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Prediction of Sulphur in Blast Furnace Pig Iron through Regression Analysis

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Abstract

Most of the pig iron that is produced is subsequently converted to steel and it must not contain more than 0.04% Sulphur and more often not more than 0.03% Sulphur in order to economize the process of steel making. This is economical because Sulphur removal is far more efficient under the reducing conditions of blast furnace than under the oxidizing conditions of steelmaking.In this present work, the data related to Sulphur content in hot metal has been collected and multiple regression analysis of practical data has been done. An empirical equation is obtained stating the relation between Sulphur and the parameters which vary it.

Keywords: Pig Iron, Sulphur, Regression Analysis

INTRODUCTION

The demands on steel grades with a low Sulphur content will increase drastically in the nearest decades because these grades have improved material properties, lower sulphur inclusions and less cracking tendencies. A low Sulphur content iron is a prerequisite for producing a steel grade with a low sulphur content. So, the major effort has been concentrating on the pre-treatment of hot metal before converter to achieve a low sulphur content in the hot metal[1].

It has been observed that the widely adopted faster BOF processes of steel making are capable of removing only up to 20-30% of the Sulphur content in the hot metal charge. It means that in order to meet the generally specified 0.025-0.040% S in the final product that hot metal charge should not contain more than 0.04% S. It should preferably be around 0.02% S to accommodate erratic analysis of the blast furnace from tap to tap. This is possible in a blast furnace practice using coke containing around 0.6% S maximum[2]. If the Sulphur in coke is around 1%, as is now commonly the case, it will be difficult to meet the hot metal and subsequently the final steel specification with respect to

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Sulphur content. The finished molten steel should have no more than 0.025% S for continuous casting to operate smoothly.

Sulphur is said to be detrimental to pig iron.The running property of the melt becomes worse with increase in the Sulphur content. When the sulphur reaches a certain level, there appears a chill phenomenon, the shrinkage becomes maximum, and blow holes form[3,4].

REGRESSION ANALYSIS

To study the concept of desulphurisation, the relation between sulphur in hot metal and hot metal temperature, slag basicity, MgO content and slag rate is required. For that, the metal and slag analysis data has been collected for Blast Furnace. For regression analysis of sulphur with other parameters, slag rate per day is taken.For the calculation of Sulphur partition coefficient, the amount of Sulphur present in slag is collected day wise for few months. From the above data collected, the graphs are obtained and regression analysis is done.

(a) *Hot Metal sulphur and Temperature Analysis*

It can be seen from the above Figure 1 that as the hot metal temperature increases, sulphur content in hot metal decreases.Regression analysis is done for hot metal sulphur and temperature assuming other parameters constant.

R square = 0.115713

Equation: Sulphur = 0.313627-0.00018(Temperature).

As R square value is less than 0.5, regression analysis done for hot metal sulphur and temperature taking other parameters constant is not reliable.

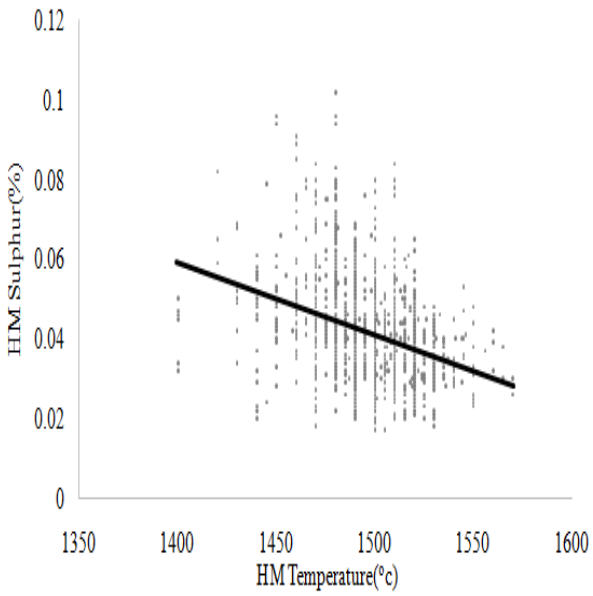

Figure 1 Graph plotted between hot metal sulphur and temperature.

(b) *Hot Metal Sulphur and Slag Basicity Analysis*

It can be seen from the above Figure 2 that as the slag basicity increases, hot metal sulphur decreases.Regression analysis is done for hot metal sulphur and slag

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basicity, assuming other parameters constant.

R square = 0.177229

Equation: Sulphur = 0.142099-0.09393(Basicity)

As R square value is less than 0.5, regression analysis done for hot metal sulphur and temperature taking other parameters constant is not reliable.

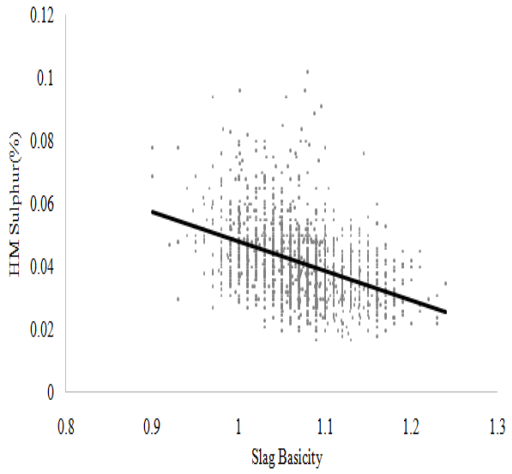

Figure 2 Graph plotted between hot metal sulphur and slag basicity.

