COMBUSTION DYNAMICS AND STABILTY MODELING OF A LIQUID OXYGEN/RP-2 OXYGEN-RICH STAGED COMBUSTION PREBURNER AND THRUST CHAMBER ASSEMBLY WITH GAS-CENTERED SWIRL COAXIAL INJECTOR ELEMENTS

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ABSTRACT

The Combustion Stability Tool Development (CSTD) project, funded by the Air Force Space and Missile Systems Center, began in March 2015 supporting a renewed interest in the development of a liquid oxygen/hydrocarbon, oxygen-rich combustion engine. The project encompasses the design, assembly, and hot-fire testing of the NASA Marshall Space Flight Center 40-klbf Integrated Test Rig (MITR). The test rig models a staged-combustion configuration by combining an oxygen-rich preburner (ORPB), to generate hot gas, with a thrust chamber assembly (TCA) using gas-centered swirl coaxial injector elements. There are five separately designed interchangeable injectors in the TCA that each contain 19- or 27- injector elements. A companion paper in this JANNAF conference describes the design characteristics, rationale, and fabrication issues for all the injectors. The data acquired from a heavily instrumented rig encompasses several injectors, several operating points, and stability bomb tests. Another companion paper in this JANNAF conference describes this test program in detail. In this paper, dynamic data from the hot-fire testing is characterized and used to identify the responses in the ORPB and TCA. A brief review of damping metrics are discussed and applied as a measure of stability margin for damped acoustic modes. Chug and longitudinal combustion stability models and predictions are described which includes new dynamic models for compressible flow through an orifice and a modification to incorporate a third feed line for inclusion of the fuel-film coolant. Flow-acoustics finite element modeling is used to investigate the anticipated TCA acoustics, the effects of injector element length on stability margin, and the potential use of an ORPB orifice trip ring for improving longitudinal stability margin.