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NUMERICAL SIMULATION OF SOLIDIFICATION OF NANOPARTICLE-ENHANCED PHASE CHANGE MATERIALS (NEPCM) CONSIDERING TRANSPORT OF SUSPENSIONS

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ABSTRACT: Nanoparticle-enhanced phase change materials (NEPCM) were proposed recently as alternatives to conventional phase change materials due to their enhanced thermophysical properties. In this study, for the first time, the effect of the mass transfer of the nanoparticles on the morphology of the solid-liquid interface and evolving concentration, during solidification has been reported. The numerical method that has been used was based on the one-fluid-mixture model. The model takes into account the thermal as well as the solutal convection effects. A square cavity was used in the simulation. The NEPCM was composed of a suspension of copper nanoparticles in water and it was solidified from the bottom. The temperature difference between the hot and cold sides was 5 degrees centigrade and the loadings of the nanoparticles that have been used in the simulation were 5%, and 10% by mass. The results obtained from the model were compared with those existing in the literature and the comparison was satisfactory. The solid-liquid interface for the case of NEPCM with 10 wt% of nanoparticles evolved from a planar shape at the beginning of the solidification process to a dendritic shape as the solidification process proceeds in time. This was attributed to the constitutional supercooling effect. Cells of thermal-solutal convection in the space between dendrites were developed due to the rejection of nanoparticles from the freezing front.