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Author: Mr. KHALID RASHID
Indian Space Research Organization (ISRO), India, khalid9835@gmail.com

Mr. Deepak K. Agarwal
Indian Space Research Organization (ISRO), India, dagarwal_iitk@yahoo.com
Mrs. Jayashree A.
Indian Space Research Organization (ISRO), India, a_jayashree@lpsc.gov.in
Mr. Pisharady JC
Indian Space Research Organization (ISRO), India, ted.prsg@gmail.com

CFD ANALYSIS OF SEMICRYO LOX BOOSTER TURBOPUMP.

Abstract

Towards the development of the 2000 kN semi cryogenic engine which uses a combination of cryogenic and earth storable propellants, namely, Liquid oxygen (LOX) and Kerosene at high operating pressure of around 200 bar, a series of turbopumps are employed. Turbopump feed systems are used to supply propellants from the stage tanks to the thrust chamber. For high chamber pressure generation in a rocket engine, booster pumps are required in addition to main pumps to provide necessary inlet pressure to the main pumps for its cavitation free operation at the specified engine inlet conditions. In booster turbopumps, high pressure ratios across the turbines are required to obtain high specific work output. This can be achieved by supersonic impulse turbine. For such turbines the mass flow rate which is limited by nozzle size, is inherently small. Further to prevent losses due to low blade aspect ratio of supersonic rotor and issues related to manufacturing and industrial problems, the turbine is used in partial admission conditions. The LOX Booster turbopump used for Semicryo engine is a similar system, consisting of an axial flow pump which is driven by an integral two stage partial admission impulse gas turbine. The gas is admitted into the rotor through nozzles having supersonic exit which generate power for pump operation. These zones are characterized by sudden expansion and shock waves across the rotor blades which affects the turbine performance. Further the rotor is a welded assembly, consisting of pump inducer and turbine rotor. LOX is flowing through the pump inducer at 91 K while gas at 550 K is driving the turbine rotor. This creates a large thermal gradient across the turbine rotor and the welded section of the inducer. Consequently thermal mapping of the LPOT structure is critical to check its integrity during the turbine operation.A detailed study of flow and performance parameters is also essential for understanding the behaviour of the pump and the supersonic turbine during its operation. In view of the above, a steady state three-dimensional CFD analysis of the Semicryo LOX booster turbopump (LPOT) is carried out to determine its flow pattern, pressure and temperature distribution along with the performance of partially admitted turbine.