IAF SPACE PROPULSION SYMPOSIUM (C4)
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DESIGN OF A HIGH THRUST SHORT DURATION SOLID MOTOR FOR CREW ESCAPE SYSTEM

Abstract

Quick action and high thrust rocket motors are the essential requirements for Crew Escape System (CES) of human space flights. In case of exigencies at the launch pad or during the initial ascent of the launch vehicle, these quick action high thrust motors are used to safely eject out the crew along with the crew module to a safe distance. The basic needs for such rocket motors are 1) compactness, 2) short ignition delay, 3) high initial thrust, and 4) short duration of operation. Solid rocket motors are best suited for such operation. There may be several such motors in a CES for lifting, pitching and jettisoning the spent CES. Also, it may be necessary to choose non-conventional nozzle arrangements in order to keep crew module away from the vicinity of the rocket jet. In the present paper, the design of an Escape System Jettisoning Motor (ESJM) is discussed. This solid motor is designed to perform two functions: 1) In a nominal mission: to jettison the CES from launch vehicle after ensuring the proper functioning of the second stage, 2) During abort: to jettison the spent CES, after the firing of the escape motors and Pitch Motor and after the crew module has achieved the proper orientation. The ESJM is positioned above the CES. In order to direct the jet away from the CES, this motor has four 35 degree canted nozzles. In addition, these nozzles are scarfed to avoid projecting nozzles outside the motor outer envelope. The motor should generate a thrust of 250 kN for initial 1s but can have fast reduction in thrust levels later. High burning rate propellant (15.5 mm/s) with HTPB/AP/Al formulation is chosen, which is achieved by increasing the fine AP content by about 2.5 times than the coarse AP content along with adding two burning rate catalysts, copper chromite and ferric oxide. The burning rate index of the propellant was comparatively higher (0.45) due to the presence of large fine AP particles. The present paper discusses in detail the grain design, performance computation procedure, and details of the various performance parameters and factors. Static test of the motor showed that the motor performed closely as predicted. The test indicated that the burning rate scale factor, combustion efficiency factor, nozzle efficiency factor, nozzle throat erosion rate etc. considered for the prediction are within an error limit of about 1 percentage only.