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Thermal energy storage control using phase change materials in a rectangular energy storage chamber with metal foam gradient and magnetic field

Somayeh Davoodabadi Farahani [a], Amir Davoodabadi Farahani [a], As'ad Alizadeh [b]

[a] School of Mechanical Engineering, Arak University of Technology, 38181-41167 Arak, Iran
[b] Department of Civil Engineering, College of Engineering, Cihan University-Erbil, Erbil, Iraq

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Abstract

Considering the low thermal conductivity of phase change materials (PCM) and the slowness of the melting process in the thermal energy storage chamber (TESC), a comprehensive study on the use of magnetic field and porous foam gradient in the phase change process of PCM in a rectangular chamber with a cylinder is presented. The numerical solution is done using the finite volume method. PCM, metal foam and nanoparticles are respectively lauric acids, aluminum and iron oxide. Porosity coefficient changes have been examined in the positive and negative directions of the coordinate axes during melting and compared to a uniform porosity coefficient in the common case. As a result of a constant magnetic field, melting does not take place as much, but when a non-uniform magnetic field is used, the process of melting in the TESC increases by about 35 times, and the intensity of the magnetic field can be used between 0.025 and 0.05 mT. The average thawing fraction of the PCM has augmented by 5.046, 6.86, 7.66 and 7.819%, respectively, compared to the no-field. The metal foam gradient has an imperative efficacy in enhancing the process of melting and up to about 97% reduces melting time. When the porosity coefficient is higher near the active wall, the heat transfer and liquifying are quicker. In the chamber, temperature changes of the cylinder can have a momentous efficacy on the thawing process. The greatest effect is observed when the changes of cylinder temperature with time are stepwise. The sensitivity analysis was done based on the Sobol method, which shows that the porosity coefficient has the greatest effect on the melting rate.