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PERIODIC ATOMIZATION OF IMPINGING INJECTORS MODULATED BY BACK PRESSURE FLUCTUATIONS

Abstract

Combustion instabilities generated by the coupling of heat release and acoustic pressure in the combustor are very complicated and dangerous phenomena in rocket engines. The Rayleigh criterion states that heat release must be in phase with the pressure oscillations to allow resonant interaction between combustion and the acoustic field. Periodicity of acoustic pressure fluctuations and heat release in unstable combustion chambers has been certified in previous literatures experimentally and numerically. The question is how the combustion heat release is modulated to be periodic by acoustic fluctuations. There are many processes taking place in combustion chambers of liquid propellant rocket engines. This paper is focused on the effect of back pressure fluctuations on injection and primary atomization. An experimental study on atomization of impinging injectors modulated by back pressure fluctuations is conducted. The importance of periodic impinging jet atomization modulated by back pressure fluctuations for acoustic liquid propellant combustion instabilities is illustrated. According to prominent periodicity and high amplitude in unstable combustion chambers, back pressure fluctuations with peak-to-peak amplitude of about 0.4MPa at frequencies from 150Hz to 2900Hz are generated in a back pressure chamber. Experiments of atomization of impinging injectors were conducted in the back pressure chamber. Time-resolved atomization backlit images are captured by using the high speed camera. It is found that periodicity of forced atomization relies on pressure drop fluctuation amplitude and phase differences between atomization and pressure drop fluctuations relate to fluctuation frequencies. In comparison with those modulated by pure pressure drop fluctuations in supply pipes, phase differences of atomization modulated by back pressure fluctuations increase first and then decrease with distance from inject plates. It is indicated that there are two effects of acoustic fluctuations on atomization. First of all, injection pressure drop modulated by acoustic pressure fluctuations leads to klystron effect on atomization. Second, acoustic fluctuations direct act on fluid mass particles after injection. Only in certain range of Strouhal numbers from 0.05 to 0.09, there is an in-phase relation between atomization and back pressure fluctuations in predicted heat release regions. It is implied that Hewitt stability correlation relates to the phase relation between periodic atomization and acoustic pressure fluctuations.