

SPACE PROPULSION SYMPOSIUM (C4)
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CONTROL OF LIQUID ROCKET ENGINE COMBUSTION INSTABILITY BY MEANS OF
PROPELLANT INJECTION DYNAMIC PARAMETERS

Abstract

High Frequency Combustion Instability (HFCE) continues to be the main cause of low reliability of Liquid-propellant Rocket Engines (LRE) and high expenses of time and money for their development. Experience in the development of LRE, theoretical and experimental research in this area confirmed complexity of this problem, connected with realization of different mechanisms of instability, probability features, non-linear interactions, due to which the strict analytical solution had not been found. In the practice of LRE development with the respect to HFCE, methods of its passive control were used such as increase in acoustic losses by means of baffles, acoustic cavities etc, or in the decrease of sensitivity of burning to external excitations. Above mentioned methods of margins of stability enlargement are very attractive as they are workable with any mechanism of instability. Though, with the increase of specific energy release, these means were not enough to provide stability. Therefore, active control of HFCE, characterized by involvement of feedback connections between combustion and injection processes that can change its stationary and/or dynamic characteristics appeared as a way to improve engine stability. Main approaches for active control of HFCE are observed in this Paper. All these methods usually require complicated, acting in real time computer machinery and rather powerful electrically driven actuators. The Paper contains analysis of possibilities of principles of active control without such electrical devices by usage of hydraulically driven dynamic characteristics of propellant injector due to its ability, besides main function to prepare combustible mixture, to serve in LRE dynamic system as a sensitive element, an amplifier, phase shifter, actuator, as a generator of pulsation and a modulator, which can change injection parameters via growth of pressure pulsation in a combustion chamber. Thus injector can serve as an element of active control system using combustion as a source of energy. For experimental studies of possibility of usage of injectors with different dynamic characteristics for active control of combustion instability, injectors-dampers and filters of mass flow rate pulsation, as well as injectors with strong response on pressure pulsation by pulsation of spray angle, atomization quality and mass flow rate were developed and tested. The Paper includes experimental results of model fire tests with different propellants, using dynamically tuned injectors and examples of successful usage of injectors with required dynamic characteristics in some serial LRE.