Abstract

An experimental investigation on the combustion characteristics of ethanol/Jet A-1 fuel droplets having three different proportions of ethanol (10%, 30%, and 50% by vol.) is performed in this study. Jet A-1 and pure ethanol burned smoothly, whereas all combinations of ethanol/Jet A-1 showed disruptive nature. The abrupt explosion is facilitated in fuel droplets comprising the lower proportions of ethanol (10%), possibly due to insufficient nucleation sites inside the droplet and the partially unmixed fuel mixture. For the fuel droplets containing higher proportions of ethanol (30% and 50%), micro-explosion occurred through homogeneous nucleation, leading to the ejection of secondary droplets and a significant reduction in the overall droplet lifetime. The rate of bubble growth is nearly similar in all blends of ethanol; however, the evolution of ethanol vapor bubble is significantly faster than that of a vapor bubble in the blends of butanol. The probability of disruptive behavior is considerably higher in ethanol/Jet A-1 blends than that of butanol/Jet A-1 blends. Sauter mean diameter of the secondary droplets produced from micro-explosion is larger for blends with a higher proportion of ethanol. Growth of the vapor bubble was also witnessed in the secondary droplets, which lead to further breakup (puffing/micro-explosion). Also, in the present study, the ethanol droplet evaporation in a high-temperature environment is studied numerically. Along with the stratified flow model, the two-fluid model and AUSM+-up scheme are used in the development of the computer program. The computer program demonstrated the capability of the algorithm in handling complex fluid flow problems with a wide range of inviscid test cases such as moving discontinuity, water-air shock tube, air-water shock tube, and cavitation. The heat transfer case proved the robustness of the algorithm in analyzing viscous flow situations, and the droplet evaporation case confirmed the accuracy of the computer program in determining and tracking the interfaces. Numerical analysis of ethanol droplet evaporation in a high-temperature environment predicted a linear behavior for the regression of the droplet diameter. The experimental and numerical predictions of the ethanol droplet regression rate were found comparable, and the difference between the results may be due to the use of a simplified evaporation model and the absence of the combustion chemistry.

Keywords: Jet A-1, ethanol, micro-explosion, bubble growth, two-fluid model, AUSM+-up scheme