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Author: Mr. Davide Pederbelli
Politecnico di Torino, Italy

Mr. Francesco Farina
Politecnico di Torino, Italy

INTEGRATED EXPERIMENTAL CAMPAIGN TO VALIDATE NUMERICAL MODAL ANALYSIS ON A FUSED DEPOSITION MODELLING CUBESAT PRIMARY STRUCTURE: A SMART TEST METHODOLOGY FOR INCREASING STUDENTS LEARNING CAPABILITIES

Abstract

The trend of the Additive Manufacturing is frequently exploited in academic environment thanks to easy-to-use and low-cost characteristics, supporting the decision-making process through rapid prototyping, evolving from scratch idea to preliminary design.
Novel additive manufacturing technologies, such as the Fused Deposition Modeling, are enabling complex geometries, unfeasible by conventional process, and rapid prototyping. For this reason, this technology is currently planned to be employed also in space application.
Promising results of this application can be found in the feasibility study of nozzles production for propulsion system using metal additive manufacturing techniques within the European Space Agency manufacturing initiative which also foreseen the installation of 3D-printer in the International Space Station. In addition, the number of space applications in which space-grade plastic materials are applied, is growing up. However, the mechanical properties between extruded material and filament are different. Indeed, proprieties depend on setting parameters of the printer, thread processes, and fiber orientation. As result, it is very difficult to verify if a plastic material manufactured by Additive Manufacturing can be applied in space application.
The aim of this work is to validate the effectiveness of using additive manufactured plastic materials in an educational project and to derive the dynamic properties of the structure and its materials.
Using a 6 unit CubeSat as specimen,development of a test methodology to validate a Finite Element Model via a "hammer test" is presented and analyzed. The 6U platform is developed in Polyactide, cheap and highly available material, in accordance with the outgassing requirements for space structures. The processes and methods provide the realization of different models: a continuous structure, a benchmark, and an assembled structure composed by elemental parts. The drivers of the manufacturing process have been derived by analysis of model dynamics through a 2D Finite Elements models, created to fulfill the structural stiffness requirements, balancing computational cost and compliance with the physical model. The test results confirm that primary structure composed by elementary joined parts satisfy the lateral and longitudinal natural frequency requirements, assuming Soyuz as reference, confirming a matching with mathematical model.
As a result, this paper increase the knowledge about the characterization of plastic structures for space application, while proving the effectiveness of additive manufacturing techniques in terms of teaching opportunities and affordability. At last a roadmap for successful integration of this methodology is drawn, highlighting future research and the performance in preparing student for their next employment in industries.