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STRUCTURALLY ELASTIC PRESSURIZED TUBE FOR FLEXIBLE SPACESUIT JOINT STRUCTURE

Abstract

Spacesuits play a key role in future manned exploration programs on lunar and Martian surfaces, where astronauts are expected to operate long-term advanced missions. At present, to enhance joint mobility, inside of spacesuits have to be depressurized to reduce pressure gap between outside (outer space) and inside of the suit. The depressurization requires astronauts to undergo oxygen prebreathing procedure and manage decompression sickness risk. Increasing internal pressure to a level as high as atmospheric pressure makes spacesuit joints quite rigid and decreases mobility. To solve the opposite issues, in other words, to manufacture highly mobile spacesuits which don't require prebreathe, novel flexible joint structures overcoming high pressure gap are demanded.

To enhance the flexibility of joints, the present study proposes a new joint structure, which is inspired by 'Origami', Japanese art of folding paper. In this structure, polygonal stainless steel frames are attached regularly in longitudinal direction on the fabric cylindrical tube. Each frame is rotated by a certain angle relative to next one; then, rhombic folding pattern is induced on the tube, enabling contraction of an inner side of joint. The polygonal frames three-dimensionally control the shape of the fabric tube and restrain axial extension due to internal pressure. It means that structurally elastic property in axial direction is built into the structure.

To measure bending property, the cantilever bending test is carried out. The free end of the pressurized structure is loaded perpendicular to tube's axial direction. The relation between load and deformation angle is measured. The results of experiments show that the proposed structure has better bending property compared with the tube without any modification. Especially, the proposed structure starts bending as soon as loading begins, while the plane tube is slightly deformed.

Numerical analysis based on applied Euler-Bernoulli beam theory is carried out to analyze the structure. From the comparison between experimental and theoretical result, it is confirmed that the proposed structure restrains itself axially against inflation and cancels the prestrain mostly, giving axial elasticity to the tube.

As another advantageous property of the tube, it is observed that the internal pressure rises more moderately than in case of the plane tube during bending deformation. This difference indicates that the proposed tube structure has capability to maintain its volume, that also contributes to higher bending property.