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NUMERICAL INVESTIGATION OF LIQUIFIED FUEL CHARACTERISTICS IN HYBRID ROCKET ENGINE

Abstract

In advanced hybrid rockets currently researched, liquefying fuel is used in order to boost up fuel regression rate. Since the characteristics of liquid film are thought to be affected by the acceleration environment, it is necessary for designers of hybrid rocket to well understand the instability nature of thin liquid film. In most of past studies that analyze instability of liquid films in hybrid rocket motors, the main stream velocity and the liquid layer thickness, though both of them strongly influence the instability of thin liquid films, are given independently each other. Since there are some relationships between the velocity and the thickness, it is necessary for making the environment closer to the actual hybrid rocket motors to take the relationships into account. Therefore we conducted two-dimensional numerical simulation and tried making a phase at any place determined automatically by introducing van der Waals equation of state so that liquid layer thickness could be calculated through conducting simulation. Stiffness in the liquid region is avoided by introducing Pre-conditioning method and steady-state solution was performed from this simulation. It is found, in the distribution of density and temperature with respect to the distance from wall, that density changes drastically near wall and numerical simulation with van der Waals equation can express the circumstance where supercritical region and liquid phase coexist. The steady-state solution was investigated before instability analysis since it is necessary for detailed instability analysis to do away with numerical errors as thoroughly as possible. In the profile of streamwise velocity with respect to the distance from wall, it is found that there is a kink which cannot be seen in Blasius solution at the interface between supercritical region and liquid phase. As one of causes that can influence the profile of velocity, indifferentiability of coefficients, such as specific heat and thermal conductivity, can be thought. However, there is also such a kink even in the case of approximating coefficients to be differentiable near critical point, therefore, it is found that the cause of the kink is not the indifferentiability of coefficients. After testifying that the steady-state solution is reliable, instability characteristics is investigated by observing whether the disturbance added to the steady field will grow or not. The objective of this study is to obtain the perception about the instability of thin liquid layers affected by variations of the magnitude and the direction of acceleration under supercritical operating condition.