NUMERICAL MODEL OF COLD ENCAPSULATED PHASE CHANGE MATERIAL (EPCM)-BASED LATENT HEAT STORAGE TANK

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Introduction

A significant part of energy demand in refrigeration systems could be successfully fulfilled by using short-term energy cold accumulation systems in a form of latent heat to increase cooling systems' working efficiency and flexibility. It is now well established that the overall behavior of a cooling facility can be substantially improved by using a short-term cold energy storage system. This system can reduce the electricity consumption significantly, and also the number of normal operation cycles, thus improving the system's durability. Given the latent heat of a substance is typically much greater than the specific heat, storing thermal energy in the form of a phase change is, in principle, much more convenient than in the form of sensible heat. Because the phase transition occurs in a narrow temperature range, a specific phase change material must be selected for every application. Furthermore, except in very particular cases, the PCM must be isolated from the heat transfer fluid. Therefore, the PCM container must also be selected carefully to guarantee proper heat transfer between the PCM and the heat transfer fluid. It is not still well recognized operating conditions of EPCMs group. Such an approach has not yet been attempted in cold storage applications and it constitutes a major technological challenge, surpassing the performance of existing solutions, thereby advancing the state of the art. The underlying idea of the presented study is to conduct a wide range of numerical simulations, which were carried out to analyze design and operating parameters of EPCMs group-based cold accumulation system.

Objective of work

- To analyze EPCMs group operating conditions and their influence one on the another;
- To recognize how differences in mass flow rate in different EPCM could influence on operating conditions of EPCMs group;
- To analyze modular design of EPCM-based latent heat storage tank.

Experiment setup and research methodology

For the analysis of heat transfer during charging and discharging of the EPCMs group-based latent heat storage tank a 2D numerical model in Ansys Fluent was created. It was assumed that fluid flow of heat transfer fluid in a single EPCM will occur only in the inner space of that EPCM. Furthermore, one EPCM with the other one will have contact only in vertical direction by walls made by HDPE. Transient simulations were performed to observe temperature changes in the EPCM system as well as to verify the potential for heat accumulation.

