ID contributo: **186** Tipo: **Presentazione orale**

ADVANCED DESIGN OF TPMS-BASED CELLULAR STRUCTURES FOR ENHANCED PERFORMANCE IN PIN-COLLAR JOINTS

giovedì 4 settembre 2025 11:15 (15 minuti)

Triply Periodic Minimal Surface (TPMS) cellular structures have been widely employed in various engineering applications to reduce component weight while maintaining mechanical performance. Unlike truss-based lattice structures, TPMS allow for a homogeneous redistribution of stress, thus reducing the risk of localised yielding and fracture. Despite extensive research on cellular solids, their potential to enhance the performance of mechanical joints remains largely unexplored.
This study delves into the application of TPMS in an adhesive joint, specifically a shaft-hub assembly. The hub was redesigned using three distinct types of cells, namely gyroid, split-P, and diamond.
The specimens were modelled using nTop software, ensuring conformity with the circular profile of the hub, and adhering to the constraints imposed by the additive manufacturing (AM) process. The overall dimensions of the components range from an inner diameter of 20 mm and an outer diameter of 48 mm, with the cellular architectures confined within a diameter range of 24 to 36 mm. To analyse structural performance variations, during the design phase three levels of volume fraction—40%, 45%, and 50%—were considered. A static simulation was performed within a linear elastic framework to inspect the distribution of von Mises stress and evaluate whether plastic deformation or failure may occur locally.
Then, samples with a volume fraction of 50% were printed in AISI 316L stainless steel via Metal Laser Powder Bed Fusion (M-LPBF). Push-out experimental tests have been carried out to assess the effect of the design on the performance of the joint.
This preliminary research unveils the potential benefits of introducing cellular solids within cylindrical couplings, offering an effective strategy to improve mechanical performance. However, further analyses are required to gain a deeper understanding of the subject and explore additional benefits that may be achieved through this innovative design methodology.

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Classifica Sessioni: Additive Manufacturing

Classificazione della track: Additive Manufacturing