The Stefan Problem

The Classical Stefan Problem: Basic Concepts, Modelling and Analysis with Quasi-Analytical Solutions and Methods, New Edition, provides the fundamental theory, concepts, modeling, and analysis of the physical, mathematical, thermodynamical, and metallurgical properties of classical Stefan and Stefan-like problems as applied to heat transfer problems with phase-changes, such as from liquid to solid. This self-contained work reports and derives the results from tensor analysis, differential geometry, non-equilibrium thermod physics, and functional analysis, and is thoroughly enriched with many appropriate references for in-depth background reading on theorems. Each chapter in this fully revised and updated edition begins with basic concepts and objectives, also including direction on subject matter was developed. It contains more than 400 pages of new material on quasi-analytical solutions and methods of classical Stefan and Stefan-like problems.The book aims to bridge the gap between the theoretical and solution aspects of the afore-mentio problems. Provides both the phenomenology and mathematics of Stefan problems Bridges physics and mathematics in a concrete and readable manner Presents well-organized chapters that start with proper definitions followed by explanations and references for fu reading Includes both numerical and quasi-analytical solutions and methods of classical Stefan and Stefan-like problems

An algorithm is proposed for solving one-dimensional free boundary problems with change of phase. The technique consists of solving the heat equation in progressively increasing rectangles whose size is controlled by the Stefan condition. Convergence of the sche shown and an estimate of the rate of convergence is given. (Author).

Pluses and Minuses

A Fast Marching Level Set Method for the Stefan Problem

The Stefan Problem with a Convective Boundary Condition

From Additive Manufacturing to Polar Ice

Translations of Mathematical Monographs

This monograph introduces breakthrough control algorithms for partial differential equation models with moving boundaries, the study of which is known as the Stefan problem. The algorithms can be used to improve the performance of various processes with phase changes, such as additive manufacturing. Using the authors' innovative design solutions, readers will also be equipped to apply estimation algorithms for real-world phase change dynamics, from polar ice to lithium-ion batteries. A historical treatment of the Stefan problem opens the book, situating readers in the larger context of the area. Following this, the chapters are organized into two parts. The first presents the design method and analysis of the boundary control and estimation algorithms. Part two then explores a number of applications, such as 3D printing via screw extrusion and laser sintering, and also discusses the experimental verifications conducted. A number of open problems and provided as well, offering readers multiple paths to explore in future research. Materials Phase Change PDE Control & Estimation is ideal for researchers and graduate students working on control and dynamical systems, and particularly those studying partial differential equations and moving boundaries. It will also appeal to industrial engineers and graduate students in engineering who are interested in this area.

Methods for Solving 1D Stefan Problems with Application to Contact Melting

Inverse Stefan Problems

Analysis of Numerical Solution of the Stefan Problem

Basic Concepts, Modelling and Analysis

The aim of the series is to present new and important developments in pure and applied mathematics. Well established in the community over two decades, it offers a large library of mathematics including several important classics. The volumes supply thorough and detailed expositions of the methods and ideas essential to the topics in question. In addition, they convey their relationships to other parts of mathematics. The series is addressed to advanced readers wishing to thoroughly study the topic. Editorial Board Lev Birbrair, Universidade Federal do Cear á , Fortaleza, Brasil Victor P. Maslov, Russian Academy of Sciences, Moscow, Russia Walter D. Neumann, Columbia University, New York, USA Markus J. Pflaum, University of Colorado, Boulder, USA Dierk Schleicher, Jacobs University, Bremen, Germany

Abstract: "This paper discusses a generalized Stefan problem which allows for supercooling and superheating and for capillarity in the interface between phases. Simple solutions are obtained indicating the chief differences between this problem and the classical Stefan problem. A weak formulation of the general problem is given."

