Tech Science Press

ICCES, 2024, vol.31, no.1
DOI: 10.32604/icces.2024.011085

PROCEEDINGS

Research on Impact Behavior of Diagonal Gradient Lattice Structure

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ABSTRACT

Functionally graded lattice structures have garnered significant interest in impact research in recent years as novel structures because of the exceptional properties, including lightweight, high specific strength, and high specific stiffness. Aiming at the problem that the current functionally graded lattice structure incorporates gradient characteristics in the longitudinal or transverse direction, with no research on the diagonal gradient characteristics, this paper proposes a diagonal gradient lattice structure (DGLS) based on the body centered cubic (BCC) lattice structure. The quasi-static compression experiments were carried out on the resin samples manufactured through the photocuring molding technique. Besides, the numerical simulation was employed to analyze the compression response and energy absorption capability of OGLS at various impact velocities. The results show that OGLS combines the benefits of uniform and linear gradient lattice structures under quasi-static conditions, exhibiting an excellent impact resistance ability as the stress rises rapidly under minor strain. The stress-strain curve shows a multi-platform upward trend, and the stress is increased by 1.96 times before the densification stage, while the mechanical properties and energy absorption capacity are also gradually enhanced. The superior impact resistance and energy absorption capability of OGLS are further validated by a quantitative measurement of the strength, energy absorption, and modulus of lattice structures. Compared to the uniform lattice structure, it exhibits improvements of 5.85% in elastic modulus, 2.94% in yield strength, 7.06% in platform strength, and 10.83% in specific energy absorption. Under low-velocity impact, the deformation mode and mechanical properties of OGLS are identical to those under quasi-static impact, and the deformation occurs preferentially in low-density areas, indicating a negative Poisson's ratio effect. When subjected to high-velocity impact, OGLS cannot respond to the compression behavior in time, so it deforms rapidly from the compression face to the fixed face, and the stress-strain curve fluctuates wildly. The diagonal gradient feature enables the structure to gather towards the impact area when facing low-velocity impact, thus forming a more substantial impact resistance and energy absorption capacity. Furthermore, the influence of rod diameter, gradient coefficient, and aspect ratio on the impact resistance of OGLS is studied. By introducing the Gibson-Ashby model, a mechanical performance prediction model of OGLS is proposed, which agrees with the numerical simulation results. This study can provide a new design for applying lattice structures in anti-impact protection devices.

KEYWORDS

Functionally graded lattice structure; photocuring; impact behavior; mechanical property; energy absorption

Acknowledgement: Funding from the National Natural Science Foundation of China is gratefully acknowledged.

Funding Statement: The work was supported by the National Natural Science Foundation of China

(51975438, U1564202); and the 111 Project (B17034).

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.