

MOTIVATION AND OBJECTIVE

Metal hydrides offer a promising solution for the efficient and safe storage of hydrogen.

- A major challenge during charging and discharging is the heat that must be supplied during discharging and dissipated during charging.
- One way to improve hydrogen loading could be **preheating**.

This work aims to investigate various preheating options for a medium-temperature metal hydride ($6\text{Mg}(\text{NH}_2)_2\text{-}9\text{LiH-LiBH}_4$) using a simulation-based approach.

PROCEDURE AND SCENARIO DEFINITION

Two existing metal hydride storage concepts from [1] (Figure 1) are to be investigated:

- Cylindrical design
- Rectangular design

All designs feature a heating jacket that is activated right at the start in every scenario.

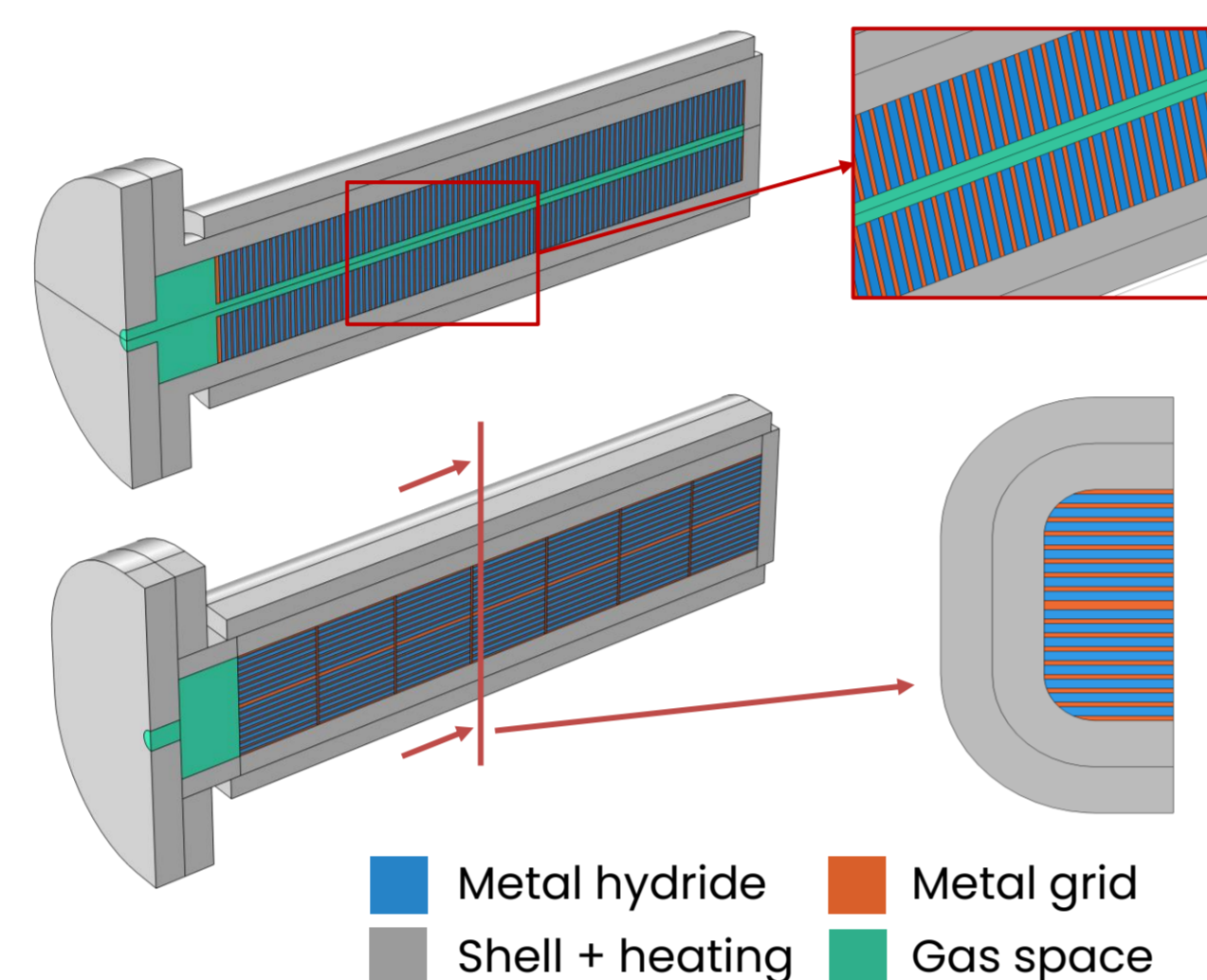
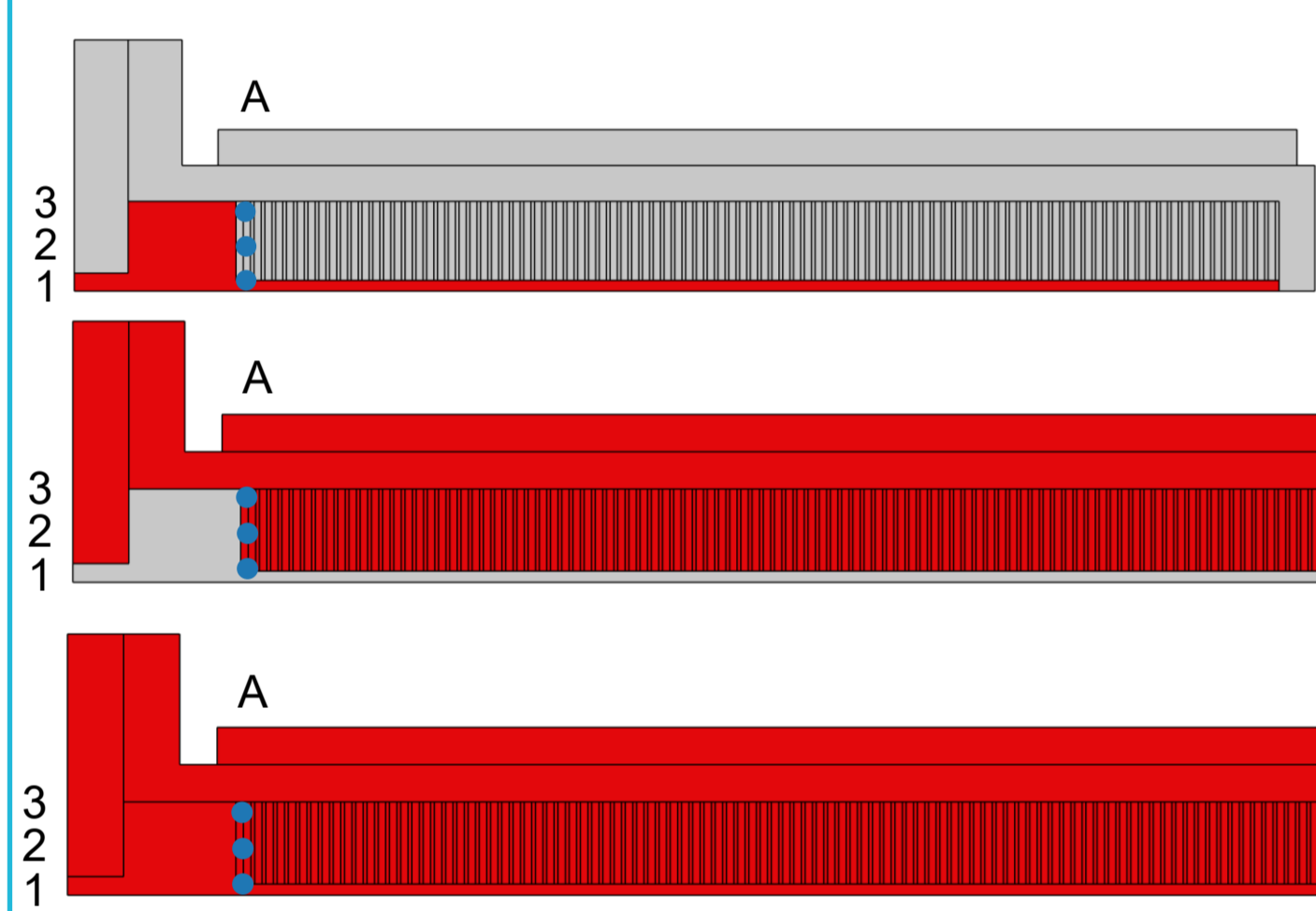


Figure 1: Design 1 (top) and design 2 (bottom) including magnification (right)



Three different options of preheating (Figure 2) are to be investigated:

- Scenario 1: Preheating of the hydrogen flowing into the storage tank.
- Scenario 2: Preheating of the metal hydride storage tank.
- Scenario 3: Preheating of both, the hydrogen and the storage tank.

