THRUST PERFORMANCE EVALUATION OF CHEMICAL ROCKET ENGINE BY THERMAL AND FLUID DYNAMIC ANALYSIS FOR EXHAUST GAS FLOW SUBJECTED TO COOLING

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ABSTRACT

Chemical rocket engines play an important role in space travel as they produce high thrust, required for initial lift- off of the rocket. Deep space exploration mission is very expensive, as most of the engines in use are chemical rocket engines and they operate with low efficiency. Even if electric propulsion systems are used, they cannot replace the solid or liquid propellant rocket engines, as only they are capable of generating high thrust. The thrust is essentially generated by combustion process of propellant and oxidizer. But the thrust is fundamentally a function of mass flow rate, pressure and velocity of the exhaust gas and the temperature gained due to the combustion does not contribute to the generation of thrust. By the conversion of a property, such as exhaust gas temperature, which cannot contribute to increase of thrust into a useful property such as the exhaust gas pressure, the efficiency of thrust generated by the rocket engine at the nozzle chamber exit can be improved. The cooling systems that are currently in use mainly focus on prevention of overheating of rocket engine structure but do not serve to cool the exhaust gas.

This paper studies the feasibility of achieving isenthalpic flow of exhaust gas in the engine nozzle chamber to convert temperature of the exhaust gas into exhaust pressure. This is achieved by cooling the exhaust gas. Thermal analysis of the temperature distribution is performed to evaluate the thrust characteristics before and after cooling of exhaust gas. The design requirements for the cooling mechanism as well as the effect of geometric modifications are discussed. Fluid dynamic analyses for flow regimes of subsonic, sonic and supersonic conditions are done for geometries to evaluate the thrust performance. Improvement of thrust efficiency can greatly reduce the cost of space travel.