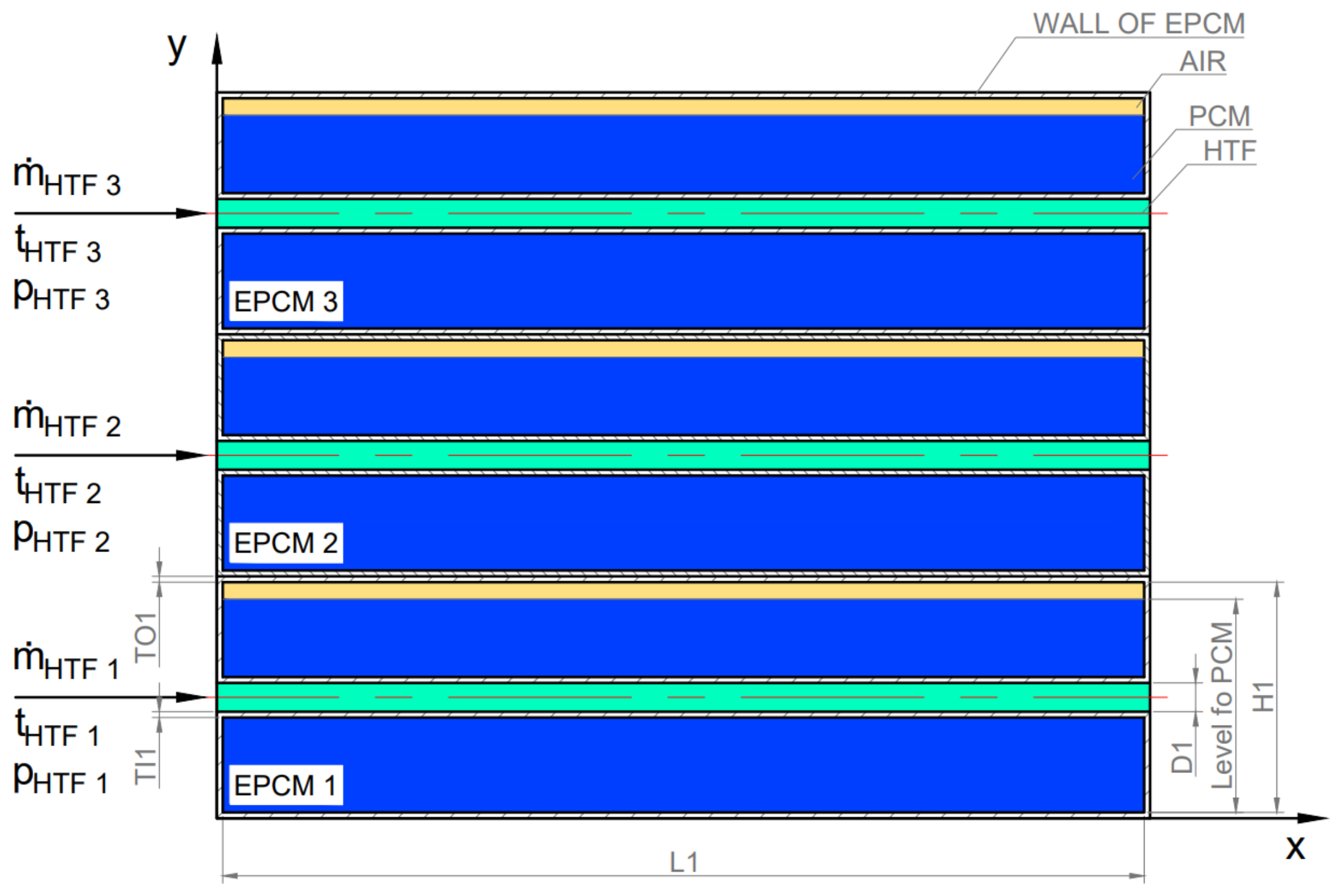

Fig. 1. Cross section of numerical model of EPCMs group

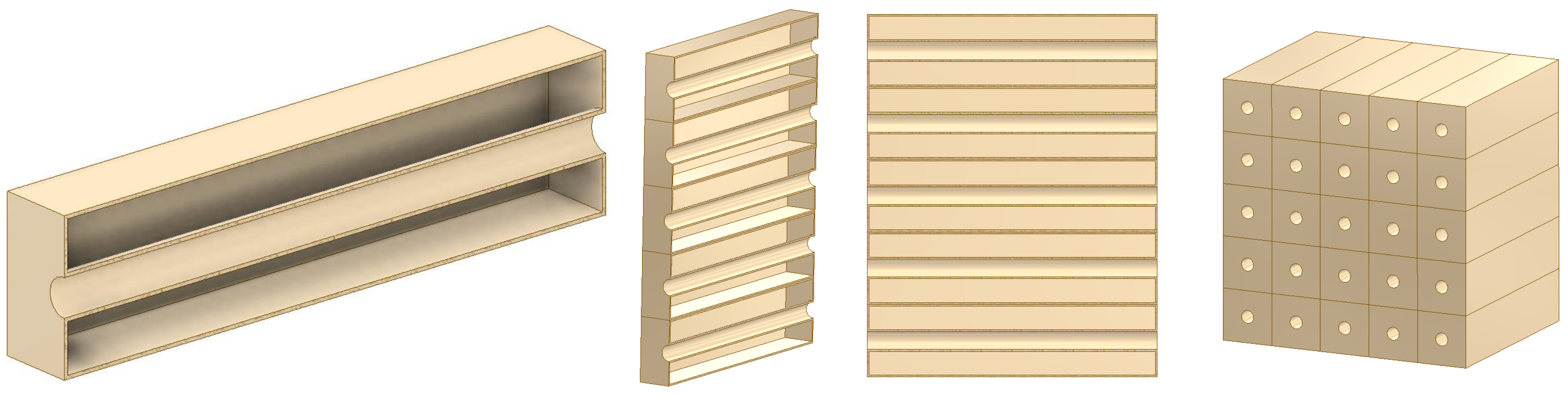

Fig. 2. Conceptual design of modular latent heat storage tank

Experiment results and discussion

Numerical simulations of operating conditions of EPCMs group focused on geometric as well as process parameters, considering its significant influence on heat transfer during charging and discharging of EPCMs group-based cold accumulation system.