Figure 2: Preheating hydrogen (top), storage tank (middle) or both (bottom)

RESULTS

The results are analyzed using the following key parameters: Hydrogen absorption in percent by weight as a function of different temperatures (at selected measuring points, Figure 2), hydrogen absorption across the entire tank, and temperature development and distribution as an example for one scenario.

Figure 3 shows the influence of **hydrogen preheating** for both design concepts in terms of **hydrogen absorption at selected points**. While there is almost no improvement in absorption for design 1, a significant improvement can be observed for design 2, especially at temperatures above 125 °C.

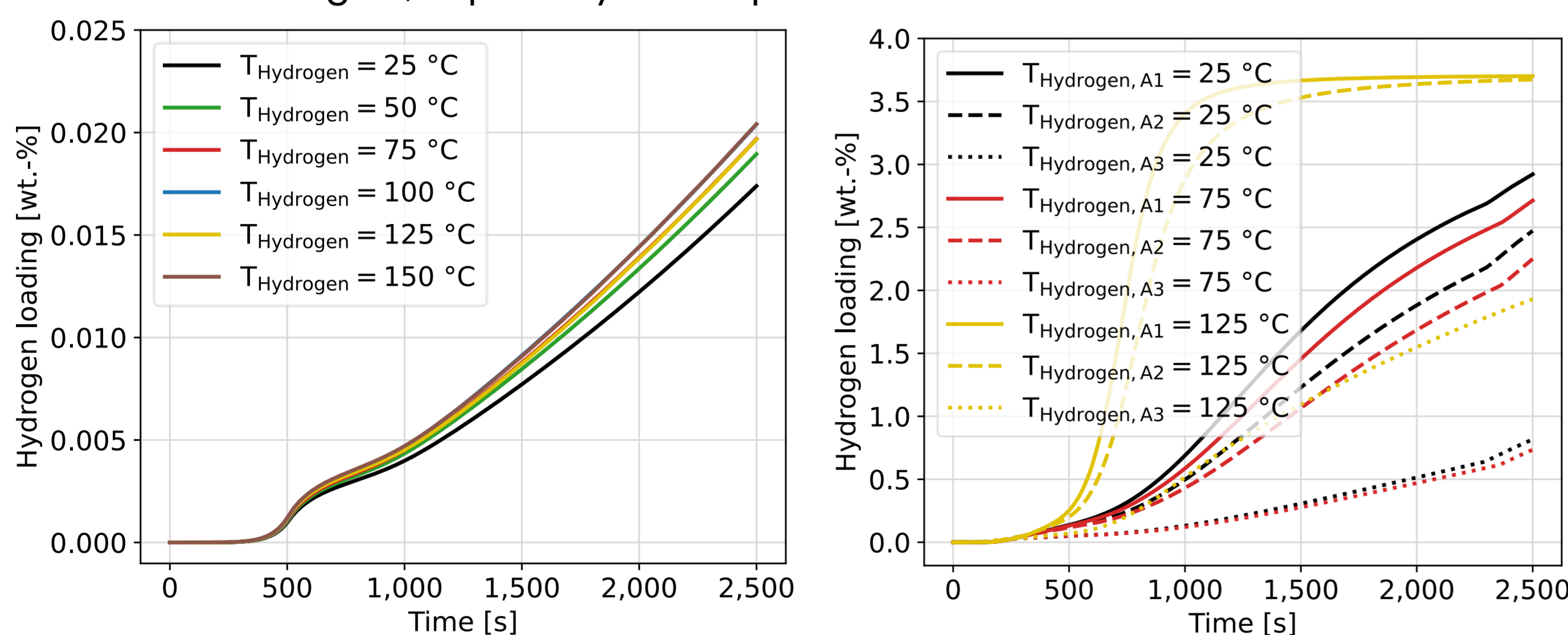


Figure 3: Hydrogen absorption within design 1 (left; all points with same performance) and design 2 (right) with preheated hydrogen

