MULTISCALE AND MULTIPHYSICS MODELLING OF POWDER METALLURGY PROCESSES

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Powder Metallurgy (PM) encompasses various technologies for the manufacturing of net-shape components from metallic or non-metallic powder mixtures. The present work aims at multiscale and multiphysics modelling of selected PM processes with a particular focus on modelling of sintering. Sintering is a key stage of many PM techniques in which bulk material is consolidated from loose or weakly bonded powder at an elevated temperature close to the melting point. Sintering can be performed without pressure (free sintering) or with pressure (pressure-assisted sintering). Non-conventional sintering technologies such as microwave sintering or electrical current activated sintering (ECAS) have been developed.

A multiscale modelling framework for conventional pressure-assisted sintering will be presented [1]. The model spans three scales: the atomistic, microscopic and macroscopic ones. Sintering is a process governed by diffusion. Therefore, atomistic modelling using molecular dynamics (MD) has been focused on the investigation of the diffusion process. Diffusion properties determined by MD simulations have been used as the parameters of the microscopic model developed in the discrete element method (DEM) [2]. The DEM simulations have allowed the determination of macroscopic properties for the FEM simulations of sintering.

The model of conventional sintering involves two different physical fields: thermal and mechanical. Modelling of the ECAS process requires consideration of three fields: the electrical, thermal and mechanical ones coupled with each other. The formulation and development of the multiphysics DEM model for this process will be presented.

The numerical model of sintering has been validated using own experimental results. Macroscopic shrinkage, the stresses at the microscopic and macroscopic levels during and after sintering have been obtained. The evolution of material thermal and electrical properties with porosity change has been investigated.

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