Impinging Acoustics Induced Combustion: An Alternative Technique to Prevent Thermoacoustic Instabilities

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Abstract : Efficient propulsive systems development is an area of major interest and concern in aerospace industry. Combustion forms the most reliable and basic form of propulsion for ground and space applications. The generation of large amount of energy from a small volume relates mostly to the flaming combustion. This study deals with instabilities associated with flaming combustion. Combustion is always accompanied by acoustics be it external or internal. Chemical propulsion oriented rockets and space systems are well known to encounter acoustic instabilities. Acoustic brings in changes in inter-energy conversion and alter the reaction rates. The modified heat fluxes, owing to wall temperature, reaction rates, and non-linear heat transfer are observed. The thermoacoustic instabilities significantly result in reduced combustion efficiency leading to uncontrolled liquid rocket engine performance, serious hazards to systems, assisted testing facilities, enormous loss of resources and every year a substantial amount of money is spent to prevent them. Present work attempts to fundamentally understand the mechanisms governing the thermoacoustic combustion in liquid rocket engine using a simplified experimental setup comprising a butane cylinder and an impinging acoustic source. Rocket engine produces sound pressure level in excess of 153 Db. The RL-10 engine generates noise of 180 Db at its base. Systematic studies are carried out for varying fuel flow rates, acoustic levels and observations are made on the flames. The work is expected to yield a good physical insight into the development of acoustic devices that when coupled with the present propulsive devices could effectively enhance combustion efficiency leading to better and safer missions. The results would be utilized to develop impinging acoustic devices that impinge sound on the combustion chambers leading to stable combustion thus, improving specific fuel consumption, specific impulse, reducing emissions, enhanced performance and fire safety. The results can be effectively applied to terrestrial and space application.

Keywords : combustion instability, fire safety, improved performance, liquid rocket engines, thermoacoustics
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