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MELTING AND FREEZING IN A FINITE SLAB DUE TO A LINEARLY DECREASING FREE-STREAM TEMPERATURE OF A CONVECTIVE BOUNDARY CONDITION

ABSTRACT

One-dimensional melting and freezing problem in a finite slab with time-dependent convective boundary condition is solved using the heat-balance integral method. The temperature, T_{inf} 1(t), is applied at the left face and decreases linearly with time while the other face of the slab is imposed with a constant convective boundary condition where T_{inf} 2 is held at a fixed temperature. In this study, the initial condition of the solid is subcooled (initial temperature is below the melting point). The temperature, T_{inf} 1(t) at time t = 0 is so chosen such that convective heating takes place and eventually the slab begins to melt (i. e., T_{inf} 1 (0) > Tf > T_{inf} 2). The transient heat conduction problem, until the phase-change starts, is also solved using the heat-balance integral method. Once phase-change process starts, the solid-liquid interface is found to proceed to the right. As time continues, and T_{inf},1(t) decreases with time, the phase-change front slows, stops, and may even reverse direction. Hence this problem features sequential melting and freezing of the slab with partial penetration of the solid-liquid front before reversal of the phase-change process. The effect of varying the Biot number at the right face of the slab is investigated to determine its impact on the growth/recession of the solid-liquid interface. Temperature profiles in solid and liquid regions for the different cases are reported in detail. One of the results for Biot number, Bi2 = 1.5 are also compared with those obtained by having a constant value of T_{inf} 1(t).

KEYWORDS

finite slab, melting, freezing, heat balance integral, time-dependent, convection

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