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COMPLETE DEVELOPMENT AND TESTING OF LAB-SCALE HYBRID ROCKET MOTORS BY UNDERGRADUATE STUDENTS

Abstract

Aeronautics Institute of Technology is a reference of school and research center in Aerospace Engineering in Brazil. The students have developed several projects and initiatives over the years involving rocket design, sattelites and propulsion systems and control. In order to motivate the students in the area, some projects involving the complete development of rocket motors are being developed during chemistry laboratory classes. The present work presents the hybrid rockets developed by 1st year students in the last project, which aimed to develop and build the combustion chamber, injector and nozzle and qualitatively test the burning behavor of a paraffin/carbon black solid fuel formulation using gaseous oxygen as oxidizer. The class was divided in some groups, which were responsible for developing and constructing the different parts and systems in the rocket. A carbon-fiber case (2.5 cm of internal diameter) impregnated with an epoxy resin was built around a PVC tube mold. Both the injector and nozzle were molded inside PVC tubes, and were made from graphite powder, mixed and cured with the same epoxy resin used to develop the case. The produced injector was similar to an orifice-plate, with orifice diameter of approximatelly 5 mm, and the nozzle presented a throat diameter of 3 mm and angle of 45 for both the convergent and divergent sections. Formulations of paraffin and carbon black were loaded into the carbon fiber case and, after the solidification, the grain was pierced with a 5 mm drill. For the burning tests, gaseous oxygen was used as oxidizer, with a 10 lpm constant flow. A total of 5 motors were built and tested, with a squib being used to ignite the devices. All of the rockets showed a good burning behavior, stable flames/reactive flow and no internal decomposition of the case and injector was observed. The nozzle suffered certain damage, but could be securely used for one other firing test. The project was successful as the objectives were accomplished, the students were highly motivated and are now pursuing emphasis in propulsion systems and are also starting some individual researches for their term paper. The impact of the project is observed in the increased number of students choosing to study aerospace engineering, instead of aeronautics engineering. All results, difficulties, lessons learned and methodologies found in this project are being applied for the next class of students, who will continue the study and the development of the lab rocket.