(c) *Hot Metal Sulphur AndMgo Analysis*

MgO indirectly effects Sulphur content. As MgOincreases, it decreases the viscosity of slag which makes the Sulphur removal easy. The same can be seen from the graph, as the MgO content increases, hot metal Sulphur content decreases.Regression analysis is done for hot metal sulphur and MgO in slag, assuming other parameters constant as shown in Figure 3

R square = 0.022259

Equation: Sulphur = 0.05872-0.0022(MgO).

As R square value is less than 0.5, regression analysis done for hot metal sulphur and temperature taking other parameters constant is not reliable.

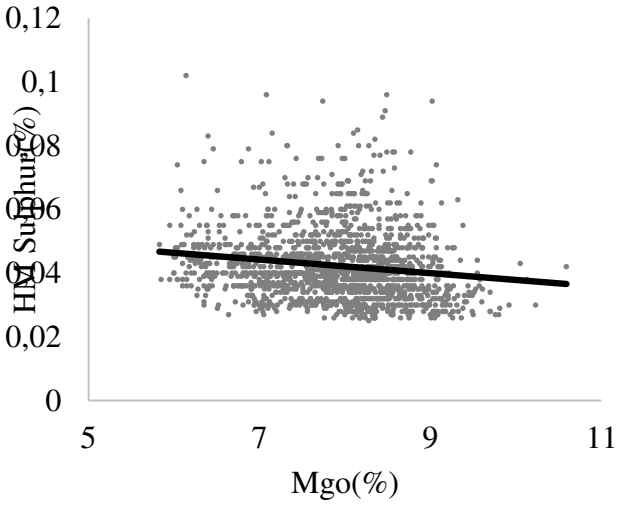

Figure 3 Graph plotted between hot metal sulphur and MgO present in slag.

(D) Hot Metal Sulphur and Slag Rate Analysis

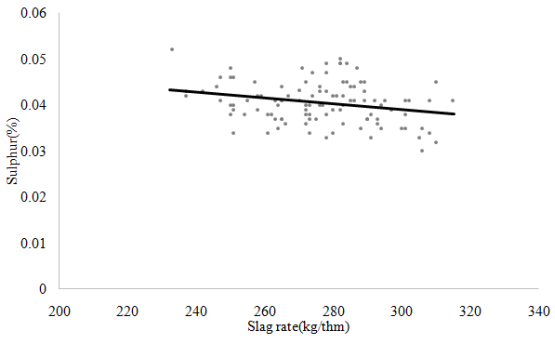

Figure 4 Graph plotted between hot metal Sulphur and slag rate.

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As the slag rate increases, the process of desulphurization becomes easy. The same can be seen in the Figure 4.Regression analysis is done for hot metal Sulphur and slag rate, assuming other parameters constant.R square =0.068867and Equation: Sulphur=0.058324-0.000065(Slag rate).

MULTIPLE REGRESSION ANALYSIS

As the individual regression analyses are not so reliable, it is done for all the four parameters i.e., slag rate, hot metal temperature, slag basicity, MgO in slag and hot metal Sulphur.

Table1 Multiple Regression Analysis Summary Output

Regression Statistics	
Multiple R	0.765769
R Square	0.586402
Adjusted R Square	0.570183
Standard Error	0.002928
Observations	107

ANOVA					
	df	SS	MS	F	Significance F
Regression	4	0.00124	0.00031	36.15411	8.62E-19
Residual	102	0.000874	8.57E-06		
Total	106	0.002114			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	0.284586	0.030885	9.214487	4.45E-15	0.223327	0.345846	0.223327	0.345846
Slag Rate	-0.00011	1.66E-05	-6.73279	9.98E-10	-0.00015	-7.9E-05	-0.00015	-7.9E-05
MgO	-0.00292	0.000379	-7.70043	9.05E-12	-0.00367	-0.00217	-0.00367	-0.00217
Basicity	-0.07015	0.009137	-7.67757	1.01E-11	-0.08828	-0.05203	-0.08828	-0.05203
Temperature	-7.6E-05	1.98E-05	-3.85182	0.000205	-0.00012	-3.7E-05	-0.00012	-3.7E-05

The equation obtained is:Sulphur=0.284586-0.00011(Slagrate)-0.00292(MgO)-0.07015(Basicity)-0.000076(Temperature)

CONCLUSION

A simple multiple regression analysis of practical data from Blast Furnace gave an empirical equation stating the relation between Hot Metal Sulphur and Hot metal temperature, slag basicity, slag rate and MgO content in slag.

The equation obtained is:

Sulphur = 0.284586 – 0.00011(Slag rate) – 0.00292(MgO) – 0.07015(Basicity) - 0.000076(Temperature)

By substituting the parameters in this equation, Sulphur can be calculated. The comparison between actual Sulphur and calculated Sulphur. As the variance of

Calculated Sulphur and actual Sulphur is less, the equation is taken as a valid one. This equation can be a tool in the operators hand to control the amount of Sulphur.

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