Contribution ID: **77** Type: **Poster**

A CFD-based Comparative Study on the Performance of Centrifugal Pumps with Water and Liquid Hydrogen

Wednesday 29 October 2025 14:09 (1 minute)

Hydrogen is increasingly recognized as a clean energy carrier with significant potential for decarbonizing hard-to-abate sectors. In hydrogen transfer systems, liquid hydrogen (LH_2) is preferred over its gaseous form due to its higher density (i.e. 70 kg/m³ compared to 0.083 kg/m³ at atmospheric pressure). Generally, centrifugal pumps are a suitable choice due to the operating conditions within the LH_2 transport sector.
So far, experimental studies on LH_2 pumps have focused mainly on aerospace sector, where pumps are characterized by low specific speeds for short duty cycles. However, commercial applications in maritime and other sectors could require a broader range of pump designs and operating conditions.
Because laboratory testing with LH_2 is expensive and complex to handle with, water could be used as a suitable surrogate to test pumps. However, it is necessary to consider how the different physical properties of the fluids could affect performance and use appropriate correction factors. Indeed, existing performance correction methods are limited to fluids denser than water.
In this framework, this study aims to numerically compare centrifugal pumps operating with both LH2 and water to assess the effects of LH2 on pump performance. In this way, it is possible to take into account performance differences when the designed pump is tested with water.
Initially, five specific speeds (i.e., 10, 30, 50, 70 and 90 with Q [m3/s], H [m] and n [rpm]) were chosen to design different pump impellers geometries for LH2. Specifically, the five impellers were designed by keeping constant the flow rate at 100 m3/h and a rotational speed of 9000 rpm. Then, each geometry was simulated by using ANSYS Fluent, with 3D RANS equations coupled with turbulence model k-ω SST.
Later, the five impellers were also simulated with water by using the same numerical set-up. With water, operating conditions were scaled using affinity laws. In both cases, pump losses were analyzed by means of rotary stagnation pressure and skin friction coefficient within the impeller channels.
The results show that pumps operating with LH_2 achieve higher hydraulic efficiencies with respect to water. The greater the specific speed, the greater the difference in terms of hydraulic efficiency, up to 6% at a specific speed of 90. These gains are primarily due to the lower viscosity (i.e. 1×10^{-5} Pa s) and density of LH_2, which lead to a higher Reynolds number, lower skin friction values, and reduced losses.
These findings support the development of performance correction factors for LH2.

Submitters Country

Are you a student?

Author Affiliations & Email Addresses

Co-Author Affirmation

Author: GIAMPIETRO, Davide

Co-authors: ANNESE, F.; STEFANIZZI, M.; TORRESI, M.; CAMPOREALE, S.M.; CAPURSO, T.

Presenter: GIAMPIETRO, Davide

Session Classification: Poster session