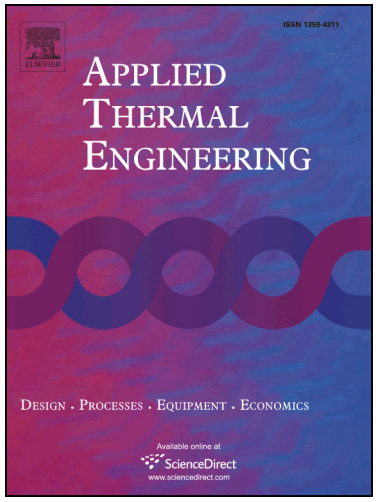

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Effect of Inlet Conditions on Swirling Turbulent Reacting Flows in a Solid Fuel Ramjet Engine

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Abstract

This paper presents experimental and numerical investigation of turbulent reacting flows in a solid fuel ramjet engine with different inlet conditions. In simulations, three main parameters were varied independently, which are the swirl intensity, mass flow rate, and air inlet temperature to study these parameters influence on the regression rate and combustion phenomena. Firstly, a numerical model has been developed to solve axisymmetric unsteady Reynolds-averaged Navier-Stokes equations of the turbulent swirling compressible flow field with chemical reactions. Secondly, experiments have been performed on the solid fuel ramjet without swirl to validate the developed code. Thirdly, in order to assess the accuracy and robustness of the code three test cases are adopted. Finally, a series of unsteady simulations are carried out for swirling reacting turbulent flows in a solid fuel ramjet using high-density Polyethylene (HDPE) solid fuel. The main results obtained from this study show that swirl flow enhances the regression rate and the turbulent mixing throughout the ramjet. In addition, the results revealed that an increase of swirl number, mass flow rate, and air inlet temperature increases the heat and mass transport at the solid fuel surface and hence enhances the local regression rate. Three relations have been proposed to correlate the average regression rate.

Keywords:
Regression rate; Swirl flow; Solid fuel ramjet; Inlet conditions; Combustion.

1. Introduction

The solid fuel ramjet (SFRJ) draws attention throughout the world because of its potential in civilian and military applications. SFRJ is the simplest, in terms of moving parts, and most reliable air-breathing propulsion system for supersonic flight. It typically consists of an air intake system, dump type combustor, and an air exhaust nozzle. The SFRJ combustion chamber, basically, is a hollow cylindrical solid fuel grain, where the incoming air passes through it and reacts with the solid fuel at certain conditions. A sudden dump inlet is used for flame stabilization, to improve the solid fuel pyrolysis, and to enhance mixing and

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