COSMHYC XL
INNOVATIVE H2 COMPRESSION

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Project acronym: COSMHYC XL

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COmbined hybrid Solution of Metal HYdride and mechanical Compressors for eXtra Large scale refuelling stations

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Deliverable 5.7
Public report on the metal hydride compressor

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Dissemination Level		
PU	Public	X
PP	Restricted to other program participants (including the FCH2 JU Services)	
RE	Restricted to a group specified by the consortium (including the FCH2 JU Services)	
CO	Confidential, only for members of the consortium (including the FCH2 JU Services)	

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Introduction

In the frame of the COSMHYC XL project, a metal hydride compressor was developed. In this deliverable, EIFER presents this compressor, incl. its main technical features.

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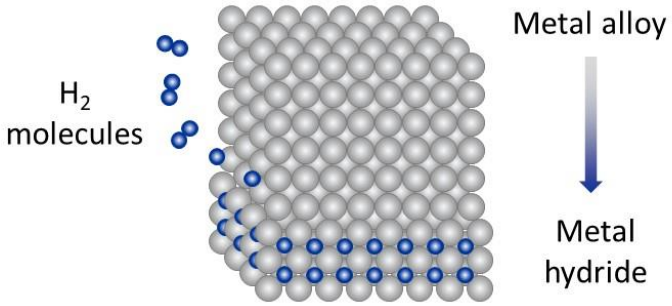
1. Objectives of the Deliverable

During the COSMHYC XL project a metal hydride compressor has been developed, built & tested. This deliverable aims at describing this metal hydride compressor, in order to provide to a broad technical and non-technical audience an understanding of the technology put in place as well as the specific features of the prototype developed in the frame of the project.

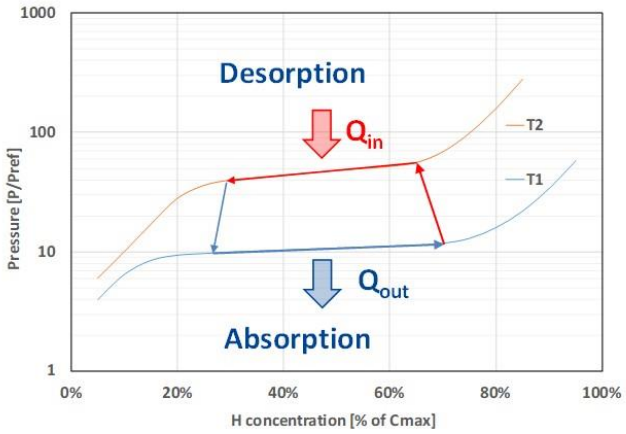
2. Metal hydride compression technology

The principle implemented in the frame of COSMHYC XL consists of an absorption/desorption effect in metal alloys that have the ability to react with hydrogen atoms to form so called metal hydrides, as illustrated below.



$$M(s) + x/2\ H_2 \underset{desorption}{\overset{absorption}{\rightleftharpoons}} MH_x(s) + Heat$$

This effect is described by the so-called Van't hoff equation, which highlights the correlation between the equilibrium pressure and temperature of the hydride. Therefore, by cycling up and down the temperature, it becomes possible to create a **compression cycle**, as highlighted below.

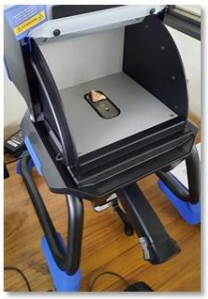


Van't Hoff equation: $\ln P_{eq} = \frac{\Delta H}{RT} - \frac{\Delta S}{R}$

This is the principle implemented in the frame of the COSMHYC XL project.

3. Metal hydrides

On big achievement of COSMHYC XL was to develop **rare-earth free metal hydrides**. This has a positive impact in terms of environmental considerations, costs and sovereignty issues. The hydrides were developed, melted analysed and prepared, as illustrated below.



The hydrides obtained are illustrated below. The performances have strongly increased since the previous COSMHYC project.

