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DESIGN OF A MECHANICAL COUNTER PRESSURE SPACESUIT INCORPORATING PASSIVE AND ACTIVE TENSIONING MATERIALS

Abstract

Future planetary excursions require highly capable spacesuits that maximize scientific output and operational efficiency. A spacesuit design that allows mobility with natural ranges of motion and low metabolic cost during locomotion will be critical towards that goal. To that end, the MIT BioSuit^{TM} is an advanced spacesuit concept under development, that works on the principle of Mechanical Counter Pressure (MCP). All current spacesuits use gas to provide the required pressure environment. The BioSuit^{TM} design replaces the gas pressure with direct MCP from suit fabric tension, thereby eliminating the work required to overcome compressing the gas volume involved in bending of joints during locomotion or EVA operations. Consequently, the overall metabolic cost in planetary EVA's is significantly reduced as compared to gas pressurized suits.

This paper discusses the current state of the BioSuit^{TM} research, the current concept design of the suit, how it achieves the technical goals, and how results from material testing inform design. In the concept described, the suit tensioning is achieved using tensioning strips that run axially along each body section such as the limbs and torso. These strips cinch and apply circumferential tension on a fabric covering the skin surface, generating MCP. The tension is achieved passively and actively using high strength elastomers and Shape Memory Polymers (that exert force above a certain transition temperature), respectively. The passive component applies the largest fraction of the required tension. The active component allows for varying the tension locally and maintaining a uniform pressure of 30 kPa. It also enables easy donning and doffing of the suit. The overall design minimizes the work required in fabric deformation involved in motion with a fully tensioned suit. Results from biaxial tensile tests on these design principles are presented. Different fabric and elastomer types are tested in order to characterize mobility offered under operational conditions.