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IMPLEMENTATION OF ADDITIVE MANUFACTURING FOR THE DESIGN & DEVELOPMENT OF THE JESSIE & JAMES LIQUID ROCKET ENGINES

Abstract

The Liquid Propulsion Laboratory (LPL) presents the implementation and impact of additive manufacturing in the development of Jessie & James, a pair of 3D printed liquid rocket engines. The Jessie and James engines (J&J) were brought from conception to operation during the year of 2018 and represented the first time a university designed and manufactured a 3D printed rocket engine entirely on campus. The Liquid Propulsion Laboratory has recently adopted additive manufacturing as the primary method of developing rocket engines with the belief that this newfound process will increase design capabilities, improve iteration turnaround time, decrease development cost, and make an overall positive contribution to the laboratory's primary mission of workforce development. The purpose of the J&J project was to introduce the lab to additive manufacturing, quantify and validate initial beliefs, test the resources and manufacturing capabilities of the university, and to provide familiarity to designers and process engineers as the laboratory moves toward to more complex rocket engine designs in the near future. This paper steps through the technical approach on how to design and manufacture a liquid rocket engine, all while demonstrating how 3D printing can be implemented into the development cycle to increase the program's probability of success. Design considerations and printer parameters to arrive at a successful print are discussed. LPL has examined and implemented a post-print process workflow to ensure quality and reliable prints. The overall manufacturing process is discussed, including decisions made, roadblocks encountered, and future process improvements. The J&J injector is a prime example of the increased capabilities enabled with the new design space of additive manufacturing. This injector is of a similar size and performance as a previous LPL injector, manufactured subtractively. This allows LPL to compare cost, lead time, and performance. By utilizing additive manufacturing, LPL has been able to fabricate a rocket engine at a 45% cost reduction and in a third of time, when compared to subtractive manufacturing. The paper also provides examples of how the additive manufacturing approach can benefit student laboratories by overcoming rapid turnover rates, improving workforce development, and creating an infrastructure where continuous technical advancements can be achieved. The paper concludes with future work for the J&J project, considerations for different rocket engine designs, and provides overall feedback on the impact of implementing 3D printing into the liquid rocket engine development process.