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The design and experimental research of a simple multiaxial test apparatus at cryogenic temperature

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Structural materials are often in a complex stress environment during cryogenic service. For example, superconductors and structures will be subject to support load, thermal residual stress, and electromagnetic force. Composites used for storing cryogenic liquids also bear with the joint action of the axial and radial load produced by internal high pressure. The complex stress state has a significant role in the failures of materials, and thus it is important to investigate the deformation and fracture behaviors of materials under complex loads at cryogenic temperatures before the practical applications. However, independently applying multi-axial loads to specimens at cryogenic temperatures is challenging and costly. In this paper, a three-axis loading device based on the uniaxial tensile machine was designed. The three-axis loading device converts the uniaxial motion into the triaxial motion with displacement ratio control, capable of applying orthogonal compression, tensile compression, and tensile bending loads to the specimen at cryogenic temperatures. The shape of the specimen is designed based on orthogonal patterns. The device can be adjusted to realize the application of loads with different displacement ratios such as 1:1:1, 1:2:2, 1:0.5:0.5, and so on. Finally, the feasibility of the device was verified by simulation and cryogenic temperature experiments, especially at 77 K and 4.2 K.

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