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Author: Mr. Johannes Reichert
Viterbi School of Engineering, USC, United States

Mr. Jaayden Thomas
Viterbi School of Engineering, USC, United States
Ms. Camila Aristimuno
Viterbi School of Engineering, USC, United States
Mr. Armen Aroutiounian
Viterbi School of Engineering, USC, United States
Mr. Danetti Martino
Viterbi School of Engineering, USC, United States
Mr. Francisco Razo
University of Southern California, United States

DEVELOPMENT OF ATLAS: A LIQUID ROCKET ENGINE CRYOGENIC TEST STAND AND FEED SYSTEM

Abstract

Student-designed engines and rocket teams have continued to advance and develop to create more powerful and complex cryogenic liquid rocket engines. The increased requirements of advanced rocket engines requires the development of test infrastructure to validate the engine research. USC Liquid Propulsion Laboratory (LPL) presents the adaptation of their existing GOx/Kerosene test stand 'HYDRA' (AIAA 2018-4601) to develop a LOx/Kerosene test stand (ATLAS) with increased testing capability and performance while maintaining a futureproof, robust design. The resulting ATLAS design is capable of safely testing cryogenic propellant engines greater than 10kN of thrust and with a total maximum expected mass flow rate of 12 kg/s.

An iterative design cycle was implemented to determine and size the components of the ATLAS test stand that would successfully meet testing requirements. The first step of this process was to identify and realize the main design constraints of HYDRA, and pinpointing the components that can be refurbished, or would need further development. A test stand MEOP of 1500 psi was determined after estimating all system pressure losses. After establishing the new requirements, it was determined that HYDRA's GOx lines and components for the fuel and pressurant side were refurbishable. LPL incorporated cost saving methods where applicable and conducted trade studies to reduce the overall cost of this project and minimize component lead time. Custom components and instruments were avoided as they are paired with long lead times, and commercial off the shelf (COTS) components were utilized where applicable. Retrofitting techniques were used on COTS components such as hand ball valves to enable them to be used safely in cryogenic environments. COTS medical oxygen tanks were also modified with an inlet at the bottom to use as fuel and oxidizer propellant tanks.

Engineering controls were implemented to ensure safe high-pressure and cryogenic operations based on a failure modes and effects analysis (FMEA) investigation. To ensure test stand operator safety, a single-key lockout system was implemented, and the test stand was designed such that all operations from the start of propellant loading could be done remotely. Maximum projected cryogenic boil-off rates were used to

size relief devices and vent paths to allow for adequate venting. The system also has redundant vent and relief paths to prevent boiling liquid expanding vapor explosion (BLEVE) from occurring in cryogenic lines, components, and the tank. Additional redundancy was incorporated by supplying independent auxiliary power sources to valves.