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Precise prediction of near net shape HIP components through DEM and FEM modelling

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In Hot Isostatic Pressing (HIP) of metal powder, anisotropic shrinkage of the capsule induced by inhomogeneity of the initial powder filling density determines the reproducible realization of small geometrical allowances. This becomes a detrimental factor in the manufacturing of near-net-shape components due to their high requirements of the final shape accuracy. This challenge can be solved by precisely predicting and controlling the shrinkage with respect to the filling density via numerical simulation. Using a Discrete-Element-Method (DEM) script, a two-dimensional initial powder density distribution on the component cross section is simulated. After being validated by experimental results from metallographic examination, the calculated powder density distribution is assigned as the initial relative densities in a Finite-Element (FE) model. An in-house developed user defined material model Subroutine (UMAT), which considers both instantaneous plasticity at lower temperatures and rate dependent plasticity at higher temperatures, is utilized in the frame of ABAQUS for the simulation. In addition, both the gravity and the friction between the capsule and the support are also taken into account in the simulation, as these two factors are not negligible in an industrial-scale HIP-process. The preliminary experimental validation using pre-prototype component reveals that the shrinkage induced shape changes during HIP can be accurately predicted by several virtual iterative simulations. Furthermore, the influences of local density distribution, gravity and friction force during HIP are also investigated. In summary, the developed simulation method demonstrates high accuracy in HIP component shape prediction and can be easily applied to design HIP capsules for large and complex components.

Innovative Aspects:

•The DEM simulation shows the feasibility to simulate the powder distribution inside a capsule taking into account the individual filling configurations and procedures.

•The FE-Model is improved with the addition of gravity and friction forces to the driving force for deformation during HIP.

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