IAF SPACE PROPULSION SYMPOSIUM (C4)
Interactive Presentations - IAF SPACE PROPULSION SYMPOSIUM (IP)

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NUMERICAL AND EXPERIMENTAL INVESTIGATION OF LAMBDA TYPE SEALS IN HIGH-PRESSURE CRYOGENIC BOLTED JOINTS

Abstract

For propelling new generation Indian launch vehicles, ISRO is developing a liquid oxygen-kerosene based high thrust engine. In liquid rocket engines, bolted flange joints are critical components and leak tightness is to be ensured for all bolted joints for safe operation. For the same reason, various metallic seals are employed and "lambda" type seal is one among them. There is little information about this type of seals in literature and its geometry is uncommon and intricate. This seal, made of high strength steel has 5 sealing faces and the mating flange interfaces are spherical in nature. Bolted joint investigated in this study is located at the inlet of pre-burner-oxidizer injection valve. Extensive nonlinear finite element simulations were carried out for understanding the radial load variation at each of these seal faces with respect to internal pressure and pre-load. For validating the numerical model, a simulator joint with similar behaviour as that of the flight hardware was configured. Subsequently, multiple tests were carried to study the effect of pre-load and temperature of operating medium on the seal behaviour. The results indicate that, at cryogenic temperatures lambda type seals can provide leak tightness at very high internal pressure with moderately low pre-load values and can accommodate large flange rotations. Results are of high reference value for finalizing the preload values for similar bolted joints in flight hardware.