Large Scale Simulation of Multi-Phase Flows in Real Blast Furnace for Minimizing of CO_2 Discharge

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Abstract

We have developed the computational program for the particle and the gas flows in an actual blast furnace using Distinct Element Method (DEM) for coke and iron ore particles of which number are 12 millions and Finite Difference Method of which computational cell number 3 millions for the numerical analysis of Navier-Stokes equations with the interaction terms between gas and particles. In this year we have calculated simultaneously the motions of coke and iron ore particles and the motion of air in the actual blast furnace. The computational domain was 1/4, which was 90 degree of the region of the horizontal plane and having 10 tuyeres, of the actual blast furnace. We used 16 nodes. The flow of solid particles and the air flow including the raceway are presented. The simulation results show the effect of mass flow rate of erasing coke particles on the stability of raceway and the interacting motions of particles and air among tuyere flows. The model softening melting zones which were formed by the cohesion force by the melting iron ore affect the air and the coke particle flows and cause the non-homogeneous and unstable flows. The coke particle velocity near the furnace wall on the tuyere is very low. This low velocity forms the high packing region which might cause the scaffold of the coke particle bed near the furnace wall. Hereafter we will continue to calculate the air and particle motions, and present the various unstable motions which would bring about an extraordinary event in the blast furnace.

Keywords : Actual blast furnace, DEM, Navier-Stokes equations, Particle, Unstable motion

1. Introduction

Unstable flows in an actual blast furnace reduce the iron manufacturing efficiency, then CO_2 discharge from the furnace increases. The objective of this study is to present various flows in the blast furnace and elucidate the unstable phenomena which cause inefficiency manufacturing operation. In this year we have calculated simultaneously the motion of solid particles which are coke and iron ore and the motion of air in the actual blast furnace. The flow of solid particles and the air flow including the raceway and the softening melting zones are presented.

2. Computational Procedure

We have used DEM for coke and iron ore particles and Finite Difference Method for Navier-Stokes equations with the interaction terms between particles and air. Coke and ore particle mean diameters were 57mm and 45mm. Total calculated particle number was 12 millions. Time step was about 0.0002s. Computational cell number for air was about 3millions.

3. Results and Discussion

Figures 1 and 2 show the instantaneous particle configuration in the horizontal plane including tuyere centers and the color iso-contour of packing fraction in the vertical plane including tuyere centers after 2.37s from the air discharge from tuyeres. Results indicate the raceways and the interaction among them. Figure 2 shows the formation of the softening melting zones, in which the packing ratios are high in the center area of the furnace.

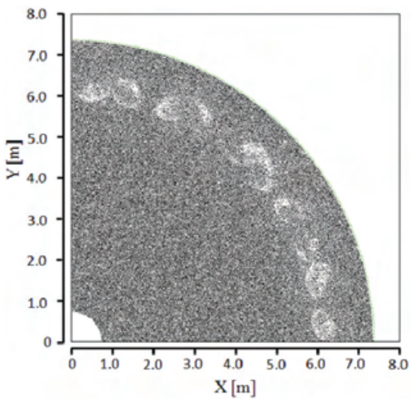

Fig. 1. Particle configuration in the horizontal plane. Time=2.37s from the start.

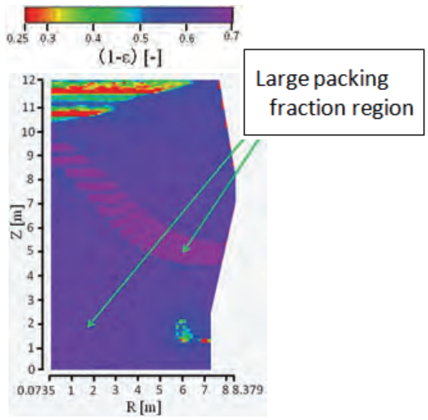

Fig. 2. Color iso-contour of packing fraction. Time=2.37s from the start.

4. Concluding Remark and Future work

We have calculated simultaneously the motions of coke and iron ore particles and the motion of air in the actual blast furnace. The model softening melting zones which were formed by the cohesion force by the melting iron ore affect the air and the coke particle flows and cause the non-homogeneous and unstable flows. We will continue to calculate the gas and particle motions using our program and elucidate the mechanism of unstable motions which cause an extraordinary event in the actual blast furnace.

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