Preface

Heat transfer problems involving melting/solidification are generally referred to as "phase-change"or "moving boundary problems". The study of moving boundary problems are important in many engineering applications such as making of ice, the freezing of food, the solidification of metals in casting, crystal growth, thermal energy storage etc. The solution of such problems is difficult because the interface between solid and liquid phase is moving and also it has to be determined as a part of the solution. Therefore, the study of such type problem is challenging and an interesting in heat transfer engineering. In any realistic problem resort must be made to numerical technique. The choice of the method is influenced by various factors, apart from the problem itself, such as the development of more powerful numerical technique for solving the problems and the computing facilities available. The wavelet based numerical methods require less computational work and providing better result.

In this study, the authors have attempted the models of moving boundary problems arising during melting or freezing, solved them using wavelet based numerical methods and analysed the obtained results. The thesis comprises five chapters including an introductory chapter which primarily attempts to offer broad foreground to study our problem by providing the fundamentals of physical phenomena and literature survey relevant to the proposed problems. Some basic definitions of mathematical methodology are also given in this chapter.

In Chapter 2, we proposed a mathematical model describing the inward solidification of melt of phase change material within a container of different geometrical configuration like slab, circular cylinder or sphere under the most generalized boundary conditions. The thermal and physical properties of melt and solid are assumed to be identical. To solve this mathematical model, the finite difference scheme is used to convert the problem into an initial value problem of vector matrix form and further, solving it using Legendre wavelet Galerkin method. The results thus obtained are analyzed by considering particular cases when one might impose either a constant/time varying temperature or a constant/time varying heat flux or a constant heat transfer coefficient on the surface. The effect of variability of shape factor, condition posed at the boundary, Stefan number, Predvoditelev number, Kirpichev number and Biot number on dimensionless temperature and solid-layer thickness have been shown graphically. Furthermore, a comparative study of time for complete solidification is presented.

In Chapter 3, we have studied the two phase moving boundary problem arising during melting/freezing of a melt in a semi-infinite region. In both solid-liquid regions we assumed that the physical properties such as thermal conductivity and specific heat are different and temperature dependent and their densities are also different in both regions. To solve this problem we used wavelet Galerkin and wavelet collocation method. The results thus obtained are compared with exact solution when thermal conductivity and specific heat are temperature independent and the agreement is excellent. The whole analysis is presented in dimensionless form. The effect of variability of thermal conductivity, specific heat with temperature, ratio of thermal conductivity of two regions, ratio of densities of two regions, Stefan number on solid layer thickness are analyzed and discussed.

In Chapter 4, we have developed the time relaxation model for solidification of a binary eutectic system. In this model, we have considered the melt of binary eutectic composite filled in container and the flat probe is kept inside the container. The surface temperature of flat probe decreases linearly with time. The solidification process is occurred in three stages and whole region is divided into solid, mushy and liquid region. The heat released in mushy region is considered as discontinuous heat generation. The solid fraction present in mushy region is characterized by two different ways: (i) when solid fraction depends on distance (ii) when solid fraction depends on temperature. To solve this model we have developed the Legendre wavelets spectral Galerkin method. The whole analysis is presented in a dimensionless form and the results, thus obtained are discussed in detail.

Chapter 5 deals with a mathematical model for two dimensional moving boundary problems arising during melting of solid whose one surface is kept under most generalized boundary conditions and other two surfaces are insulated. The particular cases when surface subjected to the boundary condition of first, second and third kinds are discussed in detail. For validity of the present method, we have been plotted graphs between residuals (obtained from original differential equation and its associated boundary conditions) and x axis, and found the effect of error on moving layer thickness and y coordinate respectively. Further, the effect of Predvoditelev number, Kirpichev number, Biot number on moving layer thickness are analyzed and discussed in details. The whole analysis is presented in a dimensionless form.