Tackling Turbulent Flows in Engineering

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Preface

As the name implies, this book presents different ways to deal with turbulent flows that are encountered in a wide spectrum of engineering applications. The objective is to provide guidelines to engineers of several disciplines on tackling turbulent flows with the use of minimum possible number of mathematical equations. The present book offers several novelties: it presents (a) engineering aspects of turbulent flows; (b) ways to handle turbulent convective heat transfer applications including both forced and free convections; (c) examples of some important practical situations in which turbulent flows are encountered.

Chapter 1 presents the basics of fluid mechanics and convective heat transfer. This chapter is expected to lay the foundation for understanding the material presented in the remaining chapters of the book. Chapter 2 presents an introduction to turbulent flows. It also describes properties of turbulent flows. Chapter 3 presents characteristics of some important turbulent flows, which include, boundary-layer flows, different types of free-shear flows and flow through a circular pipe. Chapter 4 presents a widely used approach to treat turbulent flows, that is, the use of time-averaged governing equations. It also shows that this approach results in an additional complexity termed as the closure problem. Chapter 5 presents different turbulent models based on the widely used Boussinesq approximation that can be adopted to close the system of time-averaged governing equations. Chapter 6 presents the details of the widely used standard k-ε model and some other two equation models. Chapter 7 presents the physically most rigorous method to handle time-averaged governing equations, that is, Reynolds-stress and scalar flux transport model. Chapter 8 presents another entirely different approach for turbulent flows, which involves a treatment of three-dimensional, instantaneous flow field using direct numerical simulation and large eddy simulation. Chapter 8 also presents different subgrid scale models for large eddy simulation and it also shows why it is difficult to use these two techniques as a design tool for engineering applications. Chapter 9 presents nine examples of turbulent flows from the literature covering a wide range, which include ventilation in buildings, stirred vessels used in chemical industries, heat exchangers, tundish used

in steel industry, particle deposition in a human throat. Chapter 10 presents conclusions and issues related to computational simulation of engineering turbulent flows.

The book is an outcome of my experience with the interesting subject of fluid mechanics in general and turbulence modeling in particular during the past two decades. I started appreciating the complexity of turbulence flows when I joined for Master of Technology degree at Department of Mechanical Engineering, Indian Institute of Science Bangalore and was fortunate of have Professor Jaywant H. Arakeri and Professor J. Srinivasan as my project supervisors. My appreciation continued to get strengthened while I did my Ph.D. at the same institution with the same supervisors. I thank my these two former supervisors and all my teachers at Indian Institute of Science, Bangalore, especially Professor Vijay H. Arakeri, Department of Mechanical Engineering for their excellent teaching.

A major part of this book was written from March 2008 to May 2009 while I was a Professor of Mechanical Engineering at Indian Institute of Technology Guwahati. During this time, I had the opportunity of teaching a related course entitled "Numerical Simulation and Modelling of Turbulent Flows" to B.Tech., M.Tech. and Ph.D. students, mostly from the Department of Mechanical Engineering. I thank all my students who have done this course at Indian Institute of Technology Guwahati. Their active participation in the class discussions helped me effectively understand this subject and improve the presentation of some difficult topics of this book. I thank the administration of Indian Institute of Technology Guwahati and all my former colleagues at Department of Mechanical Engineering for all their help during the book writing. I especially thank my friend and former colleague Professor Anoop Kumar Dass at Indian Institute of Technology Guwahati with whom I had numerous stimulating discussions on this subject during my employment with Indian Institute of Technology Guwahati for nearly 12 years. I thank Mr. Nandan K. Das, Indian Institute of Technology Guwahati for drawing all figures of this book.

I gave finishing touches to this book during my subsequent employment as Professor of Applied Mechanics, Indian Institute of Technology Delhi. I thank the administration of Indian Institute of Technology Delhi for creating a conducive atmosphere to write this book. I especially thank my current Ph.D. student Mr. Rabijit Dutta, who very patiently read the entire manuscript, found several typographical errors and pointed out the need for improvements in presentations at several places in the book.

I thank Springer-Verlag GmbH for readily agreeing to my proposal for this book. I also thank Dr. Christoph Baumann, Editor, Springer-Verlag GmbH, for patiently agreeing to my requests for extension in the submission date and also for promptly responding to my numerous queries.

I thank my wife Meenakshi for her continuous support and encouragement during the entire writing process. This book would not have been possible without her. I also thank my two lovely daughters Rimjhim and Sanya who very patiently tolerated long periods of my absence during weekends and holidays over the last two years. I also thank my parents Dr. Manohar Lal Dewan and Mrs. Sudershan

Dewan for their continuous encouragement and sacrifice towards my education right from my primary school days. I also thank my brother Dr. Deepak Dewan and sisters Dr. Sangeeta Khanna and Dr. Mohini Puri for their support.

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