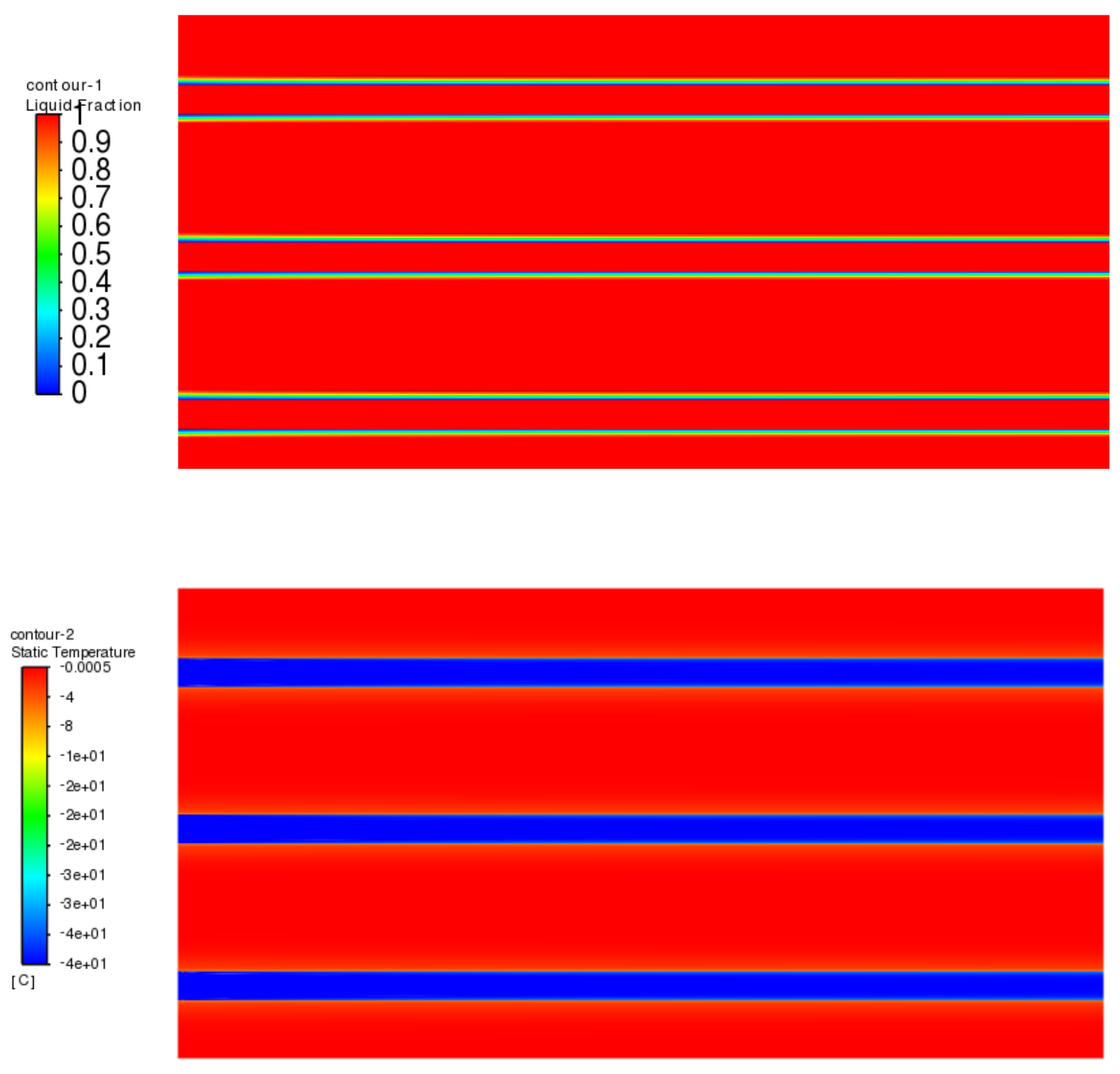

Fig. 3. Step 1 - Solidification and temperature profiles (1)

