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Title:
"Combustion Stability of the Gas Generator Assembly from J-2X Engine E10001 and Powerpack Tests"

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Abstract:

Testing of a powerpack configuration (turbomachinery and gas generator assembly) and the first complete engine system of the liquid oxygen/liquid hydrogen propellant J-2X rocket engine have been completed at the NASA Stennis Space Center. The combustion stability characteristics of the gas generator assemblies on these two systems are of interest for reporting since considerable effort was expended to eliminate combustion instability during early development of the gas generator assembly with workhorse hardware. Comparing the final workhorse gas generator assembly development test data to the powerpack and engine system test data provides an opportunity to investigate how the nearly identical configurations of gas generator assemblies operate with two very different propellant supply systems – one the autonomous pressure-fed test configuration on the workhorse development test stand, the other the pump-fed configurations on the powerpack and engine systems. The development of the gas generator assembly and the elimination of the combustion instability on the pressure-fed workhorse test stand have been reported extensively in the two previous Liquid Propulsion Subcommittee meetings.[1-7] The powerpack and engine system testing have been conducted from mid-2011 through 2012. All tests of the powerpack and engine system gas generator systems to date have been stable. However, measureable dynamic behavior, similar to that observed on the pressure-fed test stand and reported in Ref. [6] and attributed to an injection-coupled response, has appeared in both powerpack and engine system tests. As discussed in Ref. [6], these injection-coupled responses are influenced by the interaction of the combustion chamber with a branch pipe in the hot gas duct that supplies gaseous helium to pre-spin the turbine during the start transient. This paper presents the powerpack and engine system gas generator test data, compares these data to the development test data, and provides additional combustion stability analyses of the configurations.

1. Reynolds, D., Kopicz, C., and Hormozian, C.,"J-2X Gas Generator Development Testing at NASA Marshall Space Flight Center," 57th JANNAF Propulsion Meeting (JPM) and Joint Meeting of the 7th Modeling & Simulation Subcommittee (MSS) / 5th Liquid Propulsion Subcommittee (LPS) / and 4th Spacecraft Propulsion Subcommittee (SPS), Colorado Springs, CO, May 3-7, 2010.

2. Hulka, J.R., Protz, C.S., Casiano, M.J., and Kenny, R.J., "Longitudinal Mode Combustion Stability Analyses for J-2X Gas Generator Development," 57th JANNAF Propulsion Meeting (JPM) and Joint Meeting of the 7th Modeling & Simulation Subcommittee (MSS) / 5th Liquid Propulsion Subcommittee (LPS) / and 4th Spacecraft Propulsion Subcommittee (SPS), Colorado Springs, CO, May 3-7, 2010.

3. Hulka, J.R., Protz, C.S., Casiano, M.J., and Kenny, R.J., "Effect of Test Facility Feed Systems on Combustion Instability During J-2X Workhorse Gas Generator Testing," 57th JANNAF Propulsion Meeting (JPM) and Joint Meeting of the 7th Modeling & Simulation Subcommittee (MSS) / 5th Liquid Propulsion Subcommittee (LPS) / and 4th Spacecraft Propulsion Subcommittee (SPS), Colorado Springs, CO, May 3-7, 2010.

4. Kenny, R.J., Muss, J.A., Hulka, J.R., and Casiano, M.J., "Effects of Multiple Orifice Exhaust Nozzle Admittance on J-2X Gas Generator Stability," 57th JANNAF Propulsion Meeting (JPM) and Joint Meeting of the 7th Modeling & Simulation Subcommittee (MSS) / 5th Liquid Propulsion Subcommittee (LPS) / and 4th Spacecraft Propulsion Subcommittee (SPS), Colorado Springs, CO, May 3-7, 2010.

5. Reynolds, D.C., and Kopicz, C., "J-2X Workhorse Gas Generator Testing at NASA Marshall Space Flight Center," Joint Meeting of the 8th Modeling and Simulation Subcommittee (MSS) / 6th Liquid Propulsion Subcommittee (LPS) / 5th Spacecraft Joint Subcommittee (SPS), Huntsville, AL, December 5-9, 2011.

6. Hulka, J.R., Kenny, R.J., Protz, C.S., and Casiano, M.J., "Supplementary Tests and Analyses of Injection-coupled Combustion Stability from J-2X Gas Generator Development," Joint Meeting of the 8th Modeling & Simulation Subcommittee (MSS) / 6th Liquid Propulsion Subcommittee (LPS) / and 5th Spacecraft Propulsion Subcommittee (SPS), Huntsville, AL, December 5-9, 2011.

7. Kenny, R.J., "Spin Start Line Effects on the J-2X Gas Generator Chamber Acoustics," Joint Meeting of the 8th Modeling and Simulation Subcommittee (MSS) / 6th Liquid Propulsion Subcommittee (LPS) / 5th Spacecraft Joint Subcommittee (SPS), Huntsville, AL, December 5-9, 2011.