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ON THE EFFECTS OF THERMOACOUSTICS ON SOOT FORMATION AND FLAME INSTABILITY

Abstract

Past many centuries from when flame was discovered to until now, where the principle of combustion is utilized from a daily domestic cooking and automotive applications up to propelling our spacecraft out into space, mankind has constantly tried to understand the predominantly observed unsteady flames and it's intermittency that is encountered in most practical cases. The unsteady nature of combustion has led to catastrophic disasters in the aerospace industry and still remains a challenge as a safety concern and also a great setback factor in terms of efficiency of our rocket engines. The current work aims to study the various effects and changes an unsteady flame undergoes when subjected to external acoustic energy under direct impingement on the flame, similar to that of real life situation. For this purpose a scaled experimental setup was upraised consisting of a cylinder containing liquid butane fitted with a nozzle, which was maintained at constant orientation and constant fuel outflow rate, which was impinged by acoustic energy at the flame base by four independent and similar acoustic sources at linear and non-linear configurations with respect to distance from nozzle center. The source acoustic energy is varied within the human audible range at 0.1, 1, 5 and 10 kHz, this spectrum is chosen mainly because it covers the most commonly encountered acoustic spectra responsible for failure or instability caused due to pressure oscillations in many combustion based propulsion applications. The experiment is carefully video graphed for a period of 30 seconds for each case using a regular CCD camera at 30 fps and organized carefully. The resulting effects on the flame system are studied by observing changes in the flame height, shapes and flickering frequency. It was observed that predominantly with increase in acoustic frequency for a fixed acoustic source distance soot suppression takes place and the same effect was observed for increase in acoustic source distance whilst maintaining constant impingement frequency. As the coupling effect of acoustics and thermal energy is yet to be comprehensively addressed, owing to its non-linearity, the current work focuses on providing a fundamental understanding of the phenomena which may lead to better combustion and minimized risk hazards in space propulsion systems. With the prospects of space exploration involving human transportation into space being at its best presently, than any other time thus demands improvement of rocket engine design. The current work aims to provide valuable suggestions in that aspect.