Large Scale Simulation of Four Phase Flows in Actual Blast Furnace for Minimizing of CO_2 Discharge

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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 and Finite Difference Method for the numerical analysis of Navier-Stokes equations with the interaction terms between gas and particles. In this year which is the first year of this project we have mainly optimized the computational program, that is, we have improved DEM program for the vector and parallel numerical computing of Earth Simulator. In the case of 9000 thousand particle calculation in the blast furnace, the computational speed of the optimized program has been over 53 times faster than that of the original one. To make the initial conditions of coke and ore particles in the actual blast furnace, the sedimentation processes have been calculated using our optimized program. The computational domain was 1/4, which was 90 degree of the region of the horizontal plane, of the actual blast furnace. We used 16 nodes (128AP). The calculated results clearly show interactions between tuyeres, and tuyere and particles. Hereafter we will calculate simultaneously the gas and particle motions using our optimized program and present unsteady and 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 blast furnace increases. The objective of this study is to present various flows in the furnace and elucidate the unstable phenomena which cause inefficiency manufacturing operation. In the first year of this project we have mainly optimized the computational program. To make the initial conditions of coke and ore particles in the actual blast furnace, the sedimentation processes have been calculated using our optimized program.

2. Computational Procedure

We have used DEM for coke and iron ore particles and Finite Difference Method for the numerical analysis of Navier-Stokes equations with the interaction terms between gas and particles. Coke and ore particle mean diameters were 57mm and 45mm. Total particle number at that time was 5500 thousands. Time step was 0.00005s. Computational cell number for gas flow was 8400 thousands.

3. Results and Discussion

Figures 1 and 2 show particle velocity color contours in the horizontal plane including tuyeres after 10000 and 21000 time steps in the sedimentation process. Results in these figures clearly indicate the effect of tuyeres on particle motions and the randomization of particle layers.

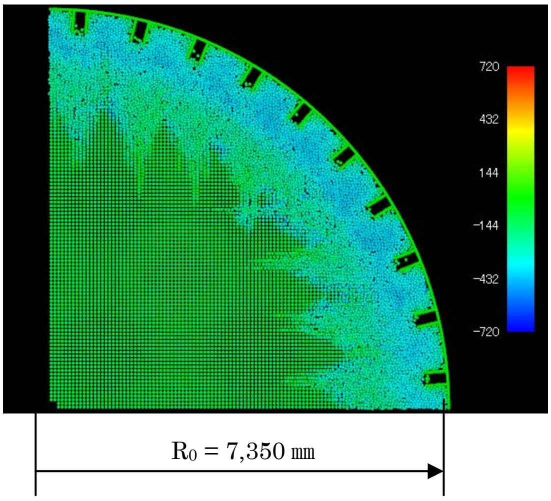

Figure 1 Calculated particle velocity contours in the actual blast furnace in the sedimentation process (horizontal plane including ten tuyeres, 10000 Δ t=0.50s)

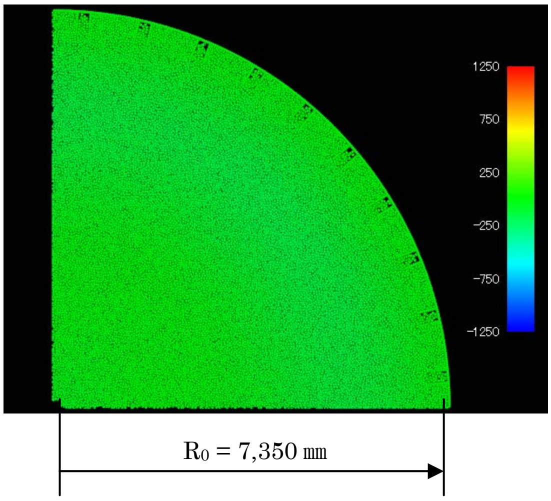

Figure 2 Calculated particle velocity contours in the actual blast furnace in the sedimentation process (horizontal plane including ten tuyeres, 21000 Δ t=1.05s)

4. Concluding Remark and Future work

The computational program has been optimized for the vector and parallel numerical computing of Earth Simulator. We will calculate simultaneously the gas and particle motions using our optimized program and elucidate the mechanism of unstable motions in the actual blast furnace.

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