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EXPERIMENTAL AND NUMERICAL ANALYSES OF MICRO-SCALE JET NOZZLE FLOW

Abstract

The behavior of the micro-supersonic jet flow was investigated by experimental and numerical methods to compare with conventional large-scale jet flow.

For experiments, sonic nozzles (exit velocity : M = 1, exit diameter : D = 440 m) and converging-diverging nozzles (M = 2, D = 880 m) were fabricated by stretching micro Pyrex glass tubes. Velocity distribution has been measured by micro pitot-tube, and supersonic length, jet core length, similarity of the velocity field and jet spreading rates have been analyzed. Schlieren visualization also has been carried out. All the results were compared with previous observations of larger supersonic jets with higher Reynolds numbers, and it was found that overall characteristics of the micro supersonic jet are qualitatively similar as those of the higher Reynolds number jets, except the jet core length and the jet spreading rate.

In order to find out the design limitations of micro-scale nozzles, numerical analysis was performed with 5 different size nozzles under 3 different pressure conditions. Realizable k-e turbulence model and enhanced wall treatment scheme were applied to simulate wall viscous drag effect more accurately. It can be said that, owing to viscous drag effect on the inner wall of nozzle, thrust efficiency is rapidly decreased under the certain size of nozzle. In other words, traditional nozzle design procedure (1D isentropic analysis) is quite unacceptable in micro-scale nozzles.