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NUMERICAL ANALYSIS OF NATURAL CONVECTION MELTING IN A SQUARE CAVITY WITH A HEAT-GENERATING SOURCE

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ABSTRACT

Nowadays, development of modern electronic devices, energy apparatus, and thermal insulation of buildings demands a creation of effective cooling systems. Therefore, a usage of phase change materials (PCM) for the abovementioned purpose has essential advantages against conventional materials. It should be noted that PCM have large latent heats of fusion at a constant temperature. At the same time, PCM release or gain isothermal energy during phase transitions and have a heat storage capacity about 5 to 14 times higher than the conventional thermal storage materials. Phase change materials have wide engineering applications including not only electronic cooling technology and thermal comfort in dwellings but also waste heat recovery; textiles; heating, ventilation and air conditioning; and thermal energy storage (containers for temperature sensitive food, isothermal water bottles, medical devices). The objective of the present work is a numerical simulation of 2D unsteady melting driven by natural convection in a square cavity with a local heater of constant heat-generation.

We consider a square cavity with a square heat source of constant heat-generation mounted on the bottom wall. At the beginning of the process the domain of interest is filled with PCM in solid state having fusion temperature. Two opposite vertical walls of the cavity have a low constant temperature. The horizontal walls are supposed to be adiabatic. Melt, formed during the process, is assumed to be incompressible and radiatively non-participating, with the change in density being incorporated through the Boussinesq approximation. It is supposed in the analysis that the local heater is a heat-generating and heat-conducting solid block, and the flow is laminar. The melt motion and heat transfer in the cavity are assumed to be two-dimensional. The melt flow and heat transfer considered inside the enclosure are described mathematically by 2D Navier-Stokes equations, including the energy equation for the melt writing using the enthalpy formulation. The heat conduction inside the heat source is governed by the unsteady two-dimensional heat conduction equation with a source term. The mathematical model written in dimensionless stream function, vorticity and temperature has been solved using a finite difference method. The distributions of velocity and temperature fields describing essential features of the investigated phenomenon have been obtained.

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