Simulation of PCM-Saturated Porous Solid Matrix for Thermal Energy Storage using the Phase-Field Method

PhD Abdel Hassan Sweidan, PhD Yousef Heider, Prof. Bernd Markert
Institute of General Mechanics, RWTH Aachen University

In the underlying research project, a latent heat storage medium using a PCM-saturated highly conductive porous metal matrix is being studied. High porosity cellular metal foams are believed to be a promising material for enhancing the heat transfer performance of the PCMs due to their high surface area to volume ratio, ultra-light weight and relatively high thermal conductivity [1-2]. The heat transfer between the solid material and the PCM as well as the flow of the liquid PCM in the voids is modeled based on the volume-averaging method (macroscopic approach), taking into consideration the effect of natural convection and thermal expansion. The system is modeled using the finite element method, where the phase-field method (PFM) is employed to account for the phase change process. The PFM relies on the specification of the free energy density function and employs a phase-field variable that defines the states of the material (solid or liquid) [3], where it is considered a reliable method to simulate phase change problems on the macro scale.

References

[1] P. Zhang, X. Xiao, Z.W. Ma. A review of the composite phase change materials: Fabrication, characterization, mathematical modeling and application to performance enhancement. Applied Energy (2016) 472-510.

[2] Y. Zhao, C. Y. Zhao, Z. G. Xu, and H. J. Xu. Modeling metal foam enhanced phase change heat transfer in thermal energy storage by using phase field method. International Journal of Heat and Mass Transfer (2016) 170–181.

[3] W. J. Boettinger, J. A. Warren, C. Beckermann, A. Karma. Phase-Field Simulation of Solidification. Annual Review of Materials Research (2010) 163-194.