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## ► To cite this version:

Oussama Rejeb, Christophe Vial, Abdelmajid Jemni, Tarik Kousksou, Nour-Eddine Fenineche, et al.. Numerical analysis of advanced thermal management for metal hydride reactors using heat pipes. 15th International Conference on Hydrogen Production (ICH2P-2024) ICH2P, Dec 2024, Sharjah, United Arab Emirates. hal-04859709

**HAL Id: hal-04859709**

**<https://hal.science/hal-04859709v1>**

Submitted on 30 Dec 2024

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# Thermal analysis of advanced thermal management for metal hydride reactors using heat pipes

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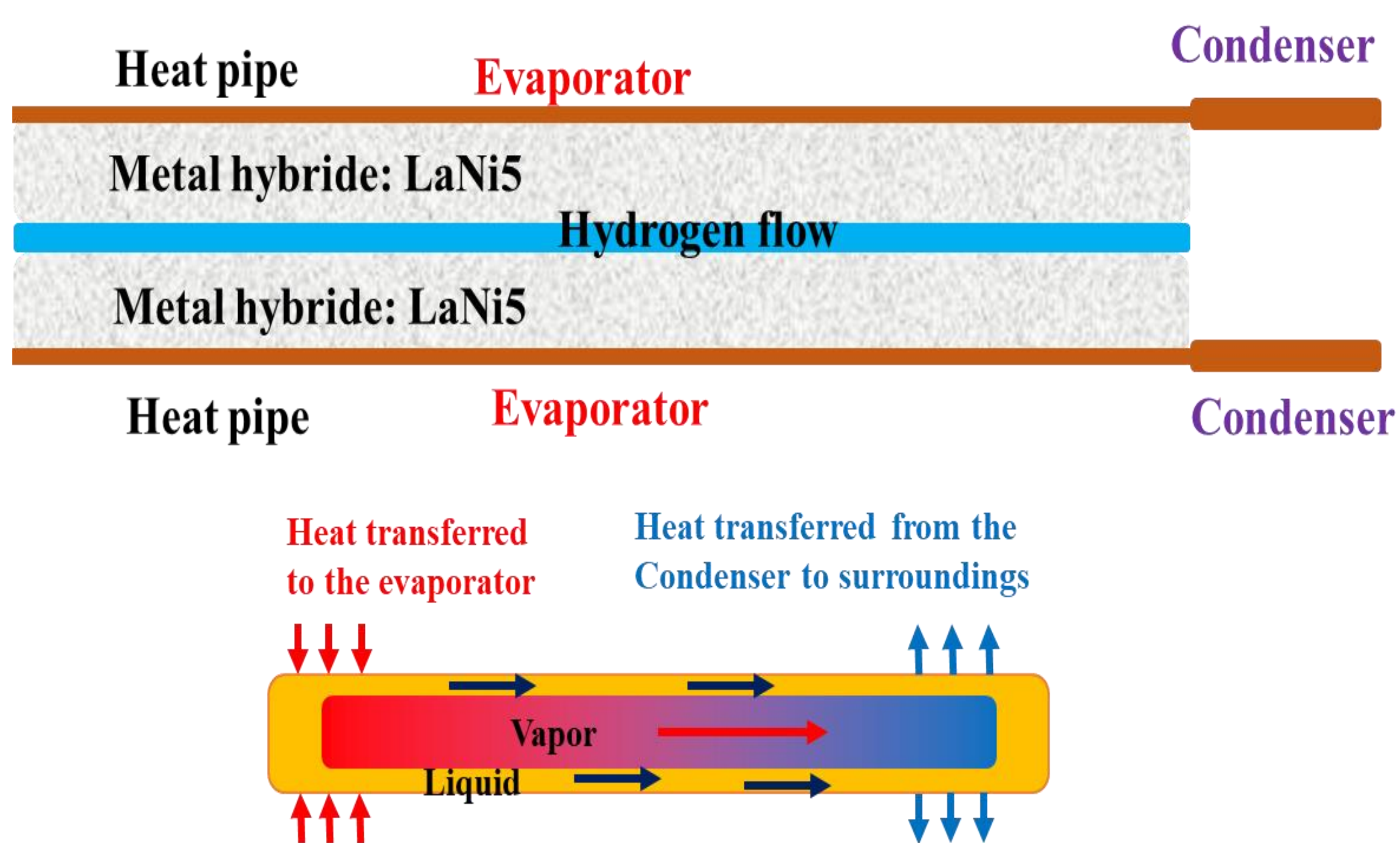
## Context

Hydrogen Storage Mode	Conditions	Advantages	Disadvantages
Compressed	150 to 700 bars	Simple, fast refuelling, compact	High pressure risks, energy for compression
Liquefied	-253 °C and 1 atm	High energy density, stable storage	Energy loss, cryogenic risks, complex insulation
Solid (Hydride)	25 °C	Safe, stable, less energy loss	Limited efficiency, slower refuelling, thermal management needed.

