3D Printing of Non-Ferrous Alloys via Metal Fused Filament Fabrication (MF^3)

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ABSTRACT

Fused Filament Fabrication (FFF) is a primitive additive manufacturing (AM) technique to fabricate intricate polymeric parts in a quick and cost-effective manner. The powder fused filament fabrication (PF3) 3D printing process utilizes powder-filled polymer filaments combined with fused filament fabrication (FFF) and sintering processes to manufacture complex metallic and ceramic structures. Powder filled polymeric feedstocks and filaments were prepared, which were subsequently 3D printed. Non-ferrous metallic alloy green parts were sintered to understand the physical and mechanical properties of the final part. The current work aims to address critical knowledge gaps to enable a seamless transition from Fused Filament Fabrication (FFF) to Metal Fused Filament Fabrication (MF3) by utilizing fundamental concepts of Powder Metallurgy (PM) and Metal Injection Molding (MIM).

1 Introduction

A large segment of metal parts that are manufactured for consumer-based products are fabricated using traditional manufacturing processes (typically metal injection molding, casting or machining). Extensive research has been conducted on such processing techniques and their influence on the structure and properties of final parts. However, such traditional manufacturing techniques suffer from limitations on design freedom. Therefore, a need for advanced manufacturing technologies such as additive manufacturing (AM) to manufacture a variety of metallic components was emphasized [1–5]. Additive manufacturing has introduced additional design capabilities to optimize part properties while ensuring the performance of the part is not compromised. Of the multiple AM technologies capable of manufacturing complex parts, metal fused filament fabrication (MF^3) is the most economical process as the cost of the machine/equipment, feedstock materials, and overall processing is relatively lower than other AM processes [4,5].

MF^3 is a hybrid additive manufacturing technique that combines FFF for green part fabrication with thermal processing fundamentals of powder injection molding for debinding and sintering. A powder binder mixture is blended and extruded into a filament, which is then passed through a heated nozzle and deposited onto a heated platform, following a predetermined path to complete a three-dimensional (3D) part. *Figure 1* shows a typical MF^3 process overview where homogeneous blends of copper powder-binder are made using an appropriate mixer (such as torque rheometer), which are then extruded to produce filaments for 3D printing. Subsequently, parts are then printed using typical desktop fused filament fabrication (FFF) 3D printers. Finally, the green parts are processed through debinding (solvent and/or thermal) followed by sintering to achieve dense, solid parts.