IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

CETCME-2017

"Cutting Edge Technological Challenges in Mechanical Engineering"

Noida Institute of Engineering & Technology (NIET), Greater Noida

Vol. 4, Special Issue 3, February 2017

Experimental Investigation of Slag Splashing in a Converter

Praveen Mishra[1], Subrata Sarkar[2]

Assistant Professor, Department of Mechanical Engineering, BIT Mesra, Ranchi, India [1]

Assistant Professor, Department of Mechanical Engineering, RRIST, Bhopal, India [2]

Abstract: The liquid steel is made in a vessel known as converter. There is a wall of refractory lining inside the converter to protect it from heavy heat which is produced at the time of making steel. Due to heavy heat and chemical erosion these refractory lining also get damaged and required to be change time to time which hampers production. To protect the lining of the converter a protective coating of the slag material is given over the converter lining which is popularly known as slag splashing. The objective of the present study is to carry out water modeling study of slag splashing process in reduced scale down model of actual converter. The study involves carrying out parametric study of various designs and operating parameters of slag splashing process.

Keywords: steelmaking, slag splashing, scale down model, lance height etc.

I. INTRODUCTION

The liquid steel is made in the converter by putting scrap, hot metal, lime, lump iron ore and blowing oxygen from the top lance with supersonic speed and argon from the bottom of the vessel. The steelmaking process is a batch process and it takes about 45-50 minutes to complete one cycle. The productivity of steelmaking depends upon the life of the converter refractory lining.

In order to improve the coating of slag on the refractory lining of the converter, a new process called Slag Splashing has been developed. This process uses the existing facilities to coat the slag on the refractory lining. The process of slag splashing is carried out by retaining the slag after the steel is made and then conditioning the slag by adding some amount of flux to change the viscosity of the retained slag and blowing the nitrogen from the same top lance which is used for blowing oxygen while making steel.

It is possible to coat the whole vessel uniformly with this process. This process takes about four to five minutes. Every steel plant has its own way of using the slag splashing process. With the new refractory lining this process is carried out after few heats. But when the lining becomes old then the process of slag splashing is carried out after every heat.

II. PHYSICAL MODELING

To carry out the slag splashing experiment in the laboratory a 1/6th scaled down model of the actual converter was made. All the geometrical dimensions of the actual converter were scaled down. The vessel model was made up of transparent perspex material. Therefore it was possible to examine the flow behaviour inside the converter because of transparency of the model.To study the slag splashing processes inside the converter a large number of investigations has been carried out by so many investigators by water model study.

Garg and Peaslee carried out water model study to understand the slag splashing process by using scale down model. They study the effect of lance height, bath height and slag viscosity. Artificial slags were used by the mixture of water and glycerol which allows a wide range of viscosity. Experiments were designed to maintain as close as possible geometric and dynamic similarity with actual converter operation. Matti et al. also carried out water model study as by Garg et al. According to Matti et al. Weber number is the most significant number for similarity criteria. The value of Weber number in their experiment is of same magnitude as in the converter. Since water was chosen to describe molten metal in the model, increasing the momentum is the simplest method to reach more accurate. According to Liu et al. in the course of researching slag splashing in a converter, the impact of a top blown gas jet and bottom string gas jet on liquid slag mainly considered. The major factor effecting slag splashing were not the viscosity or surface tension of the liquid, but the inertial force of the gas jet.

III.EXPERIMENTATION

The experimental set up consist of 1/6th scale down Perspex model. In the Perspex model arrangement has been made to collect the splashing liquid at various levels in the belly or cylindrical portion of the vessel. Four layers of collectors have been provided in the vessel model and

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
CETCME-2017
"Cutting Edge Technological Challenges in Mechanical Engineering"
Noida Institute of Engineering & Technology (NIET), Greater Noida
Vol. 4, Special Issue 3, February 2017

each layer consists of about 40 collecting boxes. The arrangement of gas blowing from the top lance as well as from bottom tuyeres has been made to simulate the combined blowing process of steelmaking. The top lance tip consists of 4 holes and 6 holes with different angles. The flow from the bottom was provided through eight tuyeres. Various rotameter have been provided to measure the top as well as bottom gas flow rate.The schematic diagram of the experimental setup with all accessories is shown in Figure 3.1

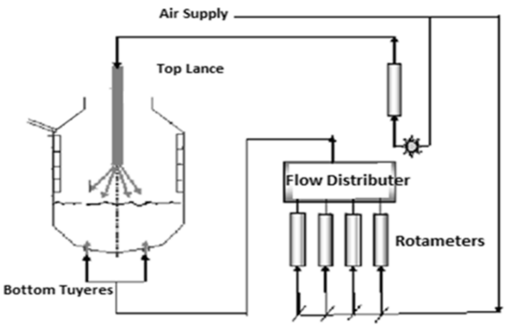

Fig. 3.1.Schematic diagram of the experimental setup

The top as well as bottom gas flow rates were calculated with the help of modified Froude similarity criteria. The other dimensionless numbers such as Reynolds number, Weber number were also computed. But it was not possible to match all the dimensionless number of actual and model because of non- availability of liquid which can match the required property. Water is the cheapest and easily available liquid. Hence this was used to simulate slag. Some experiments were also carried out with water-glycerol solution to simulate slag. The range of all the parameters considered for experimentation is shown in Table 3.1.

