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COMBINING ADDITIVE MANUFACTURING AND BIOMIMETICS FOR THE OPTIMIZATION OF SATELLITE STRUCTURES

Abstract

Successful utilization of Additive Manufacturing (AM) in the space sector implicates two aspects: First, an understanding of the process inherent characteristics has to be developed, where the anisotropic behavior of material is of significant importance. Second, the part design methodology has to be adapted, since it is often coupled and limited to traditional shapes and production methods and thus prevent an exploitation of the full AM potential. In a research collaboration between the Technical University of Munich, the Instituto Tecnológico de Buenos Aires, and the Fraunhofer Research Institution for Casting, Composite and Processing Technology, the structural optimization of a microsatellite yielded in research in both areas. We will report on the evaluation of the Total Mass Loss (TML), Coefficient of Thermal Expansion (CTE) and tensile strength for the materials polyether-ether-ketone (PEEK) and Ti6Al4V, which are both relevant for space applications. We produced tensile and dilatometer specimen with orthogonal placement on the build platform for all three printing directions via Fused Deposition Modeling (FDM) for PEEK and Selective Laser Sintering (SLS) for Ti6Al4V in accordance to national standards. Outgassing tests of the specimen show that the TML for both materials is below the limit of 1%. CTE values deviate 13% from the manufacturers' specified mean value for injection molded PEEK. Mean tensile strength values for PEEK were 57% worse than the injection molded values specified by the manufacturer. Ti6Al4V samples showed no anisotropy and fitted the expected values for both, CTE and tensile strength. The overall results indicate the need for additional tests and safety factors when using additive manufactured PEEK for space applications. The second part of this paper presents a holistic design approach, composed of several already known methodologies. For the selection of suitable part candidates for AM specific redesign, we compared different parts and assemblies in terms of manufacturability, economic feasibility and the potential of functional improvements. For the subsequent part redesign, we applied a biomimicry inspired design methodology in combination with AM design rules, overcoming common thinking patterns. We verified our approach through a case study, where we systematically redesigned a startracker's housing. The new design includes an integrated thermal link, which helps to keep the COTS sensor temperature at $-10\,^{\circ}\mathrm{C}$ during operation, and an integrated compliant mechanism for the fine adjustment of the sensor. Finally, we validated our design through thermal analysis in ESATAN-TMS and structural analysis in ANSYS.