Valve Design for Electrorheological Fluid Based Soft Hydraulic Robots

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Abstract

Soft robots are designed to utilize their compliance and contortionistic abilities to both interact safely with their environment and move through it in ways a rigid robot cannot. To more completely achieve this, the robot should be made of as many soft components as possible. Here we present a completely soft hydraulic control valve consisting of a 3D printed photopolymer body with electrorheological fluid (ER) as a working fluid and eutectic gallium indium (EGaIn) liquid metal alloy as electrodes. This soft ER valve allows actuation control onboard the robot while furthering the goal of an entirely soft controllable robot. The soft ER valve pressure holding capabilities were tested under unstrained conditions, cyclic valve activation, and the strained conditions of bending, twisting, stretching, and indentation. It was found that the max holding pressure of the valve when 5 kV was applied across the electrodes was 264 kPa, and that the holding pressure deviated less than 15% from the unstrained max holding pressure under all strain conditions except for indentation, which had approximately a 60% max pressure increase. Additionally, a soft octopus-like robot was designed, 3D printed and assembled, and a soft ER valve was used to stop the fluid flow, build pressure in the robot, and actuate six octopus tentacle-like soft bending actuators.

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