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Author: Mr. Matthew Kuhns
Masten Space Systems, United States

Mr. Tyler Roberson
Masten Space Systems, United States
Mr. Greg Rixon
Masten Space Systems, United States
Mr. Tristan Cembrinski
Masten Space Systems, United States

THE PERMIAM^{TM} ADDITIVE MANUFACTURING PROCESS FOR OPEN POROSITY IN FULLY DENSE MATERIALS

Abstract

PermiAM^{TM} is a new patent pending additive manufacturing (AM) process for laser powder bed fusion (L-PBF) which enables the creation of variable-porosity in situ with fully dense materials. The porosity is non topological, so it is not dependent on CAD geometry or AM machine resolution, enabling micron scale pore sizes and densities from 1These structures can be integrally manufactured for a range of materials using the L-PBF process. This advanced technology is exciting to the aerospace industry due to the ability to produce porosity at a smaller scale than is possible with traditional AM methods. Micron-scale porosity enables high fluid resistivity and controllable pressure drop to optimize rocket engine injector performance and thermal conditions. Another significance of this process is the ability to vary material properties of an AM component across the part. This allows novel injector geometries with structural members embedded in porous faces and small-scale porous flow paths integrated into structural elements. Varying the density across the part enables lightweight, yet stiff and strong, parts that can increase engine thrust-to-weight ratio. This is specifically enticing for propulsion applications because it enables engines to be designed and manufactured with improved cooling, better strength-to-weight ratios, and lower part count. Masten Space Systems has investigated manufacturing methods for PermiaAM^{TM} porous media and its relationship to injector face cooling performance, including investigations into material optimization and characterization, injector design, and single element testing. All three objectives were successfully completed, with 22 hot fires performed on single element injectors in both A1000-10Cost and schedule savings are realized through the capability to manufacture single parts with varying material properties where, in the past, multiple components needed to be manufactured separately and assembled with a high touch time, long lead times, and higher operations costs. With PermiAM^{TM}, the porous material is constructed in situ and requires no additional post-processing steps after cutoff. The results of the trade study for a 4,000 lbf thrust engine show 12-16 weeks manufacturing time with $46kestimatedcostforatraditionalRigimeshinjectorandonly1-2weeksmanufacturingtimewith$19k cost for the PermiAM^{TM} version. This is 60