Contribution ID: **474** Type: **Contributed Oral**

C1Or4C-06: Thermal and Structural Modification to Repurpose Existing Full Containment (FCT) Liquified Natural Gas (LNG) Tanks for Liquid Hydrogen (LH2) Storage

Monday 19 May 2025 17:30 (15 minutes)

In 2023, the global LNG industry's operational mandate reached a record high of 404 Million Metric Tonnes (MMT). In contrast, the long-term sustainability of LNG as a primary fuel is declining, particularly in view of the carbon-neutral objectives established for 2050. The proposed decarbonisation objectives for 2050, would render many re-gasification and liquefaction facilities at numerous LNG terminals obsolete. The storage tanks are the most expensive component of these LNG terminals, accounting for approximately 50% of the terminal capital cost. These LNG terminals contain FCTs with capacities of up to 200,000 m3. The potential to adapt these LNG storages to accommodate liquid hydrogen (LH2) has been recognised as a viable alternative, as the hydrogen demand is anticipated to reach 550 MMT by 2050, where LH2 will constitute a substantial portion of the anticipated demand.

In this study two distinct aspects were analysed to evaluate the efficacy of the proposed solution: the structural evaluation, which evaluated the tank's performance in static and dynamic stress conditions, and the thermal evaluation, which assessed the potential for heat in leak due to inadequacy of existing insulation. For the structural evaluation, a comprehensive design of a typical 200,000 m3 LNG FCT was conducted, and its static and seismic performance was analysed using Finite Element Modelling (FEM) and numerical analyses for both LNG and LH2 fills. The performance of the inner chamber against liquid sloshing and buckling and both inner and outer chamber against lateral deformation and base shear were evaluated following the full containment design philosophy. Additionally, the evaluation included the introduction of a new inner containment stainless steel layer held in place by thermally intercepted supports, which serves as the LH2 container in the converted storage system, due to the fact that the current inner chamber materials in the LNG storage tanks are not capable of performing well below -200 °C.

Considering the thermal analysis, preliminary finite element modelling showed that the exterior prestressed concrete section in the tank shell, bottom and dome is not exposed to significant thermal stress switching from LNG to LH2 filled cases. Hence, this analysis focused on improving insulation space between the inner tank and the outer concrete section for both the shell and the bottom, with two different insulation arrangements. In the initial arrangement, vacuum insulation was incorporated with an intermediate fill agent to achieve a rough vacuum (0.1 bar –1 bar). The boiloff rate was considerably reduced as a result. However, the second insulation arrangement assessed the potential for achieving similar insulation effectiveness with passive insulation materials, given the challenge of establishing vacuum insulation for the 200,000 m3 storage scale. This assessment primarily included Glass wool, Perlite, Cellular glass, Aerogel, Glass bubbles, and Aerogel blankets and powders in three-layer, four-layer, and five-layer configurations. The most optimal configuration was determined by calculating the heat flux and associated boiloff rates using FEMs and a unique dynamic boiloff model based on a superheated vapour model between the boiloff gas and the liquid, which accounted for the temperature difference between the two mediums. Furthermore, the model evaluated and optimised the overall tank insulation performance as the material loss by regulating thermal inleak from the roof by placing different insulations on the suspended aluminium deck as well.

This analysis facilitated the development of a viable solution for establishing large-scale LH2 storage, wherein the suggested conversion costs would constitute a fraction of the capital expenditure required for new LH2 storage while fully leveraging the strategic positions of LNG terminals. Further, the recommended retrofitting components from this research enable the incorporation into new and continuing LNG tank builds, making future conversions more feasible.

Author: KRISTOMBU BADUGE, Shanaka (The University of Melbourne)

Co-authors: PREMAKUMARA, Amila (Graduate researcher); Mr COSTA, Susiri (Graduate Researcher); Mr SAKVITHI, Hasala (Graduate Researcher); GUNARATHNE, Upeka (The University of Melbourne)

Presenters: KRISTOMBU BADUGE, Shanaka (The University of Melbourne); PREMAKUMARA, Amila (Graduate researcher)

Session Classification: C1Or4C - Liquid Hydrogen Storage