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DESIGN, ANALYSIS AND EXPERIMENTATION OF A ANNULAR PLUG NOZZLE USED IN SOLAR-THERMAL AND ELECTRO-THERMAL PROPULSION SYSTEMS FOR SPACE APPLICATION.

Abstract

Owing to the state of the environment and the crippling dearth of combustible and sustainable resources, advanced propulsion systems like solar thermal propulsion system and electro-thermal propulsion system are turned to today. Through our research and experimentation, we have designed a subsonic convergent plug nozzle and two separate functioning solar-thermal and electro-thermal systems in order to compare their performances and optimise it. Apart from iterating and obtaining the optimum structural design parameters, other parameters such as mass flow rate and type of propellant were analysed and the results were plotted to obtain various parametric studies. The functioning of the nozzle without the plug has also been tested. The various combinations of these parameters were studied and compared for both propulsion systems. This was fulfilled by going through the process of design and CFD simulations before experimentation. After analysis, for physical verification, experimentation was done assuming sea level conditions and initial calculations with a fixed desired exit Mach of 0.4 and thrust of 1N were conducted. Various inlet parameters like mass flow rate were varied to receive varied thrust output. The propellant was fixed as Nitrogen gas while the experiment was carried out considering the availability of the propellants. These mathematical, analytical and experimental results were compared and the feasibility of the nozzle was tested for space application. The choice of material used for the design of the nozzle was made considering heat transfer, weight and material properties. Materials such as copper, brass and titanium were included in the CFD simulation and analysis and results were compared. For experimental purposes, we used copper as the material considering heat transfer analysis and availability. The novelty of this work lies in comparative and parametric study of these advanced propulsive systems, specifically targeting the effect of plug in space propulsion. The main motivation for this work roots from an aspiration for a better, greener and sustainable future with a hope to design more efficient and effective propulsion systems for the future. Since the scope of space exploration is ever-expanding and the future sees numerous upcoming projects to scout the extra-terrestrial world, working on such propulsion systems with a combined study of its design optimisation will prove to be propitious for the world. Although neither provides propulsive power like combustion, they hold great applications in manoeuvres like orbit transfer, acceleration for interplanetary transfer and attitude control.