NUMERICAL SIMULATION OF THERMAL ENERGY STORAGE WITH PHASE CHANGE MATERIAL AND ALUMINUM FOAM

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A Latent Heat thermal energy storage system (LHTESS) is employed as a thermal buffer, since it avoids the intermittent supply of thermal energy due to the behaviour of the thermal source, in particular the renewable thermal source like the solar radiation. Therefore a LHTESS allows supplying the thermal energy in continuous way. The principal material of a LHTESS is the phase change material (PCM) given that it storages a high quantity of thermal energy during its phase change process thanks to the high value of latent heat. Moreover the thermal energy is stored at quasi-constant temperature because during the phase change process the heat is engaged to change phase and not to raise the temperature [1].

A numerical investigation on Latent Heat Thermal Energy Storage System (LHTESS) based on a phase change material (PCM) is accomplished. The PCM used is a pure paraffin wax with melting over a range of temperature and a high latent heat of fusion. However, its thermal conductivity is very low (about 0.2 W/K m) and a method to enhance the heat transfer is putting the PCM into an aluminum metal foam. The geometry of the system under investigation is a vertical shell and tube LHTES made with two concentric aluminum tubes. The internal surface of the hollow cylinder is assumed at a constant temperature above the melting temperature of the PCM to simulate the heat transfer from a hot fluid. The other external surfaces are assumed adiabatic or with heat losses toward the external ambient at assigned temperature. A numerical model is employed to simulate the behavior of the PCM embedded with the metal foam. The phase change of the PCM is modelled with the enthalpy porosity theory while the metal foam is considered as a porous media that obeys to the Darcy-Forchheimer law.

The results show that at high porosity the LTE and LTNE models have the same melting time while at low porosity the LTNE has a larger melting time. Moreover, the presence of metal foam improves significantly the heat transfer in the LHTES giving a very faster phase change process with respect to pure PCM, reducing the melting time more than one order of magnitude. In addition, this numerical model can be further enlarged to simulate different types of metal foam and PCM. The momentum equations are modified by adding of suitable source term which it allows to model the solid phase of PCM and natural convection in the liquid phase of PCM. Local thermal non-equilibrium (LTNE) model is assumed to analyze the metal foam and some comparisons are accomplished with the local thermal equilibrium model assumption. The governing equations are solved employing the Ansys-Fluent 15 code and verification and validation analysis are accomplished. Numerical simulations for PCM, PCM in the porous medium in LTE and in LTNE assumptions are obtained and their results are compared in terms of melting time and temperature fields. Results as a function of time for the charging phase are carried out for different porosities and assigned pore per inch (PPI).