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DESIGN AND MANUFACTURE OF A HARD SHOULDER JOINT FOR THE NDX-4 SPACE SUIT

Abstract

The development of space suits is a challenging task that requires careful consideration of the unique demands of space travel. One of the most critical components of a space suit is the shoulder joint, which must provide the necessary mobility and support for astronauts to perform their tasks. The NDX-4 space suit is a new-generation rear-entry 3D-printed space suit prototype designed to meet the needs of planetary extravehicular activities. It was developed at the Human Space Flight Laboratory at the University of North Dakota under NASA funding. This work presents the design and manufacture of a hard shoulder joint for the NDX-4 space suit. The design process and manufacturing methods will be discussed, along with the testing of the shoulder joint. Creating the shoulder joint for the NDX-4 spacesuit signifies a breakthrough in 3D-printed spacesuit design and is a crucial contribution to one of the most vital components, as it is responsible for the entire arm's mobility.

3D printing is a revolutionary approach in this domain, potentially transforming the sustainability of prolonged human space missions. It allows the on-demand production of vital parts and tools, minimizing the need for extensive pre-mission stockpiles and dependence on Earth-based resupply missions. This capability is particularly advantageous during unexpected breakdowns, where immediate access to replacement parts is crucial.

However, integrating 3D printing into space suit construction presents challenges, primarily due to the difference in mechanical properties between traditional spacesuit materials and those used in 3D printing. Traditional spacesuit materials—like advanced textiles, flexible composites, and elastomers—are engineered to balance flexibility, strength, and durability, allowing effective astronaut movement. In contrast, 3D-printed materials, such as thermoplastics, often differ in tensile strength, flexibility, and elasticity, necessitating advancements in 3D printing technology to meet traditional material standards.

The project commenced with a comprehensive review of space suit design literature, focusing on advancements in hard shoulder joint technology. Utilizing CAD tools, a detailed 3D model of the shoulder joint was created, followed by its manufacturing through 3D printing. The final stage involved testing and validating the shoulder joint to confirm it meets the required specifications and performance standards for the NDX-4 space suit.

This project not only marks a significant step forward in the field of 3D-printed space suit design but also emphasizes the crucial role of the shoulder joint in ensuring astronaut mobility, highlighting the broader implications of 3D printing technology in advancing human space exploration.