Experimental Studies on Simulated Impinging Jets of Liquid Propellants

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ABSTRACT

An experimental study was conducted to investigate the characteristics of sprays formed by two impinging water jets. The jet breakup mechanism and spray atomization characteristics are affected by a number of parameters, such as impingement angle, propellant mass flow rate, jet velocity, injector geometry, and fluid property. Based upon the image processing of recorded photographs, both the intensity of spray images and the mass distribution of droplets were obtained. As a result, the shift angle of spray fans was determined as a function of impingement angle, mixture ratio, and difference of jet momenta. The front- and side-view dispersion angles of spray fans were also deduced. The mass flow rates adopted in this study were based upon the consideration of a five-pound (about 22.2 N) thrust bipropellant engine using NTO and MMH as the propellants. In order to determine the individual mass flow rates in the fuel and oxidizer lines, the combustion characteristics of MMH and NTO was performed by the NASA CEC86 program. The propellant mixture ratio, which is as the ratio of the oxidizer mass flow rate to the fuel mass flow rate, adopted in this study were selected to be 1.0, 1.2, 1.4, and 1.6. The injectors fabricated and used in this study were made of 316 stainless steel tubes with an outer diameter of 3.175 mm (1/8 in) and a length of 30 mm. The inlet diameter of injectors is 1 mm. The orifice diameter of injectors was machined to be 0.3 and 0.5 mm. The impingement angles were 60, 90, and 120 degrees. CEC86 simulated results of MMH and NTO systems show that mixture ratios ranged from 1.0 to 1.78 yield relatively high values of Tc/M. The high value of Tc/M implies a high specific impulse. The maximum value of Tc/M is 144.21, which is at O/F equal to 1.39. While in the N2H4 and NTO combination, the maximum value of Tc/M is 152.16, which is at O/F equal to 0.8. The shift angle of spray increases with an increase of mixture ratios, because for like-doublet impingement the difference in jet momenta in the horizontal direction per unit time increases with the mixture ratio. Moreover, the shift angle increases with the impingement angle. The variation of spray dispersion angles is not consistent with the trend of the sum of horizontal momentum. It is believed to be caused by the low resolution of recorded spray images and the uncertainty of distance between two injector orifices.

Keywords : 噴注 ; 擴散角 ; 偏移角 ; 比衝值 ; 同質噴流 ; 衝擊式注油器

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