



HAL
open science

Evaluation of a two-phase piston pump model for cryogenic fluids transport

Valentin Cottarel, Timo Bouvard, Laura Matteo, François Dupouy

► **To cite this version:**

Valentin Cottarel, Timo Bouvard, Laura Matteo, François Dupouy. Evaluation of a two-phase piston pump model for cryogenic fluids transport. EFDC1 - 1st European Fluid Dynamics Conference, Sep 2024, Aix-La-Chapelle, Germany. cea-04847956

HAL Id: cea-04847956

<https://cea.hal.science/cea-04847956v1>

Submitted on 19 Dec 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Evaluation of a two-phase piston pump model for cryogenic fluids transport

Valentin COTTAREL*, Timo BOUVARD*, Laura MATTEO†, François DUPOUY*

Transporting liquid hydrogen in a circuit requires high-head pumps due to the very low density of such a fluid. Adapted technologies are limited to volumetric pumps or multi-stage centrifugal pumps. Indeed, in most cases, a single-stage centrifugal pump would be too much large in term of diameter. Taking a huge place for pumps is not something acceptable in complex energy systems containing many components because of the associated big impact in terms of global cost of the facility. This is even more important in the mobility domain. In the current context of the low car emissions objective, hydrogen circuits are studied more and more and the subject of liquid hydrogen pumping is a typical one.

The French Alternative Energies and Atomic Energy Commission (CEA) is a seven-decade research entity that plays a major role in the development of low carbon solution to produce electricity in a flexible way, provide urban and industrial heat at the right level and ensure mobility of person based on the hydrogen vector. In the frame of past works and projects, especially in the nuclear safety domain, the CEA has developed high fidelity simulation tools to address the question of how the facility behaves in accidental conditions. Such transients involve two-phase flows in circuits and components that need to be physically well described.

Today, the CEA is adapting such rich tools to the hydrogen issues and applications. The Code for Analysis of Thermal-Hydraulics during an Accident of Reactor and safety Evaluation (CATHARE) is a transient modular two-phase flow six-equation system code widely validated for nuclear power plant design and safety studies. It also has a long history of use in the domain of cryogenic fluids (rocket engines¹, cryogenic system safety²...). In the present paper, solutions to answer the need of a cryogenic pump modeling in transient and two-phase flow conditions are investigated. One case of interest³ is chosen in the literature and simulated to evaluate the choices of modeling in details. The piston pump is first modeled in liquid nitrogen (LN2) before being studied in liquid hydrogen (LH2). This work is a first step towards the simulation of cryogenic pumps and complex systems for the transport of such fluids.

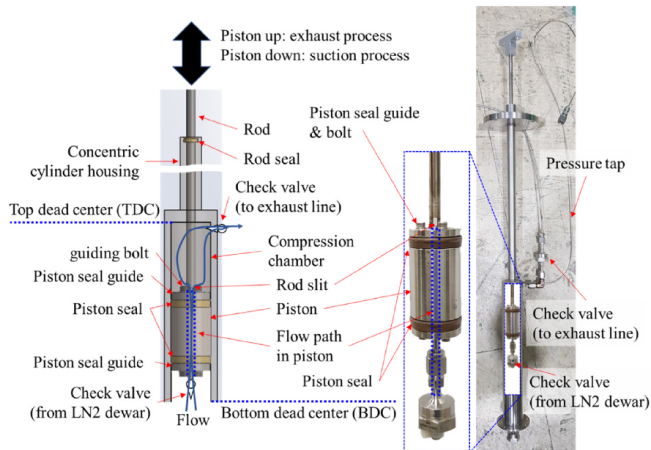


Figure 1: Scheme of the pump module from Kim et al³

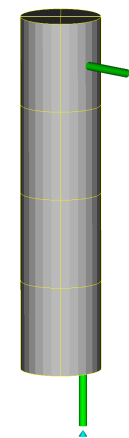


Figure 2: Visualization of the CATHARE piston pump element

*Paris-Saclay University, CEA, Thermalhydraulics and Fluid Mechanics Section, F-91191 Gif-sur-Yvette, France

†CEA, Innovative Systems Studies Section, F-13108, Saint-Paul-Lez-Durance, France

¹Moreau et al, *EU-CASS 2015-6th European conference for aeronautics and space sciences* (2015).

²Shaola et al, *Cryogenics*, **126** (2022).

³Kim et al, *International Journal of Hydrogen Energy*, **57** (2024).