are still limitations. Specific treatment has to take. By comparing different agent, which can decrease impurity. CaO-CaF2 was chosen in order to decrease cost. Results are satisfying

2 HIGH SI MNSI ALLOY PRODUCTIONS

2.1 EQUIPMENT DESCRIPTION

The furnaces capacities we used in the production of high Si MnSi alloy are 9-20MW. Their typical parameters are shown in table 1.

Table1 main furnace parameters

Capacity MW	9	20
Rated power MW	7.4	14
Polar center diameter mm	950	1300
Hearth diameter mm	5550	7500
Hearth height mm	2000	2750
Secondary Voltage V	128 (132)	152-155 (161)

() The voltage used when producing low Si MnSi alloy.

2.2 PRODUCTION DATA

The production of high Si MnSi alloy is carrying out in 9-20MW submerged-arc furnaces. Although the two furnaces adopted different raw material and correspondently producing different slag constituents, the results are satisfying. The production process is very stable and can make large scale production

Tab.2 production data

Capacity MW	Raw material (Kg)/per batch								
	Mnore	Mnore	HCslag	LCslag	Coke	Silica	Fluorite	FeSi*	Mgslag
9	240		260		235	215	30	600	150
20	280	50		170	200	160		550	

Capacity MW	Alloy composition %				Slag constituent %					
	Mn	Si	C	P	Mn	SiO2	CaO	MgO	Al_2O_3	FeO
9	61.27	28.81	0.062	0.090	4	46	15	15	7	0.5
25	60.93	30.66	0.059	0.075	3	42.6	32.5	3.6	10.4	0.3

*: The total amount of FeSi charged in each tap.

□HC: high carbon FeMn   LC: low carbon FeMn

2.3 CHARACTERRISTICS OF HIGH SI MNSI PRODUCTION

Tab.3 Comparison between high Si MnSi and low Si MnSi

Capacity MW		Slag constituents %						B_3	Melting Point℃	Viscosity	Si Yield
		Mn	SiO_2	CaO	MgO	Al_2O_3	FeO				
9	Low Si	10	42	25	4	7	0.3	0.73	1340	7.3	38
	HighSi	4	46	15	15	10	0.3	0.78	1470	7.0	50
25	Low Si	9	40	25	5	12	0.3	0.80	1368	7.0	50
	HighSi	3	42.6	32.5	3.6	10.4	0.3	0.88	1370	6.4	60

$B_3 = CaO + 1.4 \times MgO/SiO_2$

Tab.3 is the comparison between high Si MnSi and low Si MnSi alloy. Its slag smelting temperature and viscosity are nearly the same that is the key of MnSi production. But the silicon reduction rate increase greatly and Mn content in slag is less than low Si MnSi production.

2.4 SELECTING SUITABLE SLAG CONSTITUENTS

Traditionally raw material which containing high CaO are used in the smelting of MnSi alloy to adjust the basicity of slag to be sure the slag discharged out smoothly. Another way to adjust slag bascity is to adopt raw material which containing high MgO content. Production trials confirm the effect of MgO replacing CaO in slag, especially in the use of small-scale furnaces.

We can see from following thermodymic data:

$CaO+SiO_2=CaO.SiO_2$

□G_1=-5200-8.8T

$MgO+SiO_2=MgO.SiO_2$

□G_2=5700-7.7T

$MnO+SiO_2=MnO.SiO_2$

□G_3=-5920+3.0T

When the temperature is around 1500□,$CaO.SiO_2$ is more stable than $MgO.SiO_2$.If the amount of CaO increase, the activity of SiO_2 will decrease. While increasing the amount of MgO would not decrease the activity of SiO_2 as CaO does, at same time it still can adjust the slag constituents .In this way it is benefit for the reduction of silicon.

2.5 INCREASE [SI] BY ADDING FESI

The key of high Si MnSi production is the reduction of silicon. It is more difficult for 9MW furnace to produce high Si MnSi alloy because the tapping temperature of bigger furnace is usually higher than that of small one, so are the power density and the heat efficiency. The higher temperature of the hearth is more benefit to silicon formation both in thermodynamic and in kinetic of reduction process. Adding FeSi is a quick and efficient way to increase Si content in MnSi alloy. Whether adding FeSi or not depends on the cost of FeSi.

2.6 SELECTING OF COKE SIZE

From the profile chart of MnSi furnace, a layer of coke can be seen. The thickness of this coke layer is very important for quicken of reduction and power distribution. The size of coke decides the thickness of coke layer. The burning loss of coke is great because of the high temperature of high Si MnSi smelting, so the selection of coke size is very important. Production proves that the coke size range narrow up. The less the upper and lower sizes are, the better.

