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C1Or4C-05: Development of novel non-vacuum insulation system for large-scale liquid hydrogen storage applications

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Developing advanced infrastructure components, including Liquid Hydrogen (LH2) storage tank, is crucial to LH2 supply chain pathway development for maritime & international trade applications. Because of extreme cryogenic temperatures of LH2 at 20 K, the storage tank needs to be well insulated to minimize the boil off rate (BOR). While high vacuum insulation technology is commonly used for LH2 storage systems today, it is non-practical for large tanks given the high CAPEX of the storage tank with double wall steel and excessive amounts of time required to draw the vacuum to the necessary level. Alternatively, for nonvacuum insulation systems, one of the major challenges is the runaway cryopumping effect. This phenomenon is developed as air gases such as O2 and N2 will condense and freeze at the cold boundary temperature. The low pressure created drives more gases to the cold face, while the liquified gases flows under gravity to the warm side of the insulation, where it re-vaporizes and flows back towards the cold side of the insulation. This phenomenon results in loss of insulation capabilities due to the involved heat transfer operation. In addition, the scale-up of the tank possess other technical challenges such as selection of right insulating material, determination of insulation properties at cryogenic conditions, long term mechanical integrity of the tank, which must be resolved for a technical and economically feasible design.

For our DOE sponsored project (DE-EE0009387), Shell partnered with CB&I, NASA Kennedy Space Center, GenH2 and the University of Houston to develop a low-cost, large-scale LH2 storage tank design for maritime & international trade applications. Target design is based on present day commercial LNG tanks from 20,000 m3 to 100,000 m3 with target BOR of 0.1%/day. Through 3-year R&D, the project team has developed a first-of-its-kind design using a non-vacuum insulation concept based on polymeric materials with significant cost savings compared to currently used vacuum insulation system. Though polymeric insulation was applied as a thin layer on the LH2 tanks of rockets for space application, Currently, no commercially available polymeric insulation material has been applied for long-term LH2 storage. During this presentation, we will provide an overview of the project with the focus on the development of insulation concept and the derisking process by modeling and experiments. The proof of concept will be demonstrated by the demo tank constructed at NASA MSFC (Marshall Space Flight Center). The significance and application of this project will be summarized at the end.

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