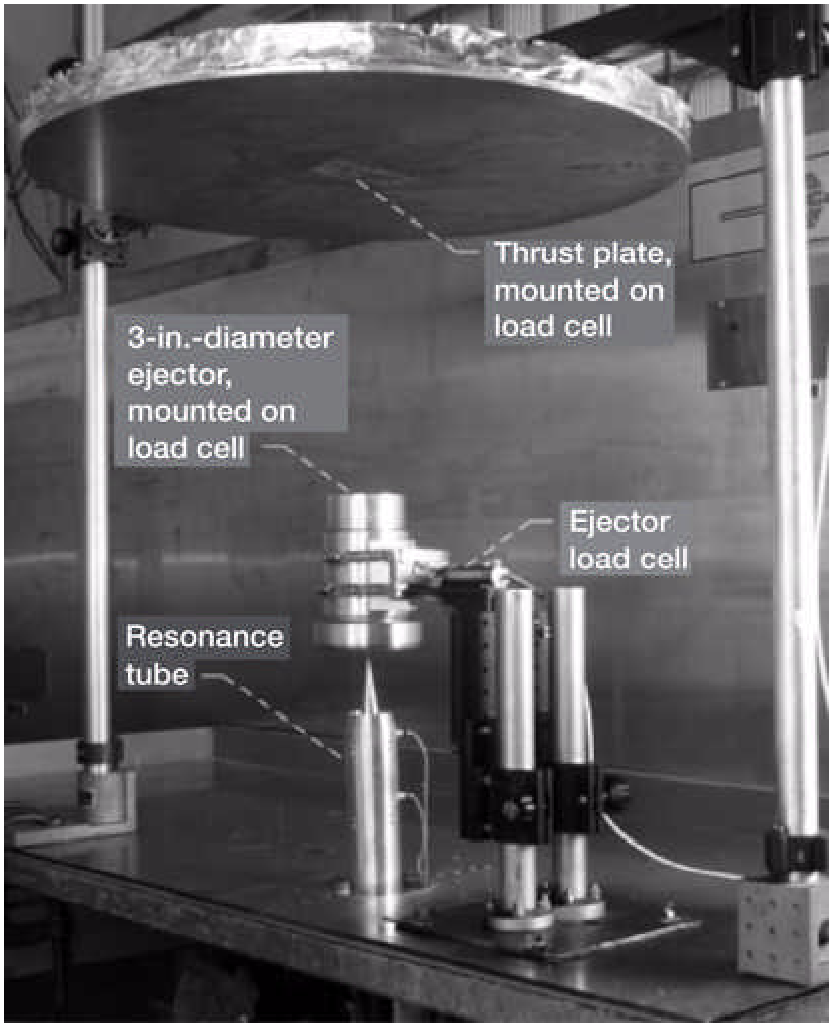
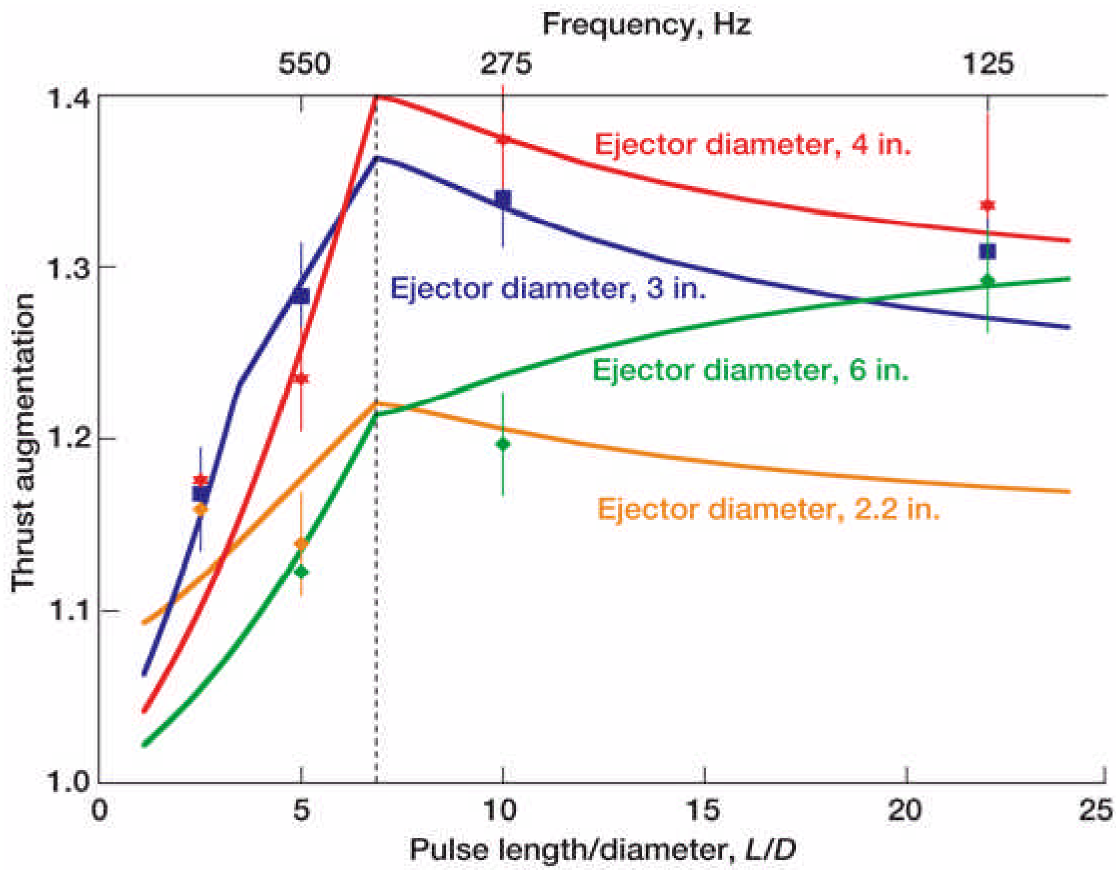
Pulsed Ejector Thrust Amplification Tested and Modeled