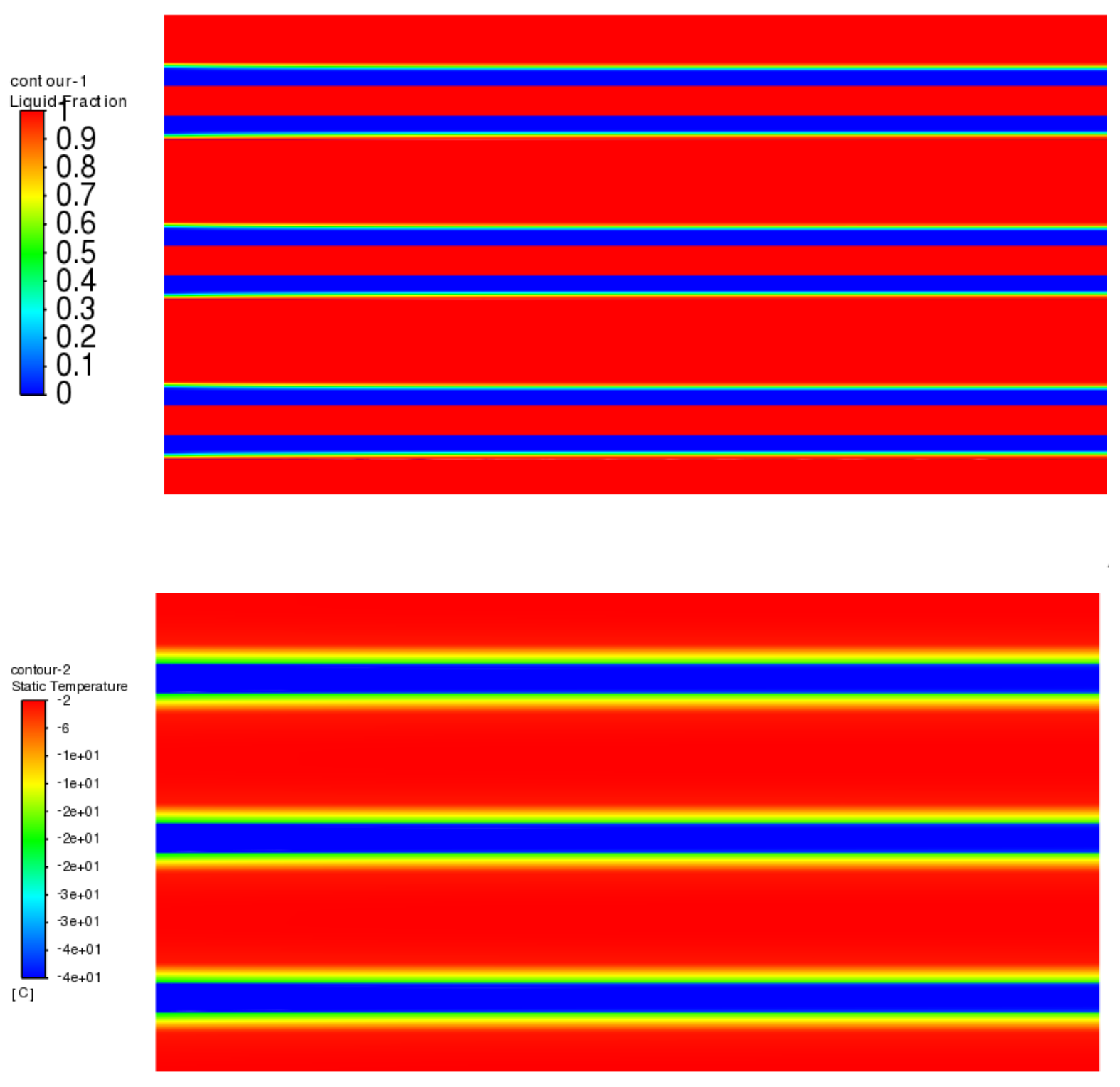

Fig. 4. Step 2 - Solidification and temperature profiles (1)

