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Chapter 4

An experimental study of a phase change storage system

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Abstract

This paper describes the heat transfer process and the movement of the solid-liquid interface when the energy is added to a PCM, paraffin wax, through a vertical wall heated under conditions of uniform heat flux and constant temperature. Experiments indicate that the initial mode of heat transfer in the melting process was purely conduction controlled, and early convection due to volumetric expansion of the liquid PCM was followed by the solely buoyancy driven natural convection within the liquid. At this stage, the superheating of the liquid led to a combined convection and conduction mode of heat transfer until eventually conduction became the dominant mode of heat transfer. Superheating and subcooling of the PCM reduce the rate of propagation of the solid-liquid interface. Numerical simulation, based on the enthalpy formulation, indicated the presence of convection in the fluid region of the PCM, which is confirmed by the results from the experiments.

Keywords: Phase change materials, latent heat storage, heat transfer processes, melt profiles

INTRODUCTION

Melting and freezing are frequently encountered in the present technology of casting and metallurgical processes, cryogenic preservation of blood, biomaterials, and thermal energy storage systems. Among these possible applications, interest has been on the use of latent heat solar walls in passive solar heating of homes (Lane, 1980). In the early studies, Carslaw and Jaeger (1959) concluded that conduction alone played the vital part in melting of the PCM. Subsequently, experimental evidence produced by Sparrow et al.(1978), and Viskanta and Bathelt (1980) indicated that conduction was present only in the initial stages of the melting while natural convection within the melt region has a greater influence on the shape and the motion of the solid-liquid interface. Hamdan (1996) further analysed that during the convection mode of heat transfer, heat is transferred across the hot boundary layer at the heated wall and the cold boundary layer at the solid-liquid interface. Numerical analysis by Bejan (1989) shed light on the effect of superheating on the melting