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ACTIVE BRAID COMPRESSION TECHNOLOGY FOR MECHANICAL COUNTER-PRESSURE (MCP) SPACE SUITS

Abstract

Gas-pressurized space suits have been used since the Apollo era to keep astronauts alive in the harsh space environment. These suits succeed at providing complete life support for the astronaut, but are known to restrict mobility and even injure the wearer as a result of their inherent stiffness. Mechanical counter-pressure (MCP) space suits, which provide identical life support capabilities but apply pressure to the wearer using tight-fitting materials rather than pressurized gas, offer numerous advantages over traditional gas-pressurized suits. However, MCP design challenges related to pressure uniformity, pressure magnitude, and donning/doffing remain unsolved.

Previous MCP efforts have focused on passive compression technologies, but an ideal MCP garment would incorporate actively controllable elements designed to dynamically change the garment's shape, which would enable real-time and high-resolution modification of compression profiles to address these issues. This research effort contributes modeling, development and testing of an active compression textile incorporating biaxially-braided elements driven by shape memory alloy (SMA) actuators.

A comprehensive and validated model for the cylindrical biaxial braid design space is presented that describes radius as a function of length and predicts the maximum and minimum radii given arc length, element cross-section and element count. A simple mechanical counter pressure model, backed by experimental validation, is described for biaxial braids.

Finally, we describe the development and characterization of SMA coiled actuators (0.3048 mm cable diameter, 1.24 mm coil diameter) for integration in a biaxially-braided garment architecture, including force, displacement, and temperature relationships. Pressure production capabilities of a first-generation MCP compression sleeve utilizing this architecture are presented.