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Coupling a mesoscale phase-field model with continuum mechanics principles to capture shrinkage during solid-state sintering

The majority of the existing phase-field sintering models is based on the seminal work of Wang that employs Cahn–Hilliard and Allen–Cahn equations to capture mass transport and grain-growth and introduces the concept of sintering forces to handle particle rigid-body motions responsible for shrinkage. However, in the original formulation, these sintering forces are converted to velocities which directly advect the phase fields. Despite simplicity, this approach neglects the underlying continuum mechanics principles and thus often renders non-physical results.

The current work targets these limitations by proposing a novel approach that enriches the Wang model with consistent mechanical behavior. The phase-field equations are coupled with the linear-elastic balance of momentum, where the latter incorporates Wang's sintering forces as distributed body loads. This formulation enables the computation of consistent advection velocities for the phase fields and thereby establishes long-range interaction mechanisms between particles.

Using a simple test configuration consisting of a chain of identical particles, we analyze in detail the deficiencies of the original Wang sintering model and then show clearly how our coupled approach resolves them. We then investigate the two- and three-dimensional benchmarks to highlight the advantages of the proposed model. Finally, we show how the coupled model can be applied to qualitative numerical analysis of sintering of pure titanium powders.

Professional Status of the Speaker

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Interest in submitting a paper in a special issue of

No interest

Invitation letter for visa

No

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