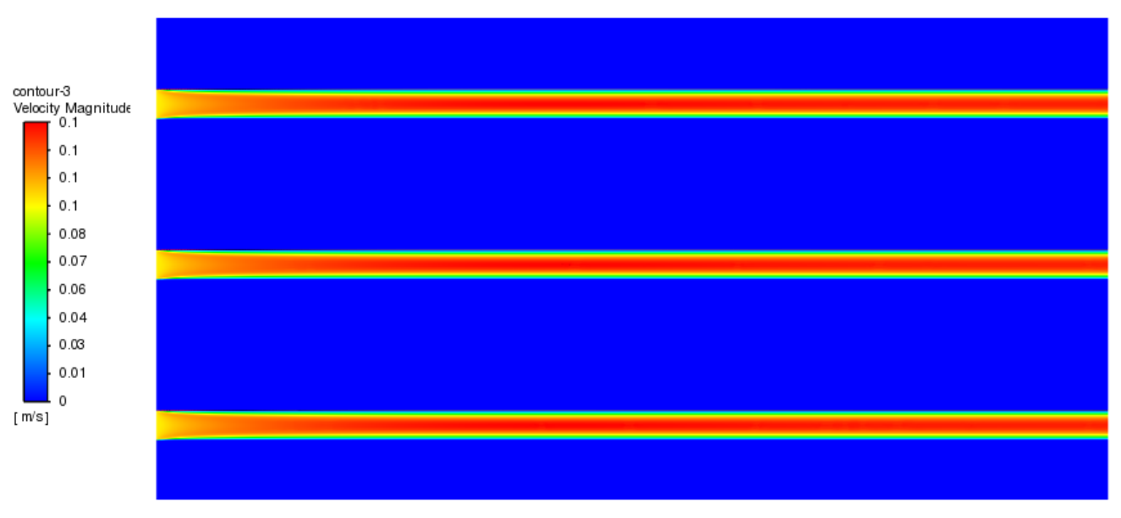

Fig. 5. Velocity profile (1) of HTF

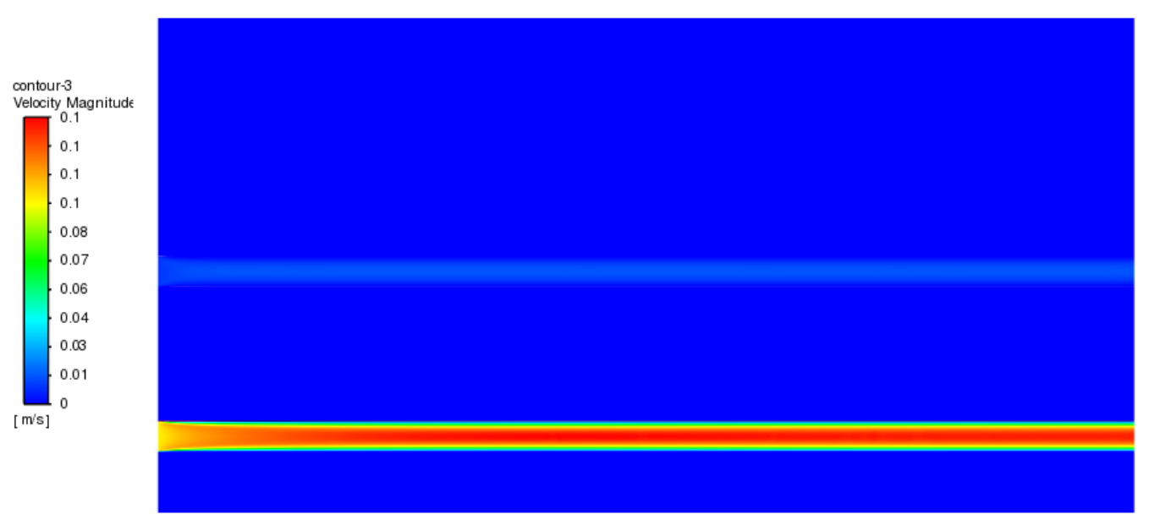