	COSMHYC	COSMHYC XL
Minimal Inlet pressure	5 bar	1 bar
Maximal outlet pressure	450 bar	500 bar
Overal compression ratio	90	500
Maximal desorption temperature	160 °C	120-140°C
Capacity	1-1,5 %	1,2-1,8%
Activation	very difficult	strongly improved

4. Metal hydrides reactor

Metal hydride reactors for 3 compression stages were developed and built. They fulfill different functions: storing metal hydrides and hydrogen, resisting to pressure increase, enabling efficient heating and cooling of the metal hydrides. An example of a tank CAD is provided hereafter.

The tanks were assembled into modules that were built together into racks. Modules were certified according to the EU PED directive. The metal hydride compression racks are illustrated below.

5. Compressor integration

A significant effort was done to integrate the overall prototype, including the following aspects:

5.1 Hydrogen piping

The hydrogen compressor is a passive system thanks to the thermochemical nature of the process. Therefore, the operation is not triggered by mechanical pistons but rather by

hydrogen fluxes and thermal effects. In particular, the hydrogen panel plays an important role, as the operation of valves enables to direct hydrogen towards appropriate reactors with the right kinetics. The hydrogen panel of the prototype is illustrated below.

5.2 Thermal integration

An important aspect of the prototype is the thermal management. This is achieved by two main subsystems: a thermal skid including heating systems, monitoring devices pumps etc.; and a roof-mounted dry cooler that dissipates low temperature calories towards the environment in the cooling phase of the reactors. An external heat exchanger can be mounted inside the thermal skid to enable the use of waste heat instead of producing the heat for the process. However, this functionality was not implemented during the project for the sake of simplicity.

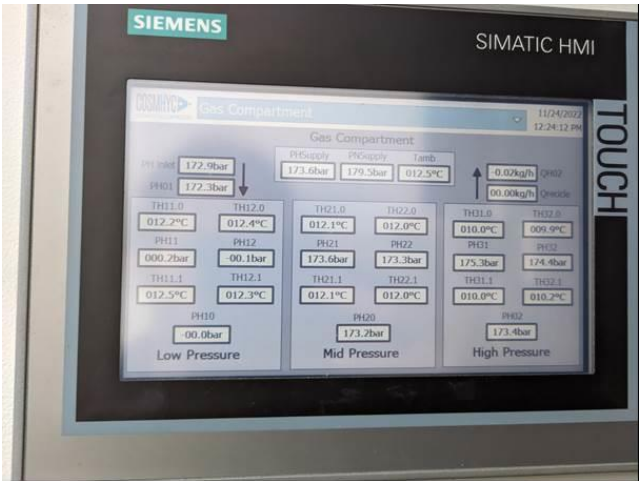
The thermal skid is illustrated below.

The roof mounted dry cooler is illustrated below.

5.3 Electrical integration, monitoring and safety

The prototype is equipped with an electrical integration consisting of a low-voltage and ultra low-voltage boxes, enabling to both control the entire prototype and supply the main components with electrical energy (pumps, dry cooler etc.).

Particular attention must be paid to safety. An overall safety concept, including ATEX study was developed and implemented, incl. the installation of smoke and H2 detectors in the compressor. A control system and the associated HMI were installed and programmed to control the overall prototype.



5.4 Containerisation

The entire prototype was containerised to enable autonomous outdoor operation and prepare for large-scale demonstration in future project. For this purpose, a dedicated ISO 20 ft container was built and transformed for the sake of the project and separated into two rooms: one for hydrogen related components, and one for electrical and thermal components.

The overall prototype, with all above mentioned subsystems, is illustrated below. The compressor was assembled and commissioned in autumn 2022 and operated until June 2023.

The overall performances of the compressor are further described in WP6.

6. Conclusion

A 3-stage metal hydride compressor was successfully developed, built and tested in the frame of the COSMHYC XL project, thereby reaching TRL 5 and paving the way for pre-commercial demonstration, that is further carried on in the frame of the follow-up project COSMHYC DEMO.