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THE PROSPECT OF ADDITIVE MANUFACTURING IN PRIMARY STRUCTURE OF LAUNCH VEHICLE

Abstract

Additive manufacturing (AM) has attracted widely attention for its advantages including rapid prototyping and free design. It is especially suitable in primary structure of spacecraft such as launch vehicle considering frequent launch and lightweight requirements. However, as emerging technology, AM has inevitably encountered some difficulties in the practical engineering application. For example, AM may bring new defects in structures, e.g., anisotropy, micro-void and surface roughness, which effects has not been studied enough; many constraints still exists, e.g., lack of material choice and limits of modeling dimension for fused deposition modeling (FDM) technology. In this paper, an innovative design as lattice sandwich cylindrical shell is proposed for primary structure in launch vehicle in terms of actual load cases, and is possible to be manufactured with AM in the near future. Firstly, two kinds of lattice sandwich test pieces including out-of-plane and in-plane compression are produced in selected laser melting (SLM) technology. The test results are highly consistent for the same piece and the SEM observation shows that the truss surface roughness is almost the same as Rz 50 microns, which prove that the defects can be ignored for the trusses with radius over 0.4 mm. Secondly, the mechanical properties of pyramidal lattice are investigated, and the carrying capacity is given analytically corresponding to every failure modes of lattice sandwich cylindrical shell. Then, one of semi-grid cylindrical cabin is re-designed in the form of lattice sandwich under the same mass, which sizes are ultimately decided through optimization analysis. Finally, finite element model of the new cabin is established and the ultimate bearing capacity is calculated. Numerical result shows that the lattice sandwich form can obvious enhance the bearing capacity of cylindrical shell. In other words, AM can greatly improve the design of primary structure of spacecraft in the future as long as continuous improvement.