Mixing Characteristics of Additives in Slag Pot

Yannan WANG, Zhongfu CHENG, Bart BLANPAIN, Muxing GUO

Department of Materials Engineering, KU Leuven, 3001 Leuven, Belgium.

KU LEUVEN

ABSTRACT

In order to stabilize the free lime in Basic Oxygen Furnace (BOF) slag, silica-rich additives are injected into the molten BOF slag with N_2/O_2 as carrier gas through a top submerged lance. The mixing characteristics of the additives in the slag are investigated by using a 3D VOF-LES-DPM numerical simulation. The results show that increasing gas flowrate and/or lance depth can reduce the dead zone. This is confirmed by visual observation of the spatial distribution of particles in the simulation. The lance depth and gas flowrate have significant influences on the additive mixing. This work provides a useful tool to study the mixing behavior of additives in the slag pot at high temperature and gives insight for the industrial operation.

INTRODUCTION

Considerable efforts to reuse BOF slag have been made in the last decades.[1] However, the application of BOF slag is restricted by its volume expansion due to the presence of free lime.[2] To stabilize BOF slag for high-added value application, silica-rich additives and/or slag modifiers are injected into the molten BOF slag with oxygen or nitrogen as carrier gas.[3] Therefore, understanding of the mixing characteristics of additives in molten BOF slag is of significant importance for process control and optimization. Due to the difficulties in performing high temperature lab experiments, in this work a modelling approach (VOF-LES-DPM) is employed to investigate influence of the process parameters such as lance depth and gas flowrate, on the additives mixing. The dead zone and mixing time in the slag stabilization process are discussed.

NUMERICAL METHODOLOGY

- VOF model was adopted for the two-phase simulation.
- LES model with the dynamic Smagorinsky-Lilly subgrid-scale model[4, 5] was used to calculate the flow turbulence.
- One-way coupling DPM was employed to track the movement of the solid additives.
- Additives dissolution is not considered.

RESULTS

The particle migration as a function of the lance depth and gas flowrate is shown in Figure 1. The comparison between Figure 1(a) and (b) demonstrates that increasing the lance depth can increase the mixing zone, which is indicated in the figure by the particles occupied zone (red color). In addition, increasing the gas flowrate enlarges the mixing zone as well (comparison of Figure 1(b) with Figure 1(c)).

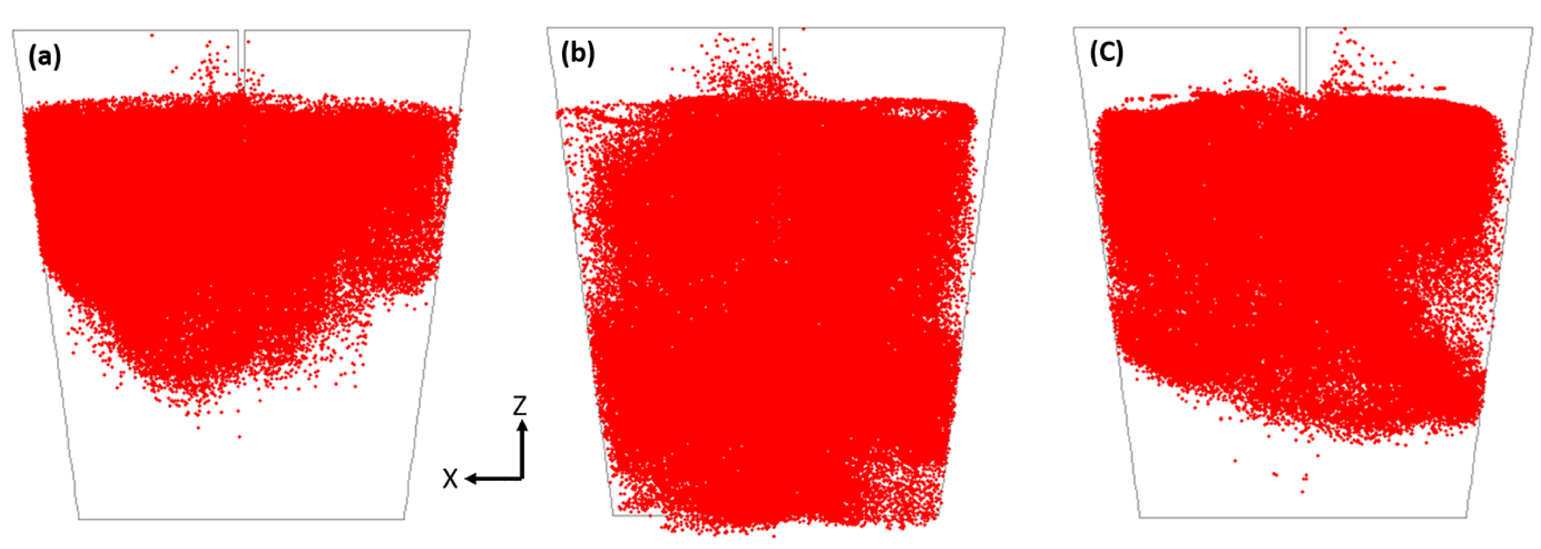

Figure 1: Particle distribution at (a) L = 0.3 m, Q = 170 Nm^3/h; (b) L = 1.0 m, Q = 170 Nm^3/h; (c) L = 1.0 m, Q = 100 Nm^3/h (X-Z median plane of a 3D model at 50 s).

The semi-quantitative mixing time obtained from the three cases are listed in Table 1. The mixing time of Case II is approximately 50 s, decreasing by 76.2% compared to 210 s of Case I. The mixing time of Case III, 140 s, is around 2.8 times larger than that of Case II. Apparently, increasing the lance depth and the gas flow rate can significantly reduce the mixing time.

Table 1: Mixing time under different operational conditions

Case	Mixing time, s
I: L = 0.3 m, Q = 170 Nm^3/h	210
II: L = 1.0 m, Q = 170 Nm^3/h	50
III: L = 1.0 m, Q = 100 Nm^3/h	140

CONCLUSIONS

- Increasing the lance depth and/or gas flow rate reduces the dead zone.
- The mixing time decreases from 210 s to 50 s when increasing the lance depth from 0.3 m to 1.0 m.
- The mixing time decreases from 140 s to 50 s when increasing the gas flowrate from 100 Nm^3/h to 170 Nm^3/h.

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