Russell Sindrey and Gary M. Bone, “Position Tracking Control of a Miniature Water Hydraulic Rotary Actuator”, *ASME Journal of Dynamic Systems, Measurement and Control*, Vol. 131, No. 6, 8 pages, 2009.

Abstract

Over the past 20 years, research in the field of miniature actuators has increased substantially due to advances in smart material fabrication, semiconductor chip technology, and computer processing capability. Hydraulic cylinders offer many potential benefits as miniature actuators, including high power-to-weight ratio, mechanical stiffness, smooth motion, and the potential for high positional accuracy. Despite their benefits, the control of hydraulic cylinders with bore diameters under 10 mm has not been previously studied. The most significant obstacle to implementing the use of miniature cylinders is the unavailability of off-the-shelf proportional valves that are compatible with hydraulic fluid and precise enough for the position control task. In this paper, two novel model-based nonlinear control strategies are presented for the position control of a rotary actuator powered by two 4 mm bore diameter cylinders. Four off-the-shelf, low cost, 2/2 on/off miniature solenoid valves were used to control the flow of water to and from the cylinder chambers. A novel valve coordination scheme is also presented that allows the on/off valves to approximate the behavior of a proportional valve. The tracking performance of each controller was experimentally tested and both controllers were found to achieve steady-state positioning accuracies of the cylinders within ±0.07 mm. The robustness of the controllers to changes in payload mass and vertical orientation was also tested. Results from several experiments are presented and compared.