There is currently much interest in pulsed detonation engines for aeronautical propulsion. This, in turn, has sparked renewed interest in pulsed ejectors to increase the thrust of such engines, since previous, though limited, research had indicated that pulsed ejectors could double the thrust in a short device. An experiment has been run at the NASA Glenn Research Center, using a shrouded Hartmann-Sprenger tube as a source of pulsed flow, to measure the thrust augmentation of a statistically designed set of ejectors. A Hartmann-Sprenger tube directs the flow from a supersonic nozzle (Mach 2 in the present experiment) into a closed tube. Under appropriate conditions, an oscillation is set up in which the jet flow alternately fills the tube and then spills around flow emerging from the tube. The tube length determines the frequency of oscillation. By shrouding the tube, the flow was directed out of the shroud as an axial stream. The set of ejectors comprised three different ejector lengths, three ejector diameters, and three nose radii. The thrust of the jet alone, and then of the jet plus ejector, was measured using a thrust plate. The arrangement is shown in this photograph. Thrust augmentation is defined as the thrust of the jet with an ejector divided by the thrust of the jet alone. The experiments exhibited an optimum ejector diameter and length for maximizing the thrust augmentation, but little dependence on nose radius. Different frequencies were produced by changing the length of the Hartmann-Sprenger tube, and the experiment was run at a total of four frequencies. Additional measurements showed that the major feature of the pulsed jet was a starting vortex ring. The size of the vortex ring depended on the frequency, as did the optimum ejector diameter.



Photograph of the apparatus, showing the thrust plate at the top, the shrouded Hartmann-Sprenger (resonance) tube at the bottom, and an ejector above it.

It is well known that the so-called slug model of vortex ring formation, which uses the ratio of the jet pulse length *L* to its diameter *D*, provides information on the vortex ring properties. For the present experiment, the value of *L*/*D* is inversely related to the pulse frequency. A calculation of the vortex ring diameter, core size, and velocity, using a modified version of the slug model, gave good agreement with experimental measurements of these quantities. From that, a model of the flow in the ejector allowed the thrust augmentation to be calculated, using a fit to the data for unknown parameters. The model shows the dependence on ejector diameter correctly, but it does not predict the ejector length. Calculated values of thrust augmentation for different ejector diameters, together with experimental values, are given in this graph, showing that there is reasonable agreement between them. Complete details on this work can be found in reference 1.



Graph of the calculated thrust augmentation (lines) versus the experimental thrust augmentation (points) as a function of pulse frequency, for four different ejector diameters.

Reference

1. Wilson, Jack; and Deloof, Richard A.: A Simple Model of Pulsed Ejector Thrust Augmentation: Final Report. NASA/CR--2003-212541, 2003. http://gltrs.grc.nasa.gov/cgi-bin/GLTRS/browse.pl?2003/CR-2003-212541.html

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