Fig. 6. Velocity profile (2) of HTF

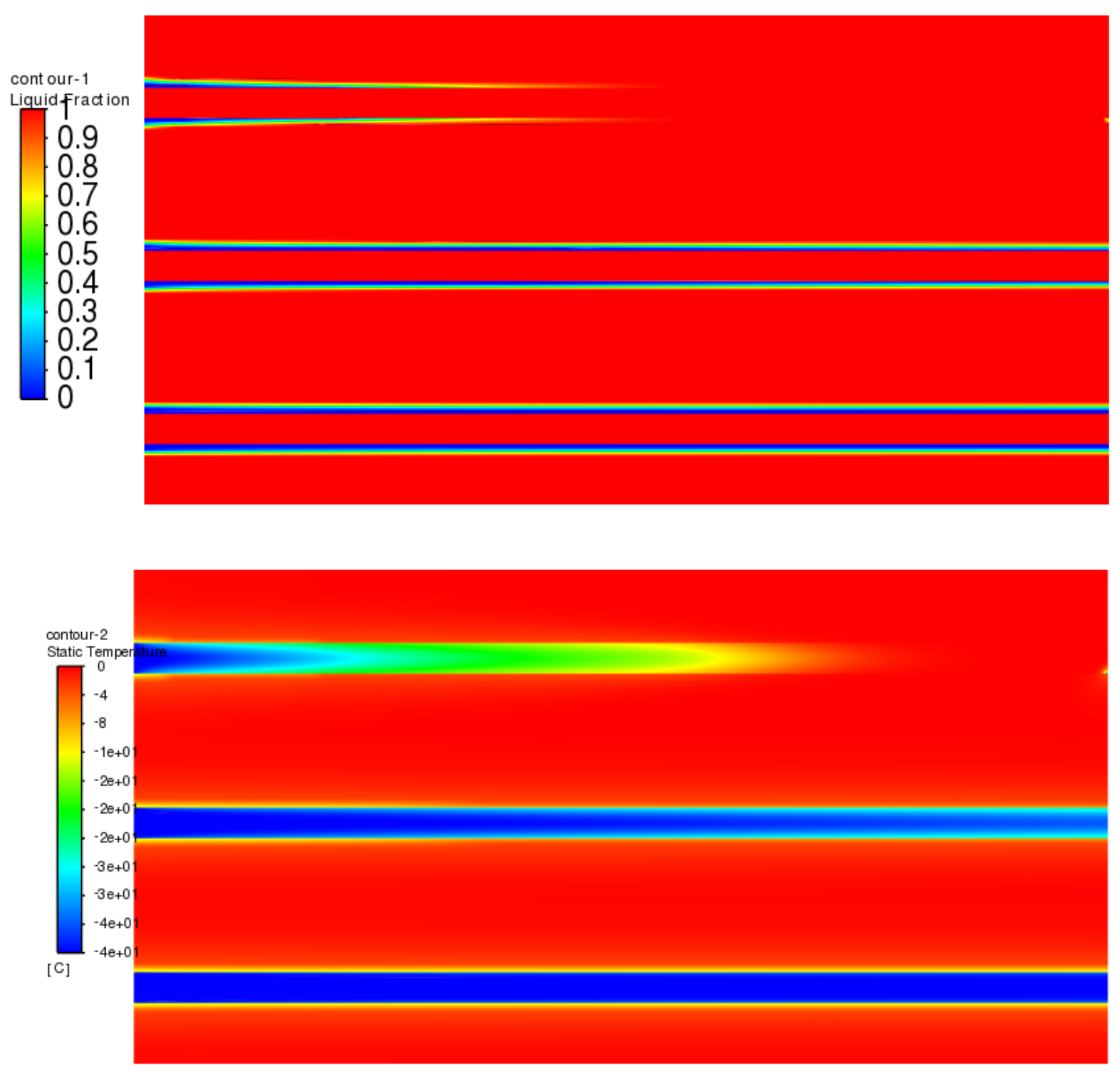

Fig. 7. Step 1 - Solidification and temperature profiles (2)