The Stefan Problem

Approximation Techniques for the Stefan Problem

Computer Analysis of the Stefan Problem in Cryosurgery

A Stable Time Discretization of the Stefan Problem with Surface Tension

A guide to changing how you think about numbers and mathematics, from the prodigy changing the way the world thinks about math. We all know math is important: we live in the age of big data, our lives are increasingly governed by algorithms, and we're constantly faced with a barrage of statistics about everything from politics to our health. But what might be less obvious is how math factors into your daily life, and what memorizing all of those formulae in school had to do with it. Math prodigy Stefan Buijsman is beginning to change that through his pioneering research into the way we learn math. Plusses and Minuses is based in the countless ways that math is engrained in our daily lives, and shows readers how math can actually be used to make problems easier to solve. Taking readers on a journey around the world to visit societies that have developed without the use of math, and back into history to learn how and why various disciples of mathematics were invented, Buijsman shows the vital importance of math, and how a better understanding of mathematics will give us a better understanding of the world as a whole. Stefan Buijsman has become one of the most sought-after experts in math education after he completed his PhD at age 20. In Plusses and Minuses, he puts his research into practice to help anyone gain a better grasp of mathematics than they have ever had.

A certain model of one-dimensional detonation waves leads to a Stefan problem: the unknown f satisfies Burgers equations on the two sides of a moving discontinuity at which it is given (f, say) and the jump in it derivative (corresponding to the exothermic reaction) is prescribed. An alternative formulation of the problem can be obtained by means of the Hopf-Cole transformation, which replaced the Burgers equations by diffusion - type equations. The problem possesses a steady solution, the discontinuity moving with constant speed and f depending only on distance from it. This solution is stable for a range of the parameter f, and unstable otherwise, as was shown at the First Army Conference, when preliminary results on the subsequent evolution of the instability were presented. The instability has now been reexamined, using three computation schemes on each of the two formulations of the problem, resulting in the more definite conclusions presented here. (Author).

The Stefan problem, by L.I. Rubenstein

Basic Concepts, Modelling and Analysis with Quasi-Analytical Solutions and Methods

Local Existence and Uniqueness of Solutions of the Stefan Problem with Surface Tension and Kinetic Undercooling

The Stefan Problem in a Concentrated Capacity

The Stefan problem describes the change in temperature distribution with respect to time in a medium undergoing phase change. In this thesis we provide a unique combination of established numerical techniques to solve the single phase Stefan problem in two dimensions. For this purpose it is necessary to solve the heat equation and to track the location of the free boundary as it moves. We define the finite difference method for approximating the solution to partial differential equations which forms the basis for our computations and a collection algorithms using finite difference approximations that we use to find the solution. To track the free boundary we use a level set method, combined with a fast marching method to determine the velocity with which the boundary will move according to the Stefan condition. The heat equation is solved with a second order accurate implicit approach.

My thesis focuses on the evolution of the solid-liquid interface during melting and solidification in a material with constant internal heat generation and prescribed heat flux at the boundary in a cylinder. A phase change process in which a material transitions between two phases, solid and liquid, is known as a Stefan moving boundary problem. We assume that the internal heat generation is constant and the same in both phases. The material properties in both phases are also taken to be constant and equal. We assume that the heat is transferred only by conduction and we neglect convection in the liquid phase. In addition, we assume that there is a sharp interface between two phases where the phase changes at a single melting temperature and there is no mushy zone at the interface. The presence of the internal heat generation makes the problem nonhomogeneous. Starting from the heat conduction equation, the approach finds steady-state and transient temperature solutions in each phase and employs the separation of variables technique to nd transient solutions. A nonlinear first-order differential equation with Fourier-Bessel series terms is derived for the time-dependent motion of the interface. Analytic solutions for temperature proles in each phase are derived. We do not introduce the Stefan number since there is only one fixed temperature: melting temperature. Instead we introduce dimensionless heat flux at the boundary. The initial value problem is solved numerically, and solutions compared to the previously derived quasi-steady ones. It is shown that when the internal heat generation and the heat flux at the boundary have a close range of values, it takes longer for the front to reach steady state than when the values are farther apart. As the difference between the internal heat generation and the flux increases, the transient solution becomes more dominant and the numerical solution of the phase change front does not reach steady-state before the outer boundary or centerline is reached. This shows that the prescribed heat flux can be used as a parameter that controls the motion of the interface. The problem has applications for a nuclear fuel rod during meltdown.