## Contribution

- ❖ **Safe hydrogen storage: solid storage ensures safety**
- ❖ **Heat pipe thermal management chosen for its efficient, passive, reliable, temperature control.**
- ❖ **Developed a Dynamic Model for the LaNi5 material with a cylindrical reactor coupled with heat pipe**

## System Description



LaNi5 cylindrical reactor coupled with heat pipe

## Mathematical Part

### Kinetics Reaction

$$\frac{dX_{abs}}{dt} = Cst_{abs} \ln\left(\frac{P}{P_{eq,abs}}\right) \exp\left(\frac{-E_{act}}{RT_{abs}}\right) (X_{lim,abs} - X_{abs})$$

### Energy equation

$$(C_{p,can}m_{can} + C_{p,MH}m_{MH}) \frac{dT_{abs}}{dt} = -Cst_x \frac{\Delta H}{MW_{H_2}} \frac{dX_{abs}}{dt} - \frac{(T_{eva} - T_{abs})}{R_{abs,eva}}$$

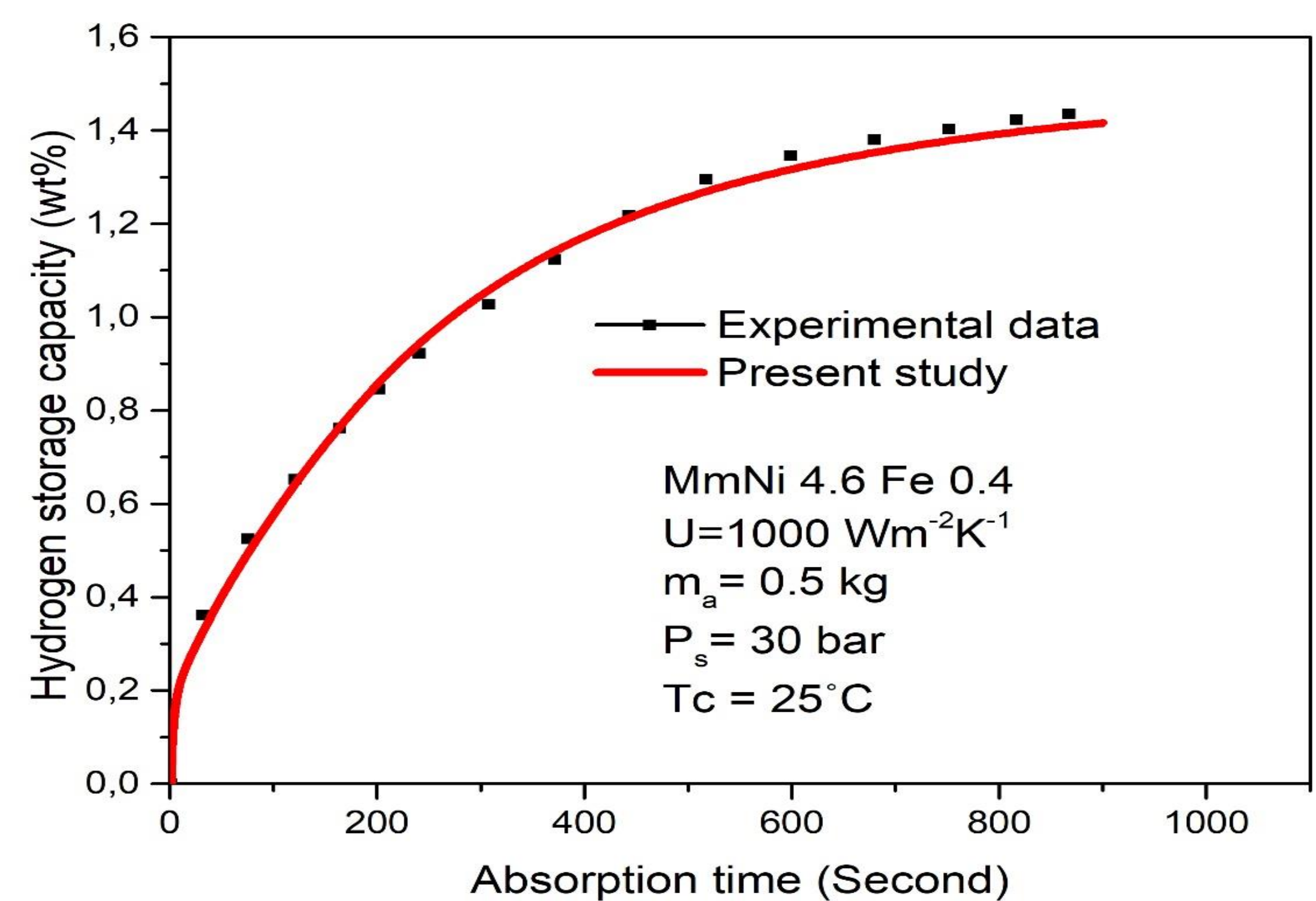
### Evaporator

$$0 = \frac{(T_{abs} - T_{eva})}{R_{abs,eva}} + \frac{(T_{cond} - T_{eva})}{R_{cond,eva}}$$

