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C1Or4C-07: Experimental Study on Thermodynamic Performance and Lossless Storage of a Vehicle-Mounted Horizontal LH2 Tank

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Liquid hydrogen (LH2) storage offers significant advantages in storage density and operating pressure, showing promising prospects for mobile applications. However, experimental studies on tank internal thermodynamics typically involve smaller tank sizes and primarily focus on vertical tanks. Detailed studies of horizontal tanks, which are more suitable for vehicle applications, are limited, particularly regarding experimental data under actual operating conditions.

This study presents experimental results from a 500L vehicle-mounted horizontal liquid hydrogen storage tank equipped with a vapor-cooling-shield (VCS) and lossless storage capabilities.

Temperature and pressure measurements were conducted using calibrated Pt-1000 and Pt-100 sensors strategically placed throughout the tank. Results show that the average daily boil-off rate with VCS operation is approximately 5.62%, compared to 7.35% without VCS, indicating that the VCS improves efficiency by approximately 23.54%. During steady-state evaporation, significant thermal stratification was observed in the vapor phase, while the liquid phase showed minimal stratification. Temperature sensors demonstrated potential for supplementary liquid level measurement, as they clearly detected stratification when liquid levels dropped below sensor positions.

The self-pressurization tests revealed that the lossless storage cycle durations gradually decreased before stabilizing, with four consecutive cycles lasting 16.23h, 13.18h, 10.83h, and 10.34h respectively. Liquid level and temperature sensor data indicate that during self-pressurization, the evaporation of liquid hydrogen may be suppressed. Therefore, thermal stratification in the vapor phase is likely a significant factor contributing to the increase in self-pressurization rates.

Liquid hydrogen storage's active cooling technology holds promise for addressing irreversible hydrogen evaporation and achieving true lossless storage. For lossless storage, the system employed two cryogenic refrigerators. The evaporated hydrogen gas was condensed in a cold box after passing through the vapor cooling screen, demonstrating an intermittent gravity-driven liquid hydrogen self-circulation process with a period of approximately 7.45 minutes. The pressure reduction from the rated pressure to atmospheric pressure demonstrated the successful implementation of lossless storage. This achievement provides valuable insights for long-term LH2 storage solutions by effectively minimizing evaporation while maintaining stable storage conditions.

These comprehensive findings not only provide essential experimental data for horizontal LH2 storage tanks and offer insights for optimizing pressure management strategies in vehicle applications, but also serve as valuable reference for the design of lossless storage systems intended for long-term storage applications.

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