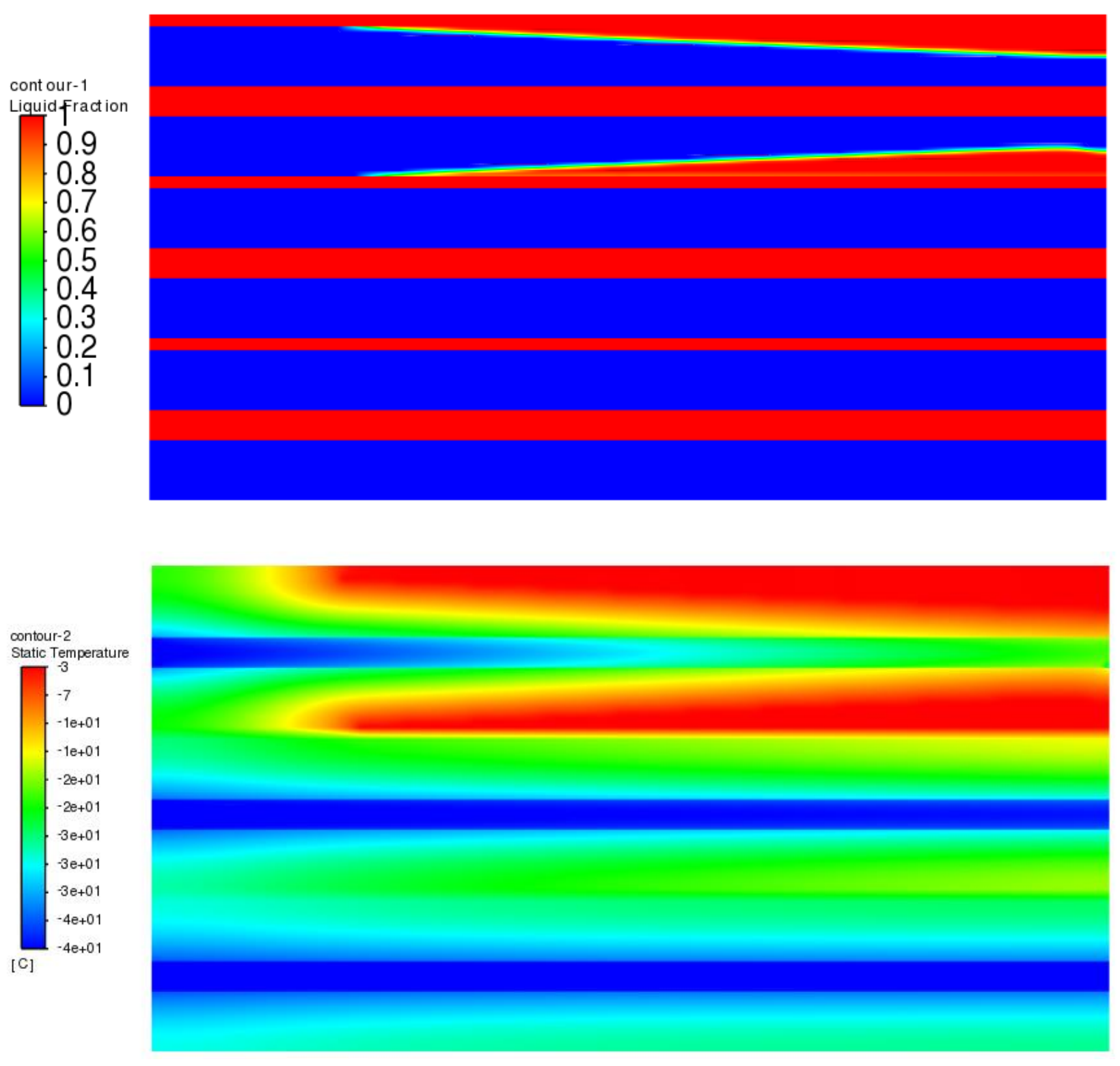

Fig. 8. Step 2 - Solidification and temperature profiles (2)

Conclusions

- It has been found that the air cushion for the volume change of PCM in macroencapsulation containment could play a significant role as an isolator in the heat transfer between EPCMs along with the vertical direction.
- Differences in mass flow rate in different EPCMs could create a non-uniform temperature profiles in some areas of latent heat storage tank and in consequence it could have influence on the effectiveness of its charging/discharging process.
- The proposed EPCMs group-based cold accumulation system's modularity makes increasing its cooling capacity, using individual design solutions straightforward; this may be important for entities with a limited assembly space.

Acknowledgements

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