Solidification Coupled to Turbulent Air Flows in Housing and Foundry Applications

Nelson O. Moraga*

* Departamento de Ingeniería Mecánica
Universidad de La Serena
Benavente 980, La Serena, Chile
e-mail: nmoraga@userena.cl

ABSTRACT

Many industrial applications include liquid to solid phase transformations inside containers that are coupled to external turbulent flows of air with either forced or natural convective heat transfer [1]. In this paper two coupled problems are solved, one related to foundry [2] and the second one to solar energy. In the first case, the natural convection and solidification of a binary Al-Si alloy inside a mold located in a horizontal channel coupled to the surrounding forced turbulent flow of air is described. The effect of the air Reynolds number on the fluid mechanics and heat transfer in the phase change material, is studied for Re= 5,000, 10,000 and 22,000 along the turbulent forced convection in the air. The second problem considers the attenuation of air temperature in a house during a day and night cycle by the use of paraffin as a phase change material located inside two vertical walls and in the roof of a house. Boundary conditions incorporate the evolution of solar irradiation, external wind velocity and external air temperature during the 24 hours of the analysis. Unsteady heat transfer in the walls is coupled to natural convection and phase-change inside the walls and in the roof that are coupled to the turbulent natural convection of air inside the room. Mathematical modeling for fluid dynamics and heat transfer is expressed in terms of primitive variables by continuity, linear momentum and energy equations. Turbulence in air flows is calculated by using the κ-ε model. Liquid to solid phase change is accounted for by either the use of the Carman-Kozeny approach or by a temperature dependent liquid phase fraction. The finite volume method with staggered grids and dynamic time step is used to solve the discretized model with sequential implicit procedures. Results for the evolution in time of velocity and temperature in the air are presented and discussed along those for the streamlines and isotherms in the phase change materials.

ACKNOWLEDGMENTS

The support provided by CONICYT-Chile to the FONDECYT 1140074 project is acknowledged.

REFERENCES

[1] C.E. Zambra, C. Rosales, N.O. Moraga, M. Ragazzi, "Self-heating in a bio-reactor: coupling of heat and mass transfer with turbulent convection", *International Journal of Heat and Mass Transfer*, Vol. **54**, pp. 5077-5086, (2011).

[2] C. Salinas, D. Vasco, N.O. Moraga, "Two dimensional non-Newtonian injection moulding with a new Control Volume FEM / Volume of Fluid", *International Journal for Numerical Methods in Fluids,* Vol. **71**, pp. 1509-1523, (2013).