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

Project Representative

Shinroku Matsuzaki

Professional Affiliation of Project Representative

Iron making R&D DIV, E P C, Technical Development Bureau, Nippon Steel Corporation

Authors

Shinichi Yuu　Ootake R and D Consulting Office

Umekage Toshihiko　Department of Mechanical and Control Engineering, Kyushu Institute Technology

Shinroku Matsuzaki [*1], Masatomo Kadowaki [*1], Kazuya Kunitomo [*1], Masaaki Naito [*1]

Yuichi Hirokawa [*2], Hitoshi Uehara [*2]

＊1　Iron making R&D DIV, E P C, Technical Development Bureau, Nippon Steel Corporation

＊2　Super Computer System Planning and Operations Department, Japan Agency for Marine-Earth Science and Technology

Abstract

We have developed the computational program for the particle and gas flows in an actual blast furnace using Distinct Element Method (DEM) for coke and iron ore particles of which number are 5.5 ～ 7.0 millions and Finite Difference Method of which computational cell number 2.7 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 (inlet nozzle to facilitate combustion), of the actual blast furnace. We used 16 nodes and about 13,000 node hours. The flow of solid particles and the air flow including the raceway (the void with the swirl flow nearby the tuyere) 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. Hereafter we will continue to calculate the air and particle motions and present unstable motions 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 are presented. The simulation results show the effect of mass flow rate of erasing coke particles for the disappearance by the combustion in the raceway on the stability and the interaction among tuyere flows.

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 5.5 ~ 7.0 millions. Time step was 0.0002s. Computational cell number for air flow was 2.7 millions.

3. Results and Discussion

Figures 1 and 2 show the instantaneous particle configuration and the color iso-contour of void fraction ε in the horizontal plane including tuyere centers after 1.04s from the air discharge from tuyeres. Results in these figures indicate the raceways, i.e. the high void fraction flows, and the interaction among them. The tightly packed layer, in other words the low void fraction area, is going to be built in the center region of furnace.

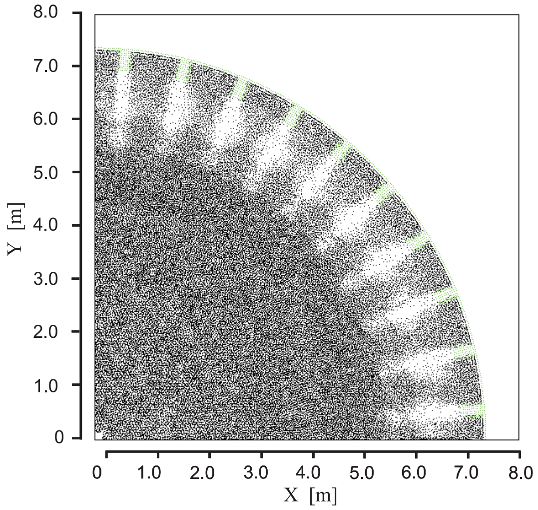

Fig. 1. Instantaneous particle configuration in the horizontal plane. 9 particles erasing per a cycle and time=1.04s from the start.

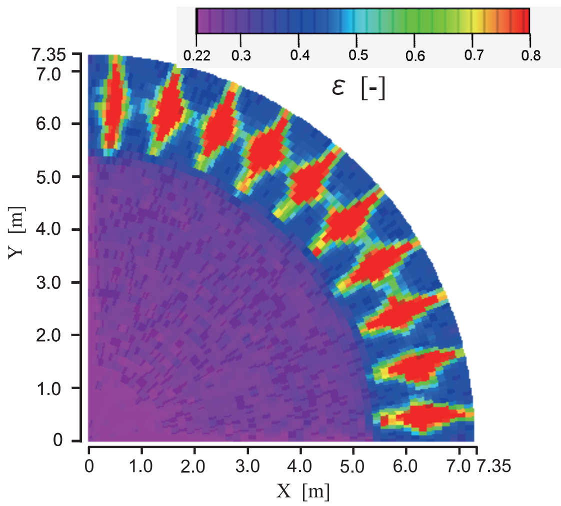

Fig. 2. Instantaneous color iso-contour of void fraction ε. 9 particles erasing per a cycle and time=1.04s from the start.

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 simulation results show the effect of mass flow rate of erasing coke particles in tuyeres on the stability of raceway and the interaction among tuyere flows. We will continue to calculate the gas and particle motions using our optimized program and elucidate the mechanism of unstable motions in the actual blast furnace.

Acknowledgement: We would like to thank H.Hirano, S.Kitawaki, and S.Shingu, Japan Agency for Marine-Earth Science and Technology, for their useful discussions and comments.