Mechanics/Machinery

Two-Stage Centrifugal Fan

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Fan designs are often constrained by envelope, rotational speed, weight, and power. Aerodynamic performance and motor electrical performance are heavily influenced by rotational speed. The fan used in this work is at a practical limit for rotational speed due to motor performance characteristics, and there is no more space available in the packaging for a larger fan. The pressure rise requirements keep growing. The way to ordinarily accommodate a higher DP is to spin faster or grow the fan rotor diameter.

The invention is to put two radially oriented stages on a single disk. Flow enters the first stage from the center; energy is imparted to the flow in the first stage blades, the flow is redirected some amount opposite to the direction of rotation in the fixed stators, and more energy is imparted to the flow in the second-stage blades.

Without increasing either rotational speed or disk diameter, it is believed that as much as 50 percent more DP can be achieved with this design than with an ordinary, single-stage centrifugal design. This invention is useful primarily for fans having relatively low flow rates with relatively high pressure rise requirements.

This work was done by David Converse of Hamilton Sundstrand for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act {42 U.S.C. 2457(f)} to Hamilton Sundstrand. Inquiries concerning licenses for its commercial development should be addressed to:

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Combined Structural and Trajectory Control of Variable-Geometry Planetary Entry Systems

This technique can be applied for use in aircraft and underwater vehicles.

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Some of the key challenges of planetary entry are to dissipate the large kinetic energy of the entry vehicle and to land with precision. Past missions to Mars were based on unguided entry, where entry vehicles carried payloads of less than 0.6 T and landed within 100 km of the designated target. The Mars Science Laboratory (MSL) is expected to carry a mass of almost 1 T to within 20 km of the target site. Guided lifting entry is needed to meet these higher deceleration and targeting demands. If the aerodynamic characteristics of the decelerator are variable during flight, more trajectory options are possible, and can be tailored to specific mission requirements. In addition to the entry trajectory modulation, having variable aerodynamic properties will also favor maneuvering of the vehicle prior to descent. For proper supersonic parachute deployment, the vehicle needs to turn to a lower angle of attack.

One approach to entry trajectory improvement and angle of attack control is to embed a variable geometry decelerator in the design of the vehicle. Variation in geometry enables the vehicle to adjust its aerodynamic performance continuously without additional fuel cost because only electric power is needed for actuating the mechanisms that control the shape change. Novel structural and control concepts have been developed that enable the decelerator to undergo variation in geometry.

Changing the aerodynamic characteristics of a flight vehicle by active means can potentially provide a mechanically simple, affordable, and enabling solution for entry, descent, and landing across a wide range of mission types, sample capture and return, and reentry to Earth, Titan, Venus, or Mars. Unguided ballistic entry is not sufficient to meet this more stringent deceleration, heating, and targeting demands.

Two structural concepts for implementing the cone angle variation, a segmented shell, and a corrugated shell, have been presented. It is possible that a multi-parameter optimization approach will be necessary to fully explore the potential of the proposed solution. Since the shape of corrugated shell deviates from the conventional sphere-cone decelerator, the variation of aerodynamic characteristics with cone angle obtained is an approximation to that of the corrugated shell decelerator. A more precise numerical computation of the pressure distribution on the corrugated shell surface using panel method is currently underway. This numerical procedure will be incorporated into the trajectory simulation and the structural analysis. Further work will include tuning the current corrugated shell geometry using an energy-based optimization approach to minimize stress and actuation force, and exploring trajectory modulation with decelerators undergoing asymmetric variation in geometry.

Variations in cone angle for a decelerator with sphere-cone geometry have the effect of altering the trim angle of attack and the corresponding lift-to-drag ratio and ballistic coefficients during flight. This capability enables trajectory optimization with fewer aerodynamic constraints. A trajectory simulation with variable aero-