Table 3.1: Various parameters and their ranges used for the study

Sl.No	Parameters	Range
1.	Bottom flow rate, lpm	20,40,60,80
2.	Bath height, mm	100,130
3.	Lance height, mm	200,150,100
4.	Lance flow rate, lpm	1100,1150,1200
5.	Number of nozzle	4,6
6.	Nozzle angle from vertical	12°,14°,17.5°
7.	Viscosity	3:10,3:12(water glycerol mixture)

IV. RESULTS AND DISCUSSION

Water model experiments were carried out to study the effect of different parameters and results were plotted with respect to the average amount of liquid collected per collector in each layer. There are total four layers of collector in the belly zone of the vessel. The first layer from the bottom of the belly portion was named as layer 1 and then layer 2 and 3. The top most layers were named as layer 4. Initially few experiments were carried out with top lance nozzle with four holes. The bottom flow rate from the tuyeres was varied from 20 to 80 lpm.

Figure 4.1 shows the effect of bottom flow rate on average amount of liquid collected per collector in different layers. The bath height, lance height and top gas flow rate was fixed at 100 mm, 200 mm and 1100 lpm respectively. Experiments were carried out with top lance nozzle with four holes having nozzle angle of 12° from vertical. It was found that the layer 1 (lowest layer) has got the maximum amount of liquid whereas layer 4 (top most layer) has got the least amount of liquid. It can be seen from the figure that average amount of liquid collected per collector remains same at different bottom flow rates. This shows that increase of bottom flow rate does not have much affect of the liquid splashed on the vessels.

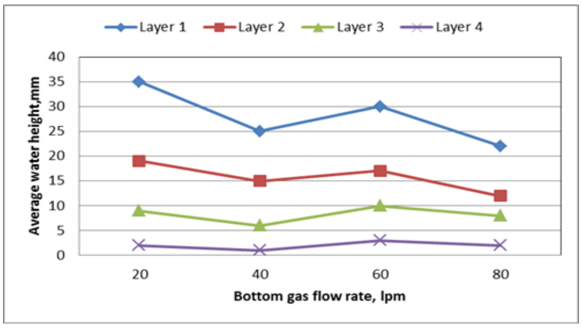

Fig. 4.1: Effect of bottom gas flow rate on average height of liquid collected per collector in different layers

Figure 4.2 shows the effect of bottom gas flow rate on slag splashing with same condition as above but with different bath height of 130 mm. It can be seen from the figure 4.1 and 4.2 that average amount of liquid collected per collector remains same in both the cases. Although the amount of liquid collected in each layer is different but it remains more or less same with the increase of bath height from 100 to 130 mm.

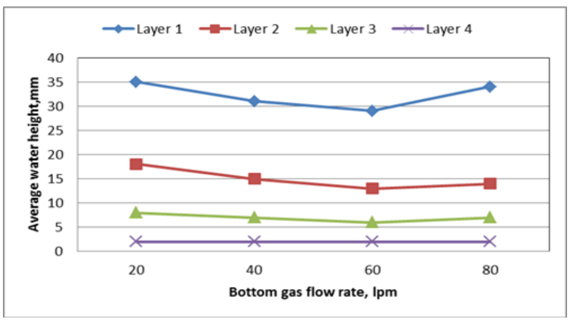

Fig. 4.2 Effect of bottom gas flow rate on average height of liquid collected per collector in different layers

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
CETCME-2017
"Cutting Edge Technological Challenges in Mechanical Engineering"
Noida Institute of Engineering & Technology (NIET), Greater Noida
Vol. 4, Special Issue 3, February 2017

Figure 4.3 shows average volume of liquid collected per collector in each layer with respect to bottom gas flow rate for six holes having nozzle angle of 14° from vertical. The other operating conditions such as bath height, lance height and top lance flow rate were kept at 100 mm, 200 mm and 1100 lpm respectively. It was observed that amount of liquid collected remains more or less constant in all the layers except in layer 1.

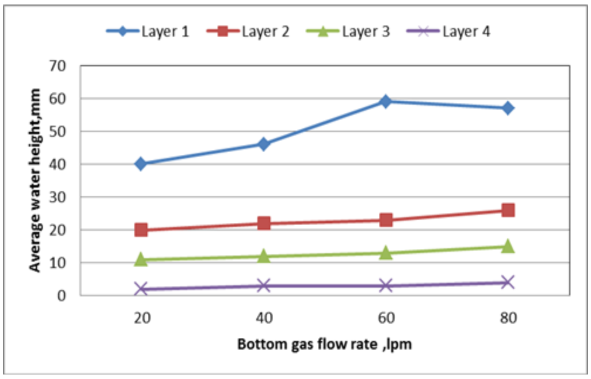

Fig. 4.3 Effect of bottom gas flow rate on average height of liquid collected per collector in different layers

Similar results were found with top lance nozzle with six holes having nozzle angle of 17.5° from vertical. Figure 4.4 shows the results of average volume of liquid collected in different layers with different bottom gas flow rate. The other conditions were kept same as mentioned for figure 4.3.

