IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Manufacturing and industrialization for Launch Vehicle and Space Vehicle Structures and components (High volume production, industrialization, automatization and digitalization) (7)

Author: Dr. Marco Grasso
Politecnico di Milano, Italy

Dr. Paolo Parenti
Politecnico di Milano, Italy
Dr. Francesco Galbusera
Politecnico di Milano, Italy
Dr. Talha Sunar
Politecnico di Milano, Italy
Dr. Tanya Scalia
Italian Space Agency (ASI), Italy
Dr. Marco Pizzarelli
Italian Space Agency (ASI), Italy
Mr. Giuseppe D'Amore
Agenzia Spaziale Italiana (ASI), Italy
Prof. Bianca Maria Colosimo
Politecnico di Milano, Italy
Prof. Barbara Previtali
Politecnico di Milano, Italy

ADDITIVE MANUFACTURING OF COPPER COMPONENTS FOR THE SPACE SECTOR: A TECHNOLOGY COMPARISON

Abstract

Additive manufacturing (AM) has been pointed out to be a pivotal enabling technology within the space sector, as it allows rethinking traditional approaches to space system design and manufacturing. Leveraging AM techniques holds immense promise for enhancing the performance and reliability of space systems, as demonstrated by the achievement of flight-proven status by a constantly increasing number of additively manufactured components. In addition, AM methods provide space companies with a new capacity to reduce production costs and lead time, to enhance the sustainability of the production chain, opening also new opportunities for in-space manufacturing. In this framework, AM of copper and its alloys has attracted a wide scientific and industrial interest in the space community. Indeed, it opens a variety of relevant applications, from high-performance propulsion systems to advanced thermal management solutions, from radio-frequency equipment to on-board electronics and new payload designs. Different AM processes are suitable to produce copper parts. Each of them is characterized by specific pros and cons and by inherent limitations. Understanding the actual application boundaries for each technology is crucial for an effective adoption of AM methods in the space sectors. This paper presents a technological comparison involving three different AM processes, namely powder bed fusion with laser and electron beam energy source, and material extrusion. In this paper, the capabilities and the limits of such processes are compared using a reference geometry representative of geometrical shapes of interest for space system applications, such as thin walls and gyroid lattice structures. Physical and functional performances have been characterized and compared, highlighting the benefits and disadvantages of each

method in a qualitative and quantitative way. The quantitative comparison includes process parameters such as printing speed, material utilization efficiency and post-processing requirements which can be quantitatively compared to assess the overall cost-effectiveness and productivity of each AM process. Optimization of these process parameters is driven also by the evaluation of microstructural analysis - such as grain structure and porosity - and mechanical properties - such as tensile and yield strength. In addition, a cost-benefit analysis considering initial investment, material costs and operational expenses is crucial for evaluating the economic viability of adopting each AM process in space system manufacturing. By systematically and critically evaluating physical and functional performances and conducting quantitative comparisons, stakeholders can make informed decisions regarding the selection and adoption of AM processes for space system applications.