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## Study of Vortex Valve for Medium Temperature Solid Propellants

The fluid state vortex valve secondary injection control system shows considerable promise for future application to solid propellant rocket engine thrust vector control. The single axis injection system tested would be capable of providing secondary injection thrust vector control using 2000°F gas.

The following summarizes the program's activities:

Six hot-gas firings were made. The gas generator supplied a flow of 1.0 lb/sec for 30 seconds. This system incorporated two vortex valves in parallel, functioning together as a flow divider circuit. One of the vortex valves utilizes active control, the other acting essentially as a pressure regulator maintaining the supply pressure constant by effectively bypassing flow when the power valve is throttled. This system demonstrated a flow modulation capability in excess of 4 to 1. The particular system concept selected, using active control on only one vortex valve, does not produce the desired total system performance. A better system approach would be to use active control on both vortex valves and operate essentially in a push–pull mode. The system dynamic response was evaluated with sinusoidal and transient inputs. At 30 cps the amplitude attenuation was –4db and the phase lag was 28 degrees. The frequency response of the basic vortex valve is fast enough so that the system dynamics are dominated by the associated manifold volume compressibility time constants.

The control system components and associated hardware functioned as desired. The performance of the vortex valve did not change during a 30-second hot-gas test, indicating insensitivity to thermal expansion. A composite structure of high density graphite backed with asbestos-phenolic eliminated erosion in the supply manifold.

Cold gas testing of a one-sixth scale model vortex valve was conducted to optimize the configuration and performance of the vortex power valve and vortex regulator valve for the selected system. The normalized performance, with regard to gains and flow modulation range, was practically identical for hot- and cold-gas tests. The two vortex valves required complementary characteristics, achieved by variation in the vortex valve geometry. This parameter variation experience resulted in further insight into the basic knowledge of vortex valve technology and control system performance.

The logical extension of this program is to develop a fluid state control system using high temperature (6000°F) aluminized solid propellant gases. Eventually, a direct engine bleed, fluid state, secondary injection thrust vector control system should provide a lightweight system with inherent simplicity and high reliability.

**Note:**

Additional information is contained in: "Research Study of the Vortex Valve for Medium-Temperature Solid Propellants," by W. D. Holt and J. G. Rivard, The Bendix Corporation, August 1965, Report No. N66-21695, which may be obtained from:

Technology Utilization Officer
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**Patent status:**

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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