Preheating the tank itself can significantly improve hydrogen absorption in both designs. Due to the slight or non-existent improvement achieved by hydrogen preheating in design 1, simultaneous hydrogen and tank preheating does not change the hydrogen absorption. In design 2, **preheating both** achieves a slight improvement compared to preheating the tank alone.

A comparison of the results with the optimal temperatures (i.e., the fastest and most complete hydrogen absorption) can be seen in Figure 4. In design 1, significantly higher preheating temperatures must be set to achieve a significant improvement in absorption.

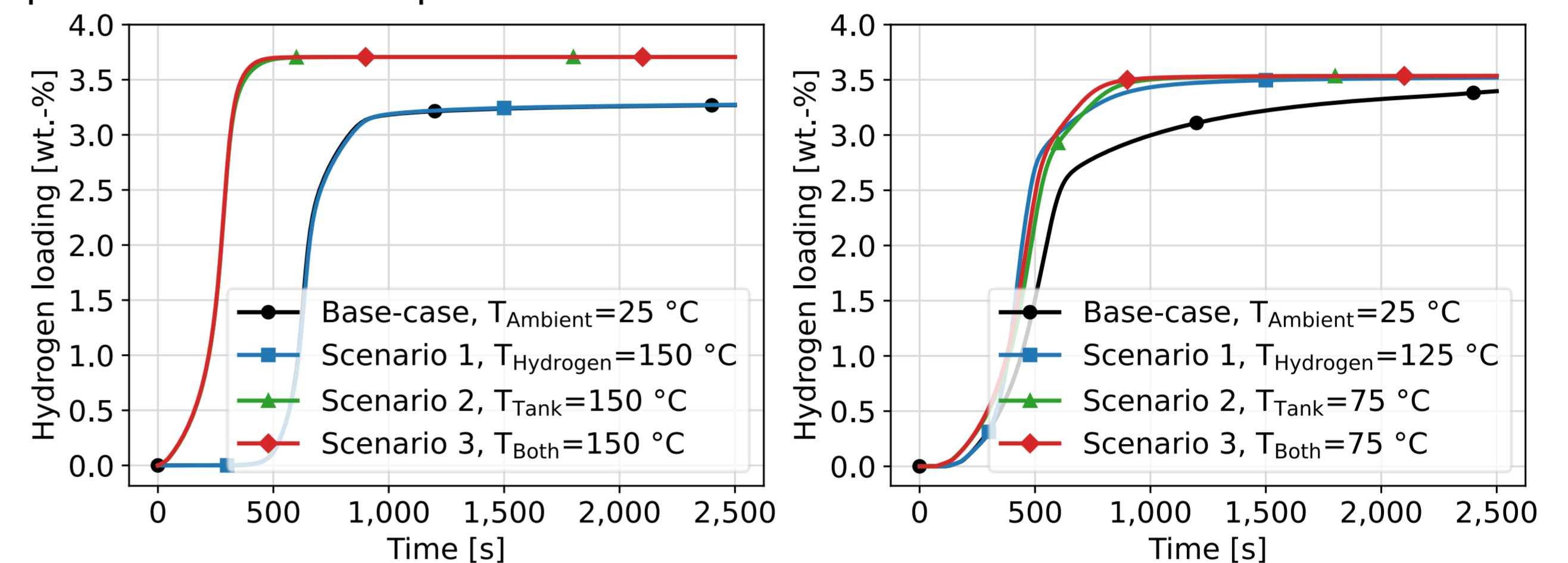


Figure 4: Hydrogen absorption within design 1 (left) and design 2 (right) with preheated hydrogen and storage tank compared to just preheating the storage tank

To analyze more precisely what causes the improvement achieved by hydrogen preheating in design 2, the **temperature distribution** can be considered (Figure 5). It can be seen that the temperature increases particularly in the front part of the tank and that the required absorption reaction temperature is reached in this part.