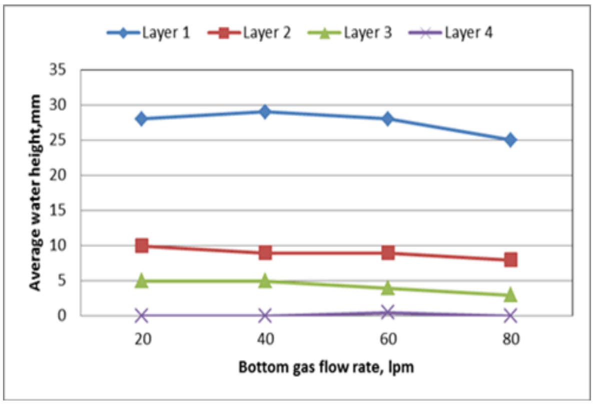

Fig. 4.4 Effect of bottom gas flow rate on average height of liquid collected per collector in different layers

Figure 4.5 shows average volume of liquid collected per collector in each layer with respect to different bath height for six holes having nozzle angle of 17.5° from vertical. The other operating conditions such as lance height and top lance flow rate were kept at 200 mm and 1100 lpm respectively. It shows that the influence of different bath height on the average amount of liquid collected per collector is not significant. Similar results were obtained with top lance with six holes having nozzle angle of 14° from vertical.

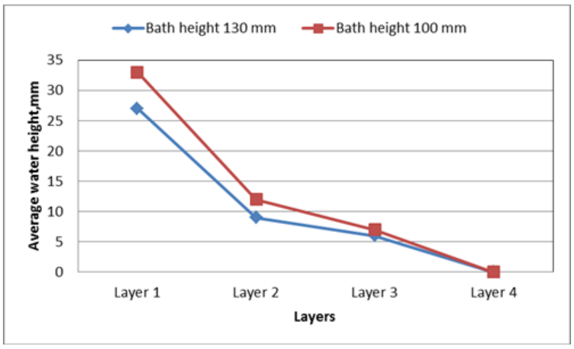

Fig. 4.5 Effect of bath height on average height of liquid collected per collector in different layers

V. CONCLUSIONS

Water model study has been carried out in a reduced scaled down model in order to understand the effect of various design and operating parameters of slag splashing. The following conclusions were drawn from the present experimental investigation:

- The effect of bottom gas flow rate and bath height on splashing is not very significant
- Top gas flow rate and lance height have significant effect on slag splashing
- Out of three top lance nozzles studied (four holes with lance angle 12°, six holes with lance angle 14° and six holes with lance angle 17.5°) for slag splashing, the top lance having six holes nozzle with 14° angle was found to be the best in terms of splashing.

REFERENCES

[1] J.Matti et al. "Physical Model Study of Selective Slag Splashing in the BOF" ISIJ International, vol.42, No.11, pp.1219-1224, 2002.

[2] Garg and K. Peaselee: Proc. 80th Steelmaking Conf., ISS/AIME, Warrendale, PA, 87, 1997.

[3] Q. L. He and N. Standish "A Model Study of Droplet Generation in BOF Steelmaking" ISIJ International, vol. 30, No.4, pp. 305-309, 1990.

[4] M. Alam, J. Naser, G. Brooks, "Computational Fluid Dynamics Simulation of Supersonic Oxygen Jet Behavior at Steelmaking Temperature" Metallurgical and Materials Transactions B , vol.41, Issue 3, pp.636-645,2010.

[5] S. C. Koria and K .W. Lange "A new approach to investigate the drop size distribution of BOF steelmaking" Metallurgical and Materials Transactions B, 15B, pp.109-116, 1984.

[6] C. Liu, Y. Zhu and M. Jiang, "Physical modelling of slag splashing in converter", Ironmaking Steelmaking, vol. 30 No.1, pp.36-42, 2003.

[7] S. Paul, D. N. Ghosh, "Model study of mixing and mass transfer rates of slag-metal in top and bottom blown converters", Metallurgical and Materials Transactions B ,vol.17, Issue 3, pp.461-469,1986.

[8] C. Roth, M. Peter, M. Juhart and K. Koch, "Cold model investigations of fluid flows and mixing within top and combined blowing in metallurgical processes" Steel research, vol.70, pp-502-507, 1999.

[9] L.Qiang, L.Mingming, S.B.Kuang & Z. Zou, "Computational study on the behaviours of supersonic jets and their impingement onto molten liquid free surface in BOF steelmaking" Canadian Journal of Metallurgy and Materials Science, vol.53, Issue 3, 2014.