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ANALYSIS OF SYSTEM DAMPING EFFECT ON TIME-LAG BASED COMBUSTION INSTABILITY MODEL

Abstract

Combustion instability (CI) is a major concern in liquid rocket engine (LRE) design. It occurs when resonant pressure oscillations in a combustion chamber are in phase with oscillations in heat release and subsequent gas expansion due to unsteady combustion. To make prediction for CI is a tremendous and complicated work in liquid rocket engine. The current state of the art combines engineering level instability models with data from sub-scale experiments to formulate an approximate model of the combustion response, such as the time-lag based CI model, which has been used in the well known ROCCID program since 1990s. Time-lag concept was probably introduced when it was observed that CI required a feedback mechanism. Despite the fact that it describes the evolution of the combustion process which is replaced with a discontinuous process for simplicity, time lag based CI model still provides a system level entrance to the problem. Based on the experiment data of an unstable sub-scaled LRE gas generator in National Key LAB of Science and Technology on LRE (KLSTND) of China, this paper will try to understand the indispensable role of system damping effect in time-lag based CI model extended by Matthew J. Casino. Analysis on this test will also be present in this paper through data reduction. Firstly, the coupled oscillation between the combustion chamber and pipelines will be analyzed through cross-correlation index calculation between all six measure points. Then according to the hypotheses that the acoustic oscillation in combustion chamber can be interpreted as a superimposed result of second order oscillators corresponding to each mode, distribution of system damping coefficients will be extracted from the test data after band-pass filtering on original experiment data. In the end, the system damping expressed as a function of frequency will be added to the extended time-lag model to get the bode plot of the combustion system. It is indicated that considering the system damping can improve the prediction precision, but simple increase of system damping cannot remove unstable frequency point because of the coupled effects with other parameters.