UNIVERSITI TEKNOLOGI MARA

INVESTIGATION OF SWIRL INJECTORS AND SUPERSONIC NOZZLES FOR THE DEVELOPMENT OF A MESO-SCALE THRUST CHAMBER

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Thesis submitted in fulfillment of the requirements

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ABSTRACT

Issues of propellant atomizing, mixing and viscous loss become increasingly more important as the thrust chamber are reduced in size. Two main components in thrust chamber have been identified as critical since small differences in its design can result in dramatically different performance. They are injector and nozzle, which have been greatly studied by many researchers experimentally or numerically.

Current research examines the performance of two solid cone and one hollow cone swirl injectors and 22 convergent-divergent nozzles for thrust chamber application. The spray characteristics of these injectors were investigated by means of cold flow test and the flow inside the nozzles were numerically analyzed by means of computational model that utilizes Spalart-Allmaras model as turbulence model, which was designed specifically for aerospace applications. In addition, optimization of the nozzle's performance was investigated, where nozzle divergence angle was reduced if flow separation occurs inside nozzle.

Main objectives of injector cold flow test lay on the determination of flow discharge coefficients, spray cone angle and spray break up length of each injector at different injection pressure. Results show an approximate direct proportion between Reynolds number and discharge coefficient. However, introducing purely axial stream inside injector's swirl chamber does not necessarily increase the coefficient of discharge. Experiment also indicates that increase in injection pressure increased the spray angle. However, at higher injection pressure, both solid cone injectors experience slight decreases in spray angle as the liquid film at the nozzle outlet contracted. Further investigation leads to general conclusion that breakup length decreased with an increase in injection pressure where hollow cone spray produces the longest liquid film.

From nozzles analysis, there was significant improvement in nozzle's performance as a result of optimization is foreseen. It is concluded that in order to operate the thrust chamber efficiently, the nozzle geometry must be contoured to prevent flow separation.

Actual testing of thrust chamber was performed by means of combustion test utilizing a specially designed test stand and feed systems. Although the test did not provide quantitative performance data of thrust chamber, the functionality and reliability of the feed system had been proved.

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