An Algorithm for the One-Phase Stefan Problem

Materials Phase Change PDE Control & Estimation

How Math Solves Our Problems

Optimal control for the Stefan problem

This bachelor thesis deals with the Stefan problem, from its historical background to the existence and uniqueness of solution to the problem. The physical background is presented at the beginning. Afterwards there are presented some results related to the problem, like explicit solutions and an analysis of the technique for obtaining solutions to the problem by perturbation methods. Also the theoretical development and mathematical formulation of supercooled Stefan problems is included in this part. Finally, results on existence and uniqueness for the Stefan problems are shown. In particular, the cases treated here are the ones concerning small and large times, both for Dirichlet boundary conditions, and Neumann boundary conditions for small times.

The Stefan ProblemWalter de Gruyter

An Introduction

The Stefan Problem with Surface Tension in the Three Dimensional Case with Spherical Symmetry: Non-existence of the Classical Solution

Numerical Analysis of a Stefan Problem

Exact solutions of the Stefan problem

In this monograph the theory and methods of solving inverse Stefan problems for quasilinear parabolic equations in regions with free boundaries are developed. The study of this new class of ill-posed problems is motivated by the needs of the mod eling and control o processes with phase transitions in thermophysics and mechanics of continuous media. Inverse Stefan problems are important for the perfection of technologies both in high temperature processes (e.g., metallurgy, the aircraft industry, astronautics and power engin hydrology, exploitation of oil-gas fields, etc. The proposed book will complete a gap in these subjects in the preceding re searches of ill-posed problems. It contains the new theoretical and applied studies of a wide class of inverse Stefan problems. The statements of the determination of boundary functions and coefficients of the equation are considered for different types of additional information about their solution. The variational method of obtaining stable approximate solutions is proposed and established. It is implemented b computational scheme of descriptive regularization. This algorithm utilizes a priori knowledge of the qualitative structure of the sought solution and ensures a substantial saving in computational costs. It is tested on model and applied problems in nonlinear thermophy particular, the results of calculations for important applications in continuous casting of ingots and in the melting of a plate with the help of laser technology are presented.

This volume emphasises studies related to classical Stefan problems. The term "Stefan problem" is generally used for heat transfer problems with phase-changes such as from the liquid to the solid. Stefan problems have some characteristics that are typical of them problems arising in fields such as mathematical physics and engineering also exhibit characteristics similar to them. The term ``classical" distinguishes the formulation of these problems from their weak formulation, in which the solution need not possess classical de suitable assumptions, a weak solution could be as good as a classical solution. In hyperbolic Stefan problems, the characteristic features of Stefan problems are present but unlike in Stefan problems, discontinuous solutions are allowed because of the hyperbolic na equation. The numerical solutions of inverse Stefan problems, and the analysis of direct Stefan problems are so integrated that it is difficult to discuss one without referring to the other. So no strict line of demarcation can be identified between a classical Stefan probl similar problems. On the other hand, including every related problem in the domain of classical Stefan problem would require several volumes for their description. A suitable compromise has to be made. The basic concepts, modelling, and analysis of the classical S have been extensively investigated and there seems to be a need to report the results at one place. This book attempts to answer that need.

The Stefan Problem with Small Surface Tension

The Stefan Problem with Kinetic Condition at the Free Boundary

Disappearance of Phase in the Stefan Problem: One Space Dimension

Contact melting is the process during which a phase change material is placed in contact with a substrate that is at a temperature above the phase change temperature. This leads to melting of the phase change material and a °owing liquid layer which is being squeezed out due to the weight of the solid pushing down upon it. This process arises in many engineering problems such as the production of construction materials and alloys. Other uses include thermal storage systems that rely on the storage of energy as latent heat, which is released upon melting. The mathematical modelling of contact melting involves two heat equations, one in the solid and one in the liquid phase, coupled with the Navier-Stokes equations for the °ow in the melt, a Stefan condition at the phase change interface and a force balance between the weight of the solid and the countering pressure in the melt. Consequently, in this thesis we will deal with the one dimensional heat equation and move on to the problem commonly known as the Stefan problem - or moving boundary problem. We will consider both one and two phase problems and eventually look at a contact melting problem. The focus of this dissertation is to develop a three dimensional model to describe a contact melting process and to develop and apply an approximation method with minimal error.

Some Historical Notes about the Stefan Problem

The Classical Stefan Problem

One-dimensional Stefan Problems

On the Stefan Problem and Some of Its Generalizations