### Condenser

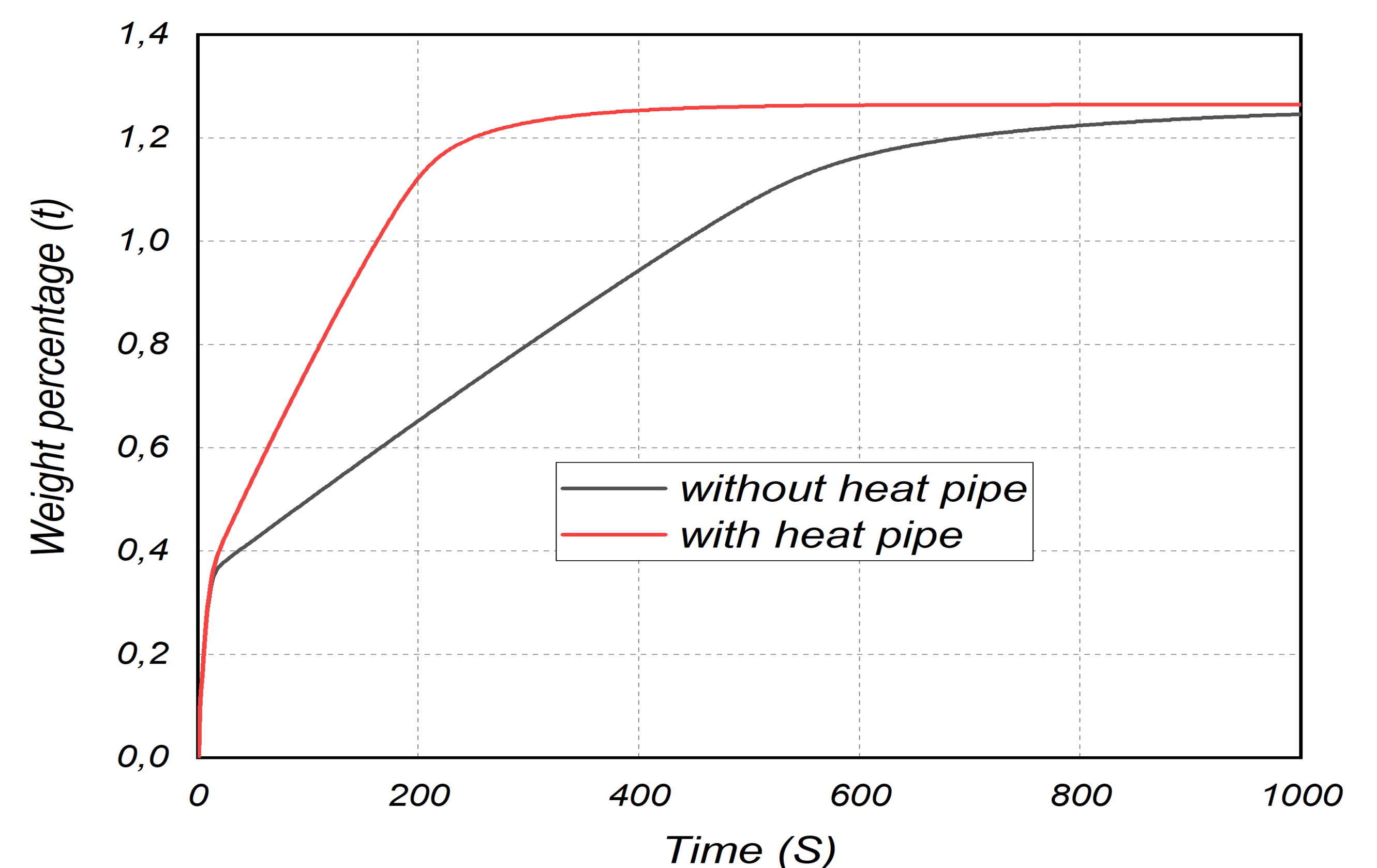
$$0 = \frac{(T_{ex} - T_{cond})}{R_{ex}} + \frac{(T_{eva} - T_{cond})}{R_{cond,eva}}$$

## Validation



Validation: Comparing the results provided by the numerical model with experimental data available in the literature.

## Results



The variation in hydrogen storage capacity (%wt) for parabolic fins, rectangular fins, and triangular fins.

## Conclusions

**Model Development:** A lumped transient model for a heat pipe LaNi5 cylindrical reactor integrates kinetics, energy, and mass transfer.

**Thermal Control:** Heat pipe reduce the charging time.

**Efficiency Boost:** Heat pipe enhance the reliability of metal hydride hydrogen storage, supporting sustainable energy solutions.