Critical Influences of Particle Size and Adhesion on the Powder Layer Uniformity in Metal Additive Manufacturing (Sim-AM 2019)

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ABSTRACT

Among the manifold of existing additive manufacturing (AM) processes, powder bed fusion additive manufacturing (PBFAM) of metals has attracted much scientific attention because it offers near-net-shape production of near-limitless geometries, and eventual potential for pointwise control of microstructure and mechanical properties. Out of the multitude of process parameters and input quantities, the powder feedstock plays a crucial role, whose importance has only been recognized in recent years [1]. Specifically, the packing density and surface uniformity of the powder layers is a critical factor influencing the quality of components produced by metal PBFAM processes such as selective laser melting, electron beam melting and binder jetting.

The present work proposes a computational model to study the critical influence of powder cohesiveness on the powder recoating process in PBFAM. The model is based on the discrete element method (DEM) with particle-to-particle and particle-to-wall interactions involving frictional contact, rolling resistance and adhesive forces [2]. The surface energy value underlying the adhesion force law is calibrated by fitting angle of repose values from numerical and experimental funnel tests based on exemplary spherical Ti-6Al-4V powders. To the best of the authors' knowledge, this procedure allows for the first time to provide an experimental estimate for the effective surface energy of the considered class of metal powders. For the recoating simulations, quantitative metrics such as the spatial mean values and standard deviations of the packing fraction and surface profile field are defined in order to evaluate powder layer quality. Based on these metrics, the size-dependent behavior of exemplary plasma-atomized Ti-6Al-4V powders during the recoating process is studied [3]. It is found that decreased particle size / increased cohesiveness leads to considerably decreased powder layer quality in terms of low, strongly varying packing fractions and highly non-uniform surface profiles. For relatively fine-grained powders (mean particle diameter 17 μm), it is shown that cohesive forces dominate gravity forces by two orders of magnitude leading to low quality powder layers not suitable for subsequent laser melting without additional layer / surface finishing steps. Besides particle-to-particle adhesion, also the influence of nominal layer thickness, blade velocity as well as particle-to-wall adhesion is analyzed.

Ultimately, the proposed recoating model shall be combined with a mesoscale melt pool model to analyze the influence of powder layer characteristics on melt track stability and, eventually, on quality characteristics of the final design part such as residual porosity and surface roughness. At the end of the talk, first steps towards the intended mesoscale melt pool model will be presented.

REFERENCES

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