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LEVERAGING AUTOMATION FOR SAFER AND EFFICIENT CRYOGENIC CHILLING IN ROCKET ENGINE TESTING

Abstract

Ground testing is a critical step in the development of rocket engines, simulating space conditions to validate performance and identify potential issues. A crucial aspect of this process is cryogenic chilling, which involves cooling engine components and associated circuits to extremely low temperatures using test fluids. Chilling large pipelines is a significant challenge, often extending test preparation time. The aim is to improve chilling efficiency and reduce overall test duration. Proper chilling is essential to achieve accurate test conditions at the test article inlet during ground testing thereby ensuring consistent flow rates, optimal combustion characteristics and enhanced performance, while minimizing the risk of propellant vaporization, thermal stress, and unexpected events. Cryogenic fluids constitute a significant cost component in testing. A well-planned propellant budget is crucial to minimize overall expenses. This necessitates an effective and resource-efficient chilling process. This paper explores the challenges and solutions associated with controlling the cryogenic chilling process. It delves into the importance of precise temperature control, flow rate management, and pressure regulation to ensure optimal engine performance and safety. To achieve robust control, advanced control algorithms and automation techniques are employed using PLC's. By automating the manual process, the system significantly reduces the risk of human error, improves test repeatability and enables real-time decision-making. A modular software design approach is adopted to enhance flexibility and adaptability. This allows for efficient testing of various engine configurations and reduces preparation time. By integrating anomaly detection and sensor health monitoring, the system can respond effectively to unforeseen events. The effectiveness of the developed control algorithms and automated sequences is validated through rigorous simulations. The successful integration of the implemented control strategies and software into actual cryogenic tests led to a 2 hour reduction in preparation time and a 30 percent reduction in propellant usage. Ultimately, this work contributes to the advancement of rocket engine testing, enabling more accurate simulations, improved safety, and enhanced overall test performance