THE UNIVERSITY OF ADELAIDE

DEPARTMENT OF MECHANICAL ENGINEERING

THE ENHANCED MIXING BURNER

submitted by

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Summary

A new type of enhanced mixing nozzle has been developed, which generates extremely strong mixing and a very rapidly spreading jet. The mechanism is investigated using high speed schlieren photography, surface flow visualisation within the nozzle, dye injection in water, acoustic frequency spectra measurements, smoke visualisation and hot wire anemometry.

It is postulated that the enhanced mixing is generated by a precessing asymmetric jet which is instantaneously directed at a large angle from the nozzle axis at the exit plane, but on average produces a rapidly spreading, symmetric jet. This instantaneous jet does not occupy the whole of the exit plane of the nozzle, and highly three dimensional secondary flow patterns are established as ambient fluid is drawn into the nozzle through the remainder of the exit plane.

The precessing motion is generated within the nozzle without any mechanical parts or acoustic coupling. The fluid is passed through an abrupt expansion, with a large expansion ratio, and reattaches asymmetrically to the nozzle wall downstream from the expansion. The pressure imbalances within the nozzle cause the resulting precession, and a small lip at the exit plane of the nozzle causes the jet to leave the nozzle at a large angle to the nozzle axis.

The postulate is supported by the experimental evidence, and is compared with the findings of other researchers who have investigated flow through abrupt expansions, and with acoustic, mechanical and fluidic means of jet excitation. The precession is found to occur at constant Strouhal Number based on the velocity at the throat, the step height at the upstream expansion and the precession frequency. The Strouhal Number is approximately $5 \times 10^{-3}$ which is much lower than that typical of acoustic excitations, but is similar to those for two-dimensional mechanically and fluidically excited jets.

Half jet spreading angles of the order of $70^\circ$ have been observed which indicates that very strong mixing is occurring. To provide quantitative measurement of the characteristics of the jet, an "entrainment shroud" was used to directly determine the rate of entrainment in cold flow, and flame stability was assessed in a combustion rig.
In order to sensibly compare the characteristics of the present nozzle with a simple nozzle, it was necessary to introduce "equivalent" exit diameter and velocity scales, defined as the mean velocity and diameter of the instantaneous jet at the exit plane. Using these scales, the present nozzle has an entrainment appetite of approximately five times that of a simple nozzle and produces a flame with one fifth of the standoff distance and four times the blow-off velocity. This indicates a definite improvement in flame stability, which is consistent with the increased rates of mixing and spread angles observed in the cold flow experiments.
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