Design and Kinematic Analysis of a Semi-Compliant Swashplate Mechanism

Abstract

Compliant mechanisms generate motion through the deformation or deflection of its flexible members rather than the revolute joints utilized in traditional rigid link mechanisms. If a compliant mechanism is designed as a single piece without the need of joints to create relative motion, then it is a monolithic system. If at least one part of the mechanism is flexible and assembled with rigid parts and joints, then it is a partially compliant mechanism. The superiorities of compliant mechanisms over rigid mechanisms are the reduced number of parts required to build the system, simple design, no backlash, no lubrication, less friction, light weight and thereby increased performance. As the new materials and new manufacturing methods such are developed, compliant mechanisms found more application areas in the field of MEMs, aerospace, medical and robotics. This study presents the design, analysis and modelling of a large deflecting compliant swashplate mechanism that is actuated by rigid pitch links. Pitch links are actuated by high torque servo motors. Kinematic analysis of the entire mechanism is obtained by integrating vector closure loop equations. Modelling of small length flexural pivots using pseudo rigid body model (PRBM) and Adams analysis is performed to model flexure hinges by fitting higher order polynomial to load deflection curve. Effects of thickness and length on deflection of flexible segments are analyzed experimentally. Experimental setup is built by 3D printing mechanism parts using polylactic acid (PLA) and assembling together with ball bearings and pin joints. Tip position of the mechanism is recorded by laser displacement sensor, Arduino and Matlab. It is observed that higher amplitude, quicker response time and precise motion can be achieved by the proposed compliant mechanism.