Numerical Investigation on the Influence of Suction Filling

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Suction filling is widely employed for the powder compaction in pharmaceutical engineering. In suction filling, a downward motion of the punch draws powder particles into the die region and shorten the powder filling time. However it is recognized that die filling has critical influence for the efficiency of the whole manufacturing processes and suction filling can increase the efficiency, the optimizing method was not clarified so far. This is because that the experimental analysis of powder flow in suction filling is impossible realistically, hence application of numerical technologies is desired. In the present study, numerical simulations were performed to verify the validity of the coupled discrete element method (DEM) and computational fluid dynamics (CFD) for suction filling and it was found that suction filling generated the air pressure gradient which influenced to the powder filling.[1] In this study, the signed distance function (SDF) and the immersed boundary method (IBM) were employed as the wall boundary conditions for the solid phase and the gas phase, respectively in addition to a coupled DEM and CFD. In the SDF, the wall boundary is defined by the scalar field and it is saved at the first time. In the IBM, the interaction between the wall boundary and the gas phase is calculated only with the ratio of the wall in each grid and this ratio is gained easily by the scalar field of the SDF. This combination of boundary conditions is enabled to calculate the moving wall boundary with simple algorithms and simulate suction filling in the gas-solid phase. According to the simulation results, it is found that the air pressure gradient occurred above the punch only at the moment it started downward motion. The air pressure gradient suctioned particles onto the top surface of the punch and made a path of particle flow and accelerate the flux of particle flow. As a result, the powder filling time was shortened. It is suggested that the moving speed of the punch could be optimized for the powder filling time. As the moving speed of the punch was higher, two influences for powder flow were more remarkable. At first, the initial flux of the particle flow was higher. Second, the volume of the bubble thrust into the die region was larger, and it had prevented the flux of the particle flow with rising up. By these two influences affects to the particle flow, the moving speed of the punch had the optimal value for the powder filling time.

[1] Wu, C.-Y., Guo, Y., 2012. Numerical modeling of suction filing using DEM/CFD. Chem. Eng. Sci. 73, 231-238.

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