NEW REACTORS FOR SORPTION PROCESSES

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Introduction

Sorption-based thermochemical energy storage (TCES) is a promising technology for sustainable heating systems due to its high energy density and the possibility of long-term or seasonal heat storage. However, conventional fixed-bed reactors still present several limitations related to heat and mass transfer processes, reducing the overall storage performance and system compactness. In this context, the development of new reactor concepts is essential to improve the efficiency and applicability of TCES technologies in building applications.

This work proposes the development of novel reactors for sorption processes, combining thermochemical composite materials, fluidized bed configurations and advanced 3D-printed geometries.

Materials and methodology

An experimental facility is developed to investigate low-temperature sorption processes under controlled operation conditions (Fig. 1). The system allows independent regulation of air flow rate, humidity, and temperature through dedicated conditioning units located upstream of the reactor. This configuration ensures reproducible inlet conditions for the evaluation of sorption and desorption processes.

The conditioned air stream would be introduced into a vertical reactor consisting of a central quartz tube containing the sorbent particles. Depending on the inlet gas velocity, the reactor could operate under both packed-bed and fluidized-bed conditions, allowing the analysis of different heat and mass transfer regimes during sorption and desorption processes.

In addition, additive manufacturing approaches based on Direct Ink Writing (DIW) are proposed for the fabrication of porous zeolite-based structures with controlled geometries for fixed-bed operation. Special attention is given to the development of printable slurries and advanced channel geometries inspired by triply periodic minimal surfaces (TPMS) in order to improve heat and moisture transport inside the reactor.

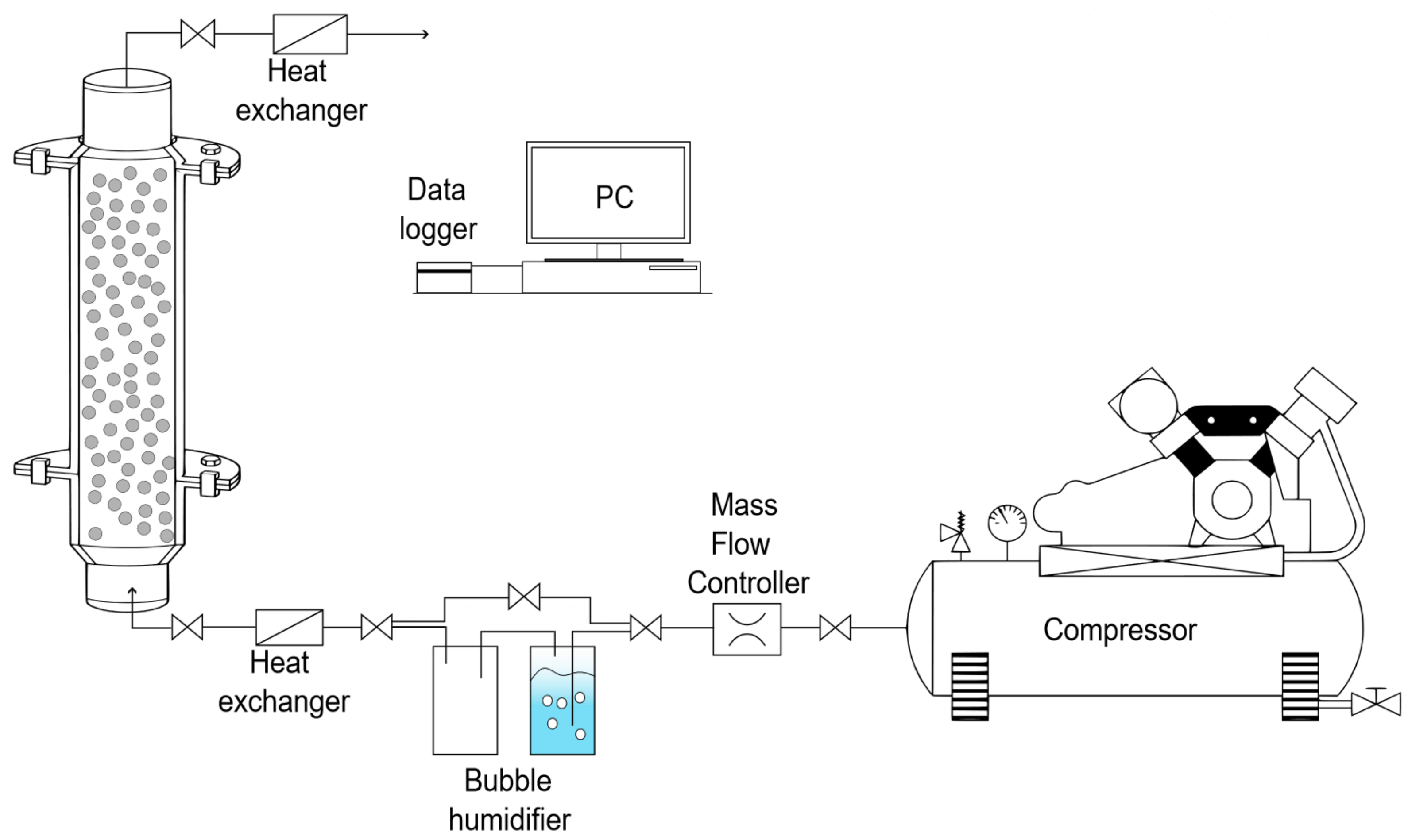

Figure 1. Experimental setup for sorption processes.

The proposed facility also includes temperature, humidity and pressure monitoring systems to evaluate the thermal behaviour and operating stability of the reactor under different experimental conditions.

Expected results and discussion

This reactor configurations are expected to improve heat and mass transfer processes during sorption operations compared to conventional packed-bed systems. In particular, fluidized-bed operation may enhance gas-solid interaction and thermal homogeneity inside the reactor, while 3D-printed porous structures could improve flow distribution and moisture transport through the sorbent material.

The combination of additive manufacturing and thermochemical sorption processes is also expected to provide new possibilities for the design of advanced reactor geometries with enhanced surface area and improved thermal performance. In this context, TPMS-inspired structures may contribute to reducing transport limitations typically observed in conventional fixed-bed reactors.

The setup will also allow comparison between fixed-bed and fluidized-bed operating regimes under controlled conditions, providing valuable information for the future development of compact and efficient thermochemical energy storage systems for building applications.

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