The required temperature increase cannot be achieved with design 1 using **hydrogen preheating**, as the temperature difference is too high.

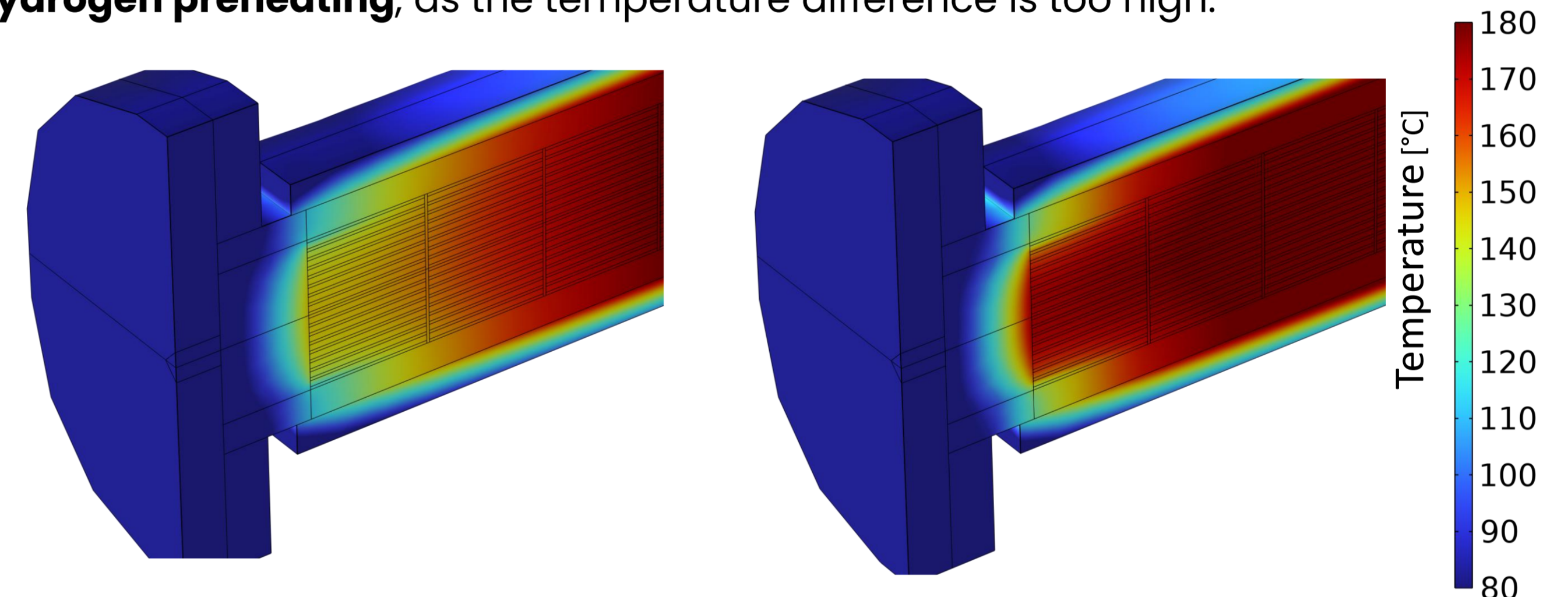


Figure 5: Temperature distribution in design concept 2, scenario 1 with no hydrogen preheating (left) and hydrogen preheating at 125 °C (right), 750 s after the start of the simulation

CONCLUSIONS

The following key findings were obtained by analyzing various preheating options.

- Preheating hydrogen alone is not sufficient to improve the hydrogen uptake of the proposed cylindrical concept (design 1), but significantly improved the hydrogen uptake of the rectangular concept (design 2).
- Preheating the storage tank itself is beneficial for both concepts investigated.
- Preheating both the hydrogen and the hydrogen storage tank improved hydrogen uptake the most for both design concepts.

→ If the temperature difference between the optimal absorption reaction and the initial storage tank temperature is too high, preheating hydrogen will result in almost no improvement in the absorption reaction.