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Subdivisional Modelling Method for Matched Metal Additive Manufacturing and Its Implementation on Novel Negative Poisson's Ratio Lattice Structures

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ABSTRACT

As metal additive manufacturing (MAM) becomes more widely used in engineering, an increasing number of novel lattice structures are being developed. However, most recently developed lattice structures do not match the requirement of MAM efficiently. Based on the Design for Additive Manufacturing (DfAM), comparing the mainstream implicit and explicit modelling methods, it is proposed to introduce a Subdivisional (Sub-D) modelling method to model lattice structures with better modelling versatility, 3D printability, and mechanical properties. To this end, a novel negative Poisson's ratio (NPR) structure is developed as an example to demonstrate the efficient and wide applicability of the Sub-D modelling method. The structure is a lattice structure that is complex to model, difficult to print, and has specific mechanical properties. The results show that the Sub-D modelling method allows for the intuitive design, flexible adjustment, efficient G2 surface generation, and robust model output of truss-based and sheet-based NPR structures (modelling versatility); the generated G2 curvature continuum surface can mitigate manufacturing difficulties and form lightweight structures. In comparison to NURBS modelling methods, it can generate cantilever truss structures with a 1.33 times greater span and 55% higher geometric fidelity (3D printability); its Young's modulus, yield strength, compressive strength, and specific energy absorption are 186%, 60%, 66% and 50% higher, respectively (mechanical properties). In addition, the use of highly ductile silver as a material has provided new insights into the structural mechanics of MAM lattice structures with high ductility.

KEYWORDS

Subdivisional modelling methods; lattice structures; negative Poisson's ratio structures; structural design and optimisation; 3D printing

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