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Title:
"Analyses of Longitudinal Mode Combustion Instability in J-2X Gas Generator Development"

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Abstract:
The National Aeronautics and Space Administration (NASA) and Pratt & Whitney Rocketdyne are developing a liquid oxygen/liquid hydrogen rocket engine for future upper stage and trans-lunar applications. This engine, designated the J-2X, is a higher pressure, higher thrust variant of the Apollo-era J-2 engine. The contract for development was let to Pratt & Whitney Rocketdyne in 2006. Over the past several years, development of the gas generator for the J-2X engine has progressed through a variety of workhorse injector, chamber, and feed system configurations on the component test stand at the NASA Marshall Space Flight Center (MSFC). Several of the initial configurations resulted in combustion instability of the workhorse gas generator assembly at a frequency near the first longitudinal mode of the combustion chamber. In this paper, several aspects of these combustion instabilities are discussed, including injector, combustion chamber, feed system, and nozzle influences. To ensure elimination of the instabilities at the engine level, and to understand the stability margin, the gas generator system has been modeled at the NASA MSFC with two techniques, the Rocket Combustor Interaction Design and Analysis (ROCCID) code and a lumped-parameter MATLAB® model created as an alternative calculation to the ROCCID methodology. To correctly predict the instability characteristics of all the chamber and injector geometries and test conditions as a whole, several inputs to the submodels in ROCCID and the MATLAB® model were modified. Extensive sensitivity calculations were conducted to determine how to model and anchor a lumped-parameter injector response, and finite-element and acoustic analyses were conducted on several complicated combustion chamber geometries to determine how to model and anchor the chamber response. These modifications and their ramification for future stability analyses of this type are discussed.