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Multiscale modeling of pressure-assisted sintering process

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Pressure-assisted sintering is a technique of powder metallurgy consisting in consolidation of loosely bonded ceramic or metal powders at elevated temperature with pressure. During sintering particulate material is converted into compact solid material. At sintering, processes at different levels interact with one another, therefore in numerical modelling we should consider physical phenomena occurring at various scales.
In this work, development of numerical models allowing us to analyze sintering at various scales will be presented. Theoretical formulations and numerical models for three scales relevant for sintering: atomistic, microscopic and macroscopic one will be presented. Modelling at lower scales will provide parametric information to the upper scale while the upper scale models provide boundary conditions for lower scale analysis.
The macroscopic model employed for sintering is based on the formulation proposed in [1]. The model incorporates mechanisms of thermal and elastic deformation and viscous creep flow. Macroscopic constitutive properties are determined from micromechanical simulations of sintering. The micromechanical model of sintering has been developed within a framework of the discrete element method [2]. The DEM considers large assemblies of particles which interact with one another through contact forces. The constitutive parameters of the DEM model of sintering depend on the parameters which can be determined using atomistic models. The multiscale numerical model will be validated using the results of own experimental studies sintering of NiAl powder.

[1] R. Zhang (2005). PhD Thesis, The Pennsylvania State University.

[2] S. Nosewicz, J. Rojek, K. Pietrzak, and M. Chmielewski (2013). Viscoelastic discrete element model of powder sintering, Powder Technology, 246, 157–168.

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