Numerical study on die filling process by the DEM-CFD method

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Abstract

This study mainly concentrates on the numerical simulations of die filling procedure. As a typical particulate flow problem, die filing is an important process and widely used in various fields of manufacturing industries. A basic geometry of such system contains a die and a shoe. In the previous studies [1], numerical simulations of the die filling were performed without modeling the airflow. Detailed phenomena were not sufficiently comprehended in the existing die-filling simulations. In this study, numerical simulations were performed to simulate a gas-solid flow in a die filling process. The numerical model is based on discrete element method – computational fluid dynamics (DEM-CFD). Signed distance functions (SDF) [2] was used for creating a scalar field where the wall boundary is represented as the zero level contour. The direction inside and outside the wall boundary is represented by plus-minus so that the particles recognize the wall as the sign indicated. The interaction between boundary and air is modeled by the immersed boundary method, where the fluid velocity field affected by the moving boundary is calculated by the local volume fraction.

In this study, light density powder such as NONPAREIL-108® is used, where the total number of the spherical particle is set to be 150,000 with 200 μm of the diameter and 1379 kg/m^3 of the density. The dimension of the die is a 10 x 10 x 10 cubic structure with a 5 x 5 x 10 mm cubic hollowed out at bottom-right corner of the die. The dimension of the shoe is 10 x 10 x 30 mm. The granular flow tendency was compared with/without calculating gas phase. Through this study, the airflow is shown to prevent the powder from going into the die. It is also confirmed that the simulation results qualitatively agree with the experimental results.

Keywords: Particulate flow, discrete element method, computational fluid dynamics, signed distance function, die filling.

References

[1] Y. Shigeto, M. Sakai, "Arbitrary-shaped wall boundary modeling based on signed distance functions for granular flow simulations," Chem. Eng. J., 231, 464-476 (2013)

[2] Y. Tsunazawa, Y. Shigeto, C. Tokoro, M. Sakai, "Numerical simulation of industrial die filling using the discrete element method," Chem. Eng. Sci., 138, 791-809 (2015)