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DESIGN AND DEVELOPMENT OF LATCHING SOLENOID VALVE FOR ACTIVE PRESSURE REGULATION SYSTEM

Abstract

Need for Active Pressure Regulation System (APRS) is increasing in both Launch vehicle and Spacecraft Propulsion Systems. In APRS, set pressure variation can be accomplished in real time based on the system demand. This flexibility in varying set pressure is not possible in conventional mechanical pressure regulators wherein set pressure is fixed at a predefined value. APRS offers other advantages of robust system with reduced complexity, lighter in weight and facilitate accurate and precise pressure regulation even at lower inlet pressure.

APRS predominantly use solenoid valves with higher cyclic life, which are operated in Bang-Bang mode of pressure regulation. Solenoid valves require continuous power to remain in commanded position. Some solenoids employ two coils, viz, one coil for switching and another coil for holding in commanded position in order to optimize power consumption.

This paper discusses the design and development of fast acting Latching Solenoid Valve (LSV) with infinite cyclic life for APRS. LSV has solenoid coil which will be powered during switching and latching in commanded position is effected by means of permanent magnet. LSV is designed for the regulation of inlet pressure ranging from 20 MPa - 0.6 MPa to an outlet pressure up to 0.5 MPa. Present APRS employs LSV, electronic controls for Pulse-width Modulation (PWM), pressure transducers, plenum volume and control orifice.

APRS demand faster response time (< 10 ms) coupled with higher cyclic life (> 1 million cycles) from LSV. These requirements are accomplished by optimizing actuation force, design of magnetic circuit, suspension of dynamic elements in flexure pack and minimizing bearing stress between seating surfaces. This design methodology helped in reducing the mass of LSV by 40% when compared to that of solenoid valve designed for the same application. Modeling of APRS was done to estimate the total system response.

Development tests were carried out to validate the design. Simulation tests conducted to demonstrate capability of LSV for meeting the dynamic requirements of APRS. One million cyclic actuations on

two valves were conducted to qualify the design for infinite cyclic life. Environmental tests carried out simulating service conditions. Performance of the valve is consistent throughout the development cycle.

Keywords: Latching solenoid valve, flexure, permanent magnet, cyclic life, response time and Pulse Width Modulation.