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MATHEMATICAL MODEL AND EXPERIMENTAL RESULTS FOR HYBRID ROCKET ENGINE, TYPES OF INJECTORS, SCRATCHES DESIGN, THRUST CONTROL

Abstract

In this paper we describe experiments performed within a national research program with hybrid rocket engines and various types of injectors. Experiments were performed using NOX as oxidizer and PVC as fuel. We used various effective diameters for injectors and measured the thrust force diagram, hence, comparing the specific impulse performance for the various injectors used. Additionally, a swirl injector is proposed and experimental results are compared with the ones obtained from straight cone injectors. A model is proposed that takes into account various types of injectors and their effect on hybrid rocket motor performance. A mathematical model is developed in order to take into account the coupling between injector scale and the performance of the rocket engine. This check is performed using several performance parameters amongst which we mention specific impulse. We also propose to use a performance parameter in such studies which is the volumetric specific impulse. This is a critical parameter when volume is a constraint, especially in the case of reducing the cross section of the vehicle in order to minimize the drag force. By carefully designing the injectors and the overall hybrid rocket engine, one can obtain the same performance from a smaller volume and this converts directly in less cross section of the vehicle. At the same time by minimizing the volume, not only that the cross section is minimized but the length of the vehicle is reducing simplifying structural and stability problems typically associated with long length launch vehicles. We perform experiments with solid fuel with cylindrical geometry and cylindrical combustion port. As a novel technique, we show the influence of "geometrical scratches" on the inner walls of the combustion port and the relation between their sizes and geometry and the overall performance of the hybrid rocket engine studied herein. We specifically design scratches with a certain spatial distance between them and we show a possible relation between this distance and the increase of the regression speed. The distance is related with the acoustic waves formed inside the hybrid rocket engine during the combustion process and when a certain resonance is reached the efficiency of the combustion process increases and hence the regression speed increases. Finally a other direction underlined in paper is related to improvement the possibility of traction control by regulating the oxidizer flow.