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Modelling Acoustic Excitation of High Frequency Combustion Instability Experiments

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Abstract

High frequency combustion instabilities refer to a coupling between acoustic and combustion processes which occurs inside combustion chambers. If unimpeded, this coupling may produce acoustic disturbances that can affect the operation and structural integrity of the combustion chamber. High Frequency combustion instability is poorly understood and cannot be predicted; increasing risk and necessitating extensive ground testing to verify the safe operation of new hardware designs and configurations.

In order to study the coupling between acoustic and combustion processes, a number of experimental combustion chambers featuring acoustic excitation systems have been developed and operated. An acoustic disturbance is produced by the excitation system and the response of a flame or study element to the acoustic field is observed. Toothed-wheel and nozzle excitation systems are often used however the exact nature of the acoustic disturbance produced by such systems has not been examined in detail.

An experimental combustor, designated BKH, has been developed at DLR Lampoldshausen to investigate combustion instability. The combustor operates at supercritical conditions analogous to real rocket engines and features a Toothed-wheel and nozzle excitation system for generating acoustic disturbances in order to study combustion instability phenomena. The experimental results gathered from BKH experiments are being used to develop and validate numerical models.

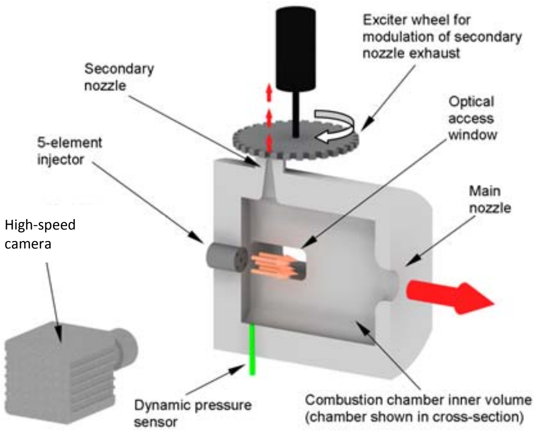

Diagram of the BKH Combustion Chamber (Hardi 2012)

To model experimental combustion chambers that use an excitation system the disturbance produced by the system must be replicated numerically. However it remains impractical to simulate the excitation system in its entirety. Therefore the systems influence is often approximated by assuming some ideal disturbance profile. These assumptions may inadvertently neglect important acoustic phenomena. Methods of simulating the excitation systems influence on the BKH chamber have been examined and compared with BKH experimental results to ensure the correct disturbance is replicated numerically.

References

Hardi 2012 J. Hardi, *Experimental Investigation of High Frequency Combustion Instability in Cryogenic Oxygen-Hydrogen Rocket Engines*, PhD Thesis, The University of Adelaide, 2012.