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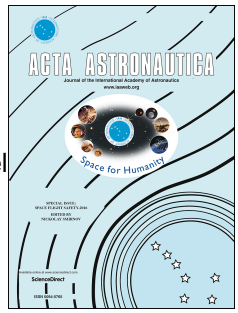

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Investigation on the effect of diaphragm on the combustion characteristics of solid-fuel ramjet

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Abstract: The flow field characteristics and the regression rate distribution of solid-fuel ramjet with three-hole diaphragm were investigated by numerical and experimental methods. The experimental data were obtained by burning high-density polyethylene using a connected-pipe facility to validate the numerical model and analyze the combustion efficiency of the solid-fuel ramjet. The three-dimensional code developed in the present study adopted three-order MUSCL and central difference schemes, AUSMPW+ flux vector splitting method, and second-order moment turbulence-chemistry model, together with *k*-ω shear stress transport (SST) turbulence model. The solid fuel surface temperature was calculated with fluid-solid heat coupling method. The numerical results show that strong circumferential flow exists in the region upstream of the diaphragm. The diaphragm can enhance the regression rate of the solid fuel in the region downstream of the diaphragm significantly, which mainly results from the increase of turbulent viscosity. As the diaphragm port area decreases, the regression rate of the solid fuel downstream of the diaphragm increases. The diaphragm can result in more sufficient mixing between the incoming air and fuel pyrolysis gases, while inevitably producing some pressure loss. The experimental results indicate that the effect of the diaphragm on the combustion efficiency of hydrocarbon fuels is slightly negative. It is conjectured that the diaphragm may have some positive effects on the combustion efficiency of the solid fuel with metal particles.

Keywords: solid-fuel ramjet; diaphragm; regression rate; combustion efficiency; numerical method; connected-pipe test

1. Introduction

Solid-fuel ramjet (SFRJ) is the simplest and hence an attractive air-breathing propulsion system. The schematic diagram of solid-fuel ramjet is shown in Fig. 1. The incoming air compressed by an air intake system mixes and reacts with the solid fuel pyrolysis products in the recirculation zone behind the backward-facing step. Downstream of the reattachment point, the diffusion flame between the solid fuel pyrolysis products and the incoming air exists near the solid fuel surface. In the aft-chamber, the unreacted mixed gases will continue to react, which improves the ramjet combustion efficiency.

Many researches on the combustion process in SFRJ have been conducted for decades, which mainly focused on the effects of various parameters on the combustion characteristics of solid fuel [1-6]. As the combustion process in the solid-fuel ramjet is mainly diffusion-controlled, the combustion efficiency is relatively lower for the SFRJs with small length-diameter ratio. Moreover, the combustion efficiency of SFRJ with fuel-rich solid fuel containing metal particles is also relatively lower due to the lower

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