NASA TECH BRIEF

Ames Research Center

Vented Vectoring-Nozzle for STOL and V/STOL Aircraft
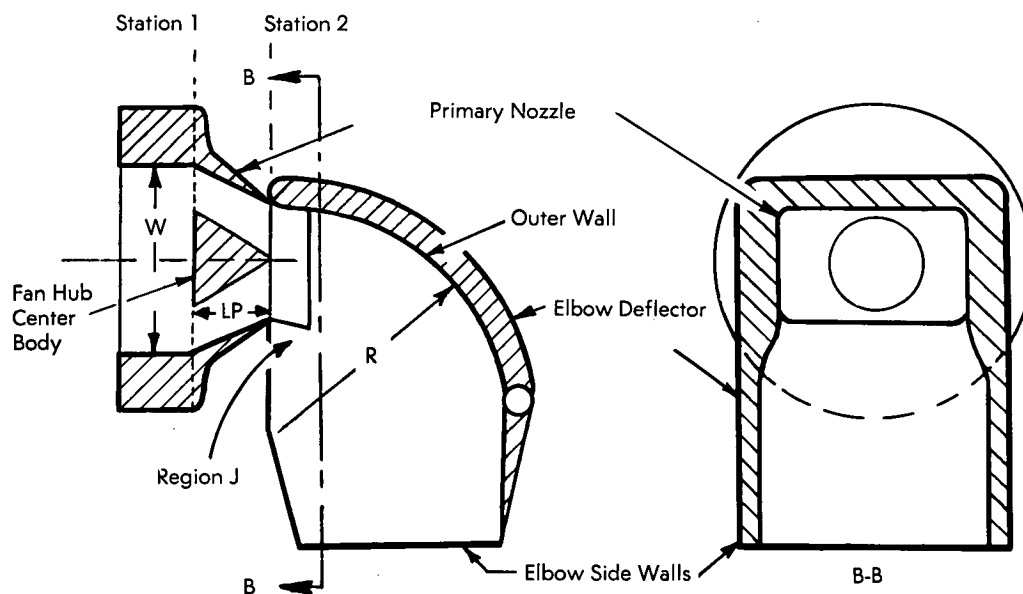
Thrust-vectoring nozzles are utilized on many STOL and V/STOL aircraft to provide powered lift for takeoff, landing, and transition to horizontal flight; they are also used to provide aircraft side-force control in the low-speed flight mode, in hovering, and whenever there is insufficient aerodynamic control.

Inasmuch as aircraft payload capacity is sharply dependent on the efficiency of thrust-vectoring nozzles, it is necessary to utilize nozzles which provide a large thrust coefficient (i.e., ratio of the actual thrust to the thrust theoretically obtained from isentropic flow in the nozzle). In actual vectored nozzles, differences between theoretical thrusts and available thrusts are directly related to total internal pressure losses within the nozzles which, in turn, are primarily a function of nozzle internal geometries and total pressure levels of exhaust flows. The effect of total pressure losses on thrust performance becomes in-creasingly important as the nozzle total pressure ratio (total pressure to ambient pressure) decreases below a level of 2.0; clearly, losses are particularly great in the nozzles used in fan-powered aircraft because exhaust total pressure ratios are about 1.3. The vectoring-nozzles of some V/STOL fighter aircrafts currently operate at pressure ratios of 2.2 with a thrust coefficient of 0.95; thrust coefficients of about 0.93 have been reported for experimental nozzles at pressure ratios in the vicinity of 1.3, but coefficients of the order of 0.98 must be available (at pressure ratios about 1.3) for aircraft of adequate payload and range.

A vented vectoring-nozzle has been developed which, in experimental thrust performance tests at 90° thrust deflection and nozzle pressure ratio of 1.3, has been found to have a thrust coefficient of 0.971 (about 4% higher than presently known devices). In

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addition to the demonstrated superior thrust coefficient at 90°-deflection at pressure ratio ranges of 1.1 to 1.5, the new vectoring-nozzle is lighter in weight because it does not require the completely enclosed elbow duct ordinarily used to deflect nozzle flow.

As illustrated in the diagram, the improved vented vectoring-nozzle consists of a primary nozzle and a three-sided elbow deflector. Airflow enters the deflector by way of a primary nozzle that is mated to the fan by an appropriate axial shroud which surrounds the centerbody of the fan hub. The entry cross-section of height-to-width ratio 0.65; the cross-section is reduced by 5 percent over the length (LP) of the primary nozzle. The nozzle has a length which is 0.381 times the diameter of the entry-cross section.

The airflow ducted into the deflector from the primary nozzle is rotated 90° from the centerline of the primary nozzle by the three-sided elbow deflector, which has a rectangular, U-shaped cross-section of width equal to 1.07 times the width of the exit port of the primary nozzle; the side walls of the deflector are of a circular-sector shape. The deflector's outer walls have a radius of curvature (R) which is 1.25 times the width of the section W.

The high performance of the nozzle is attributed to the absence of structure in the inner corner (region J) of the elbow deflector. It is anticipated that small variations of the nozzle geometry and dimensional ratios will not produce large changes in nozzle per-performance as long as the entry port of the deflector is maintained free of structures which can interfere with fluid flows in the vicinity of the exit of the primary nozzle.

Note:

No additional documentation is available. Specific questions, however, may be directed to:

Technology Utilization Officer
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Patent status:

NASA has decided not to apply for a patent.

Source: Donald W. Esker of
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