Developmen ow-cost Wearable Servo Valve Using Buckled Tubes and Embedded Controller

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Abstract

In this study, a small-size, lightweight and low cost servo valve is developed to replace the typical solenoid valve. As an inexpensive method of changing the opening area of the valve, the method of changing the buckling condition of the tube using a RC servo motor is proposed. 3-port twisting type valve is also proposed and tested to adjust its supply and exhaust states at the same time. In order to decrease its non-linear characteristics in relation between output flow rate and motor rotational angle, a new 3-port bending type servo valve that has smaller hysteresis characteristics and smaller overlap zone is proposed. Furthermore, position control of rubber artificial muscle using twisting and bending type valve are carried out. As a result, the standard deviation of positioning errors using bending type valve is improved from 2.0 mm to 0.9 mm. Also, pressure controlled type servo valve is proposed. By using bending type valve with smaller dead zone, the dead time of the valve is decreased. From the pressure tracking control result, the improved bandwidth frequency of 4.1 Hz was obtained compared with the previous pressure controlled twisting type valve that is 2.2 Hz. Therefore, the validity and better performance of bending type valve was confirmed. For optimal design of the valve, an analytical model of the valve with embedded controller is proposed. The system parameters are also identified. Especially the relations between the buckling angle with respect to the restoration torque and the tubes opening area are assumed as empirical formula from experimental results. In order to confirm the validity of the proposed model and identified parameters of the valve, the calculated statics and dynamics behaviors of the valve model is compared with the experimental results. It is obtained that the calculated results using the model agree well with the experimental results. It can be concluded that the proposed model and identified parameters are useful to estimate the performance of the valve by changing the arrangement of two buckled tubes. Moreover, in order to obtain the optimal arrangement of buckled tube, the calculation results of pressure tracking control performance using the valve with various arrangements of two buckled tubes is carried out. Thus, the optimal design parameter of buckling point and the initial buckled angle of tubes and optimal control gain can be obtained. Based on the calculated transient response of tracking pressure using the optimal values, it can be confirmed that the valve performance with optimal design parameters can be theoretically improved.