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Design Development and Qualification of a Magnetically Levitated Blower for $C0_2$ Scrubbing in Manned Space Missions

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Abstract : The Marshall Space Flight Center is designing and building a next-generation CO_2 removal system, the Four Bed Carbon Dioxide Scrubber ($4BCO_2$), which will use the International Space Station (ISS) as a testbed. The current ISS CO2 removal system has faced many challenges in both performance and reliability. Given that CO2 removal is an integral Environmental Control and Life Support System (ECLSS) subsystem, the 4BCO2 Scrubber has been designed to eliminate the shortfalls identified in the current ISS system. One of the key required upgrades was to improve the performance and reliability of the blower that provides the airflow through the CO_2 sorbent beds. A magnetically levitated blower, capable of higher airflow and pressure than the previous system, was developed to meet this need. The design and qualification testing of this next-generation blower are described here. The new blower features a high-efficiency permanent magnet motor, a five-axis, active magnetic bearing system, and a compact controller containing both a variable speed drive and a magnetic bearing controller. The blower uses a centrifugal impeller to pull air from the inlet port and drive it through an annular space around the motor and magnetic bearing components to the exhaust port. Technical challenges of the blower and controller development include survival of the blower system under launch random vibration loads, operation in microgravity, packaging under strict size and weight requirements, and successful operation during $4BCO_2$ operational changeovers. An ANSYS structural dynamic model of the controller was used to predict response to the NASA defined random vibration spectrum and drive minor design changes. The simulation results are compared to measurements from qualification testing the controller on a vibration table. Predicted blower performance is compared to flow loop testing measurements. Dynamic response of the system to valve changeovers is presented and discussed using high bandwidth measurements from dynamic pressure probes, magnetic bearing position sensors, and actuator coil currents. The results presented in the paper show that the blower controller will survive launch vibration levels, the blower flow meets the requirements, and the magnetic bearings have adequate load capacity and control bandwidth to maintain the desired rotor position during the valve changeover transients.

Keywords : blower, carbon dioxide removal, environmental control and life support system, magnetic bearing, permanent magnet motor, validation testing, vibration
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