3 THE PRODUCTION OF PURIFIED MNSI ALLOY

We can see from table2 that the carbon and phosphorous content are all over 0.05%. The carbon content depends on the silicon content. Increase the silicon content will correspondently decrease the carbon content. But it is not economic to increase [Si] content in order to decrease [C] content, for the power consumption will increase. From production experiments we can see when silicon is over 30%, the carbon will mostly be below 0.05%.

Phosphorous in MnSi alloy mainly comes from manganese ore and coke. It is limited to produce P<0.05% MnSi alloy with present raw material in China.

By semi-industry trial we select CaO-CaF_2 as dephosphorous agent. Put solid MnSi alloy and CaO-CaF_2 slag in a 1MW fixed furnace. After they melt together and react for nearly 1 hour, the contents of phosphorous carbon and sulphur decrease greatly.

Table 3 Comparison of MnSi alloy before and after dephosphorous treatment.

Treatment	Alloy composition %				
	Mn	Si	C	P	S
Before	61.00	30.70	0.060	0.09	0.01
After	60.00	30.73	0.033	0.033	0.005

Experiment proves CaO-CaF_2 (1:1) is effective only to Si>25% MnSi alloy. The higher the silicon content is, the higher of dephosphorous rate for a fixed slag/metal rate in 1350-1450℃. But when silicon is over 33%, the dephosphorous rate changes little.

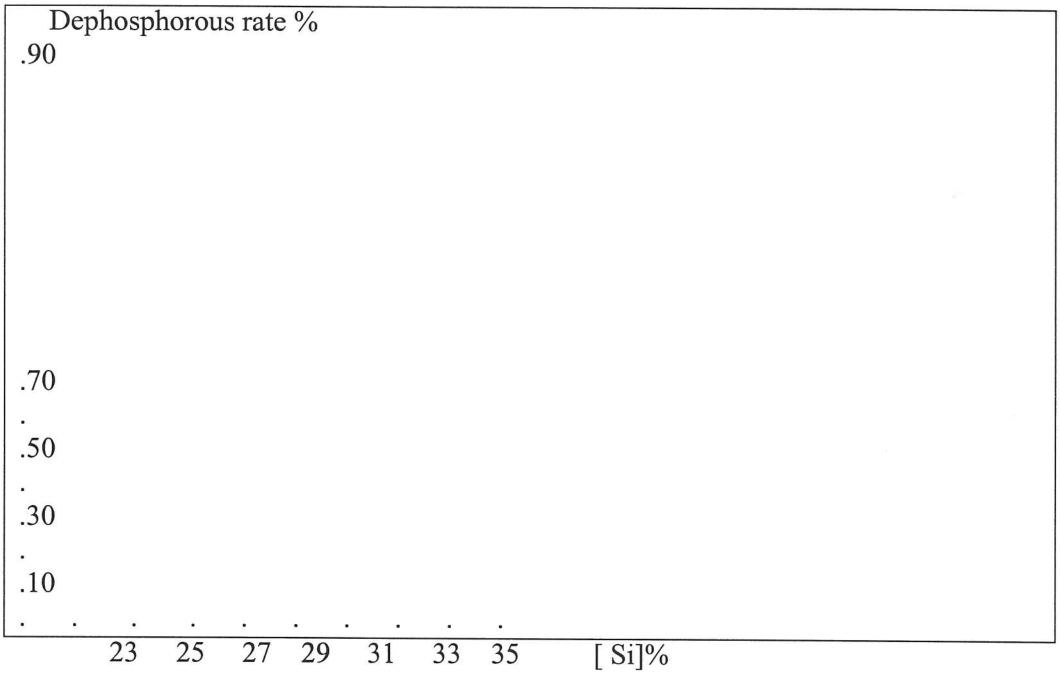

Fig.1 Relationship between [Si] and dephosphorous rate

4 DISCUSSIONS

Although the result is satisfying the purifying process still need to be improved. With the restriction of experimental condition, the shortness is mainly as follow: The purifying process was carrying out in a fixed furnace. the MnSi alloy and slag can not thoroughly mixing and reacting. It had to increase slag/metal ratio and prolong time to compensate. So the slag needed is much great and Mn, Si losses increase with time going on. so does the power consumption.

To solve above problems, a premium process needed is as follow: that is first smelting $CaO-CaF_2$ slag, then pouring this slag and liquid MnSi alloy into a shaking ladle where the reaction will take place. In this way the slag/metal ratio and power consumption will decrease greatly.

5 CONCLUSIONS

5.1 It is a great breakthrough to produce Si>28% MnSi alloy in bigger submerged-arc furnace in China. The key is to select rational slag constituent and coke size.

5.2 5.2 It is benefit to adopt high MgO slag in small furnace to increase Si recovery.

5.3 5.3 The [p] content in MnSi alloy mostly depends on the [p] content in raw material. With $CaO-CaF_2$(1:1) slag reacting with MnSi alloy, slag/metal ratio 60%,the dephosphorous rate can be over 60%,decarbon rate and desulphur rate over 50% in 1350-1450℃.