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Numerical Calculation of Lubrication ——Methods and Programs

润滑数值计算 ——方法与程序

黄平 著

清华大学出版社

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内 容 简 介

本书针对 Reynolds 方程、能量方程和弹性变形方程结合计算方法介绍实用计算程序。前 9 章主要介绍了不同工况下的 Reynolds 方程的数值计算与程序，如：滑块不可压稳态润滑、径向滑动轴承润滑、动载轴承润滑、气体润滑和脂润滑等数值计算方法与程序。第 10、11 章结合能量方程的求解介绍了热流体润滑的数值计算方法与程序。第 12～20 章主要介绍了弹流润滑数值计算与程序，方法是通过对弹性变形方程的计算，结合与 Reynolds 方程以及能量方程的联立求解能量方程等考虑等温、热和脂润滑弹流润滑计算的方法和程序。第 21～24 章介绍了作者针对工程润滑问题开发的一些程序，包括：微型电机人字沟轴承润滑计算程序及其优化设计、磁盘磁头薄膜气体稳态润滑计算及优化设计程序。

本书可供高等学校的相关专业的教师、硕士生、博士生，以及工程技术人员和科研人员使用。

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Preface

Lubrication calculation is the most successful area of tribology, using mathematical methods to obtain numerical solutions. Due to the development of computer science in the recent half a century, it has made remarkable achievements.

However, most books on tribology mainly introduce theories or calculation methods of lubrication. They rarely give and discuss numerical calculation programs. Not only is this inconvenient for research or the production of practical lubrication, but also many similar programming tasks have to be carried out repeatedly. Furthermore, because of the limitations of lubrication theory, some numerical calculation programs may give mistaken solutions, leading to wrong conclusions.

This book is different from previous theoretical books or monographs on lubrication; it mainly introduces the numerical calculation programs of lubrication. This is the main feature of the book. Some of the programs have been used for many years in lubrication calculations and research by the author.

Due to the complexity of lubrication problems, the book mainly focuses on how to numerically solve the Reynolds equation, energy equation, elastic deformation equation and their combinations. The analyzed lubrication problems include line, surface and point contacts, which correspond to thrust bearings, journal bearings and rolling contact bearings. Furthermore, the working conditions include incompressible, compressible, nonthermal, thermal, isoviscosity, variable viscosity, Newtonian fluid, non-Newtonian fluid (only grease), rigid and elastic deformation situations.

The book is divided into four parts, covering 24 chapters:

The first part (Chapters 1–9) is about the solution of the Reynolds equation, which is the basic technique for the numerical analysis of lubrication. The contents include the boundary and connection conditions of the Reynolds equation, discretizing the Reynolds equation, numerical methods and programs of slider lubrication, numerical methods and programs of journal bearing lubrication, numerical methods and programs of dynamic bearing lubrication, numerical methods and programs of gas lubrication (especial magnetic hard disk/head) and so on. In this part, we also discuss the rheology of lubricants. As an example, grease lubrication is discussed, which is a kind of non-Newtonian fluid.

The second part of the book (Chapters 10 and 11) is on temperature calculation. First, we give a discrete form of the energy equation and the temperature–viscosity

equation. Then, combining the Reynolds equation and the energy equation, we give numerical methods and programs of thermal hydrodynamic lubrication.

Elastohydrodynamic lubrication (EHL) is a difficult topic in lubrication calculation, because of its poor convergence. In the third part (Chapters 12–20), calculations of elastic deformation equations for line and point contacts are given first. Then, combined with the Reynolds equation, the pressure–viscosity equation and the elastic deformation equation, calculation programs of EHL are introduced in detail. Furthermore, combined with the energy equation, numerical methods and programs of thermal EHL are given. We also give numerical methods and programs of EHL and thermal EHL for grease in this part, and we consider the rheological effect.

Finally, in the last part of the book (Chapters 21–24), we introduce some programs developed for practical lubrication design. These programs include a lubrication calculation package and its optimized design package for the herringbone groove bearing of a micro motor and a calculation program and balancing attitude program of ultra thin gas lubrication for magnetic hard disk/head design. Because these packages and programs have some special requirements, pre-treatment and post-treatment have been added for easy usage in engineering. Although the basic theories of these contents are introduced at the front of the book, more details about the function and usages of the packages and programs can be found on the Wiley Companion Website: www.wiley.com/go/huang/lubrication.

The reason why we provide all source codes and an attached source code disc for all the programs is that most users need not repeat programming tasks even if they have well mastered the principles of lubrication. Especially, those who are not familiar with lubrication analysis can directly use the programs to carry out lubrication calculation. If some users have enough lubrication knowledge, they can use the programs or need only rewrite the pre-assignment or data sentences to input the different parameters to solve their own lubrication problems more easily. This will bring great convenience for researchers and technical staff in this field.

The book is mainly aimed at teachers, post-graduate students and doctoral students at colleges and universities. It can also be used as a reference book for technical personnel and research staff in engineering.

I would like to thank all of my post-graduate students who participated in the program writing and debugging and the book writing. Among them, I thank Li Ping for Chapters 2 and 3, Sun Zhonghua for Chapters 5 and 6, Niu Rongjun for Chapter 8, Wang Qiliang, Glenn and Liu Ping for Chapters 10 and 11, Wang Yazhen for Chapters 12–14, Yu Mei for Chapters 15 and 19, Lai Tianmao for Chapters 16 and 20, Yao Huaping for Chapters 21 and 22, and Wang Hongzhi for Chapters 23 and 24.

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31 August, 2012

Contents

Part One

Numerical Method for Reynolds Equation