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Model and dynamic simulation of the liquid hydrogen distribution by trailer

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Liquid hydrogen (LH2) is gaining attention as a low-carbon energy vector and fuel in the clean energy sector. This has led to a significant growth in the worldwide production and distribution of LH2 in recent years. Today, the distribution of LH2 from the liquefier facility to the user is almost entirely performed by road trailers. In the future, the LH2 distribution via rail cars, the transport on ships, and the usage as fuel in heavy duty mobility will become more important. LH2 transfer processes used for filling and unloading of these tanks play a substantial role in the efficiency of the overall LH2 distribution chain. To minimize the losses in today's LH2 supply chain, as well as for efficient transfer operations in emerging LH2 systems, it is essential to understand the thermodynamic processes occurring in the tanks. Studying the current LH2 distribution by trailer enables the development of models that can support the planning of an efficient future LH2 infrastructure.
In this work, the LH2 distribution by trailer is explained and the different process steps occurring are defined. In the ullage of the LH2 trailer gaseous hydrogen is present above the loaded liquid. During the different process steps, depending on the magnitude of the phase transition, vapor-liquid equilibrium can be reached between the phases, or non-equilibrium can be induced whereupon superheated gas is present above subcooled liquid. The work shows the significant influence that this phase transition has on the efficiency of the process steps in the LH2 distribution chain. In the study, a thermodynamic model is developed using MATLAB with thermodynamic property data from REFPROP. With the model, a generic LH2 trailer route is simulated and the influence of the phase transition is investigated. The study suggests ways to minimize losses in the LH2 distribution chain by purposely adjusting the phase transition to target vapor-liquid equilibrium or non-equilibrium in the LH2 trailer.

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