

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 $k-\varepsilon$ 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 to 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

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Contents

1	Basics of Fluid Mechanics and Convective Heat Transfer	1
1.1	Fluid Properties	1
1.1.1	Viscosity	1
1.1.2	Density	2
1.1.3	Thermal Conductivity	2
1.1.4	Surface Tension	3
1.1.5	Speed of Sound and Mach Number	3
1.1.6	Newtonian and Non-Newtonian Fluids	3
1.2	Treatments and Visualization of Fluid	4
1.2.1	Eulerian and Lagrangian Approaches	4
1.2.2	Streamline, Streakline and Pathline	4
1.2.3	Integral and Differential Treatments	5
1.3	Vorticity and Irrotational Flow	6
1.4	Force, Strain and Stress	7
1.5	Fluid Acceleration	9
1.6	Mass Conservation	9
1.7	Conservation of Linear Momentum	10
1.8	Navier–Stokes Equations	11
1.9	Conservation of Energy	11
1.10	Boundary Conditions	12
1.10.1	No Slip and No Temperature Jump Conditions	12
1.10.2	Inlet and Outlet	13
1.10.3	Interface	13
1.11	Convective Heat Transfer	13
1.12	Examples	15
1.12.1	Flow Normal to an Infinite Circular Cylinder	15
1.12.2	Thermal Boundary-Layer Inside a Heated Circular Tube	17
1.13	Concluding Remarks	18
	References	18

2	Fluid Turbulence	19
2.1	Physical Description	19
2.2	Stability of Laminar Flows	22
2.3	Transition and Onset of Turbulence	22
2.4	Types of Turbulent Flows	23
2.5	Significance of Turbulent Flows and Heat Transfer	24
2.6	Turbulence in the Vicinity of a Solid Wall	25
2.7	Task of a Turbulence Model	28
2.8	Concluding Remarks	29
	References	29
3	Characteristics of Some Important Turbulent Flows	31
3.1	Boundary-Layer Flow Past a Flat Plate	31
3.2	Forced and Free Convections	34
3.3	Simple Free Shear Flows	35
3.4	Circular Pipe and Parallel Plates	38
3.5	Separated Flows	40
3.6	Concluding Remarks	42
	References	42
4	Reynolds-Averaged Governing Equations and Closure Problem.	43
4.1	Types of Reynolds-Averaging	43
4.1.1	Time-Average	44
4.1.2	Spatial-Average	44
4.1.3	Ensemble-Average	44
4.2	RANS and Scalar Equations	46
4.3	Closure Problem	47
4.4	Concluding Remarks	48
	References	48
5	Models Based on Boussinesq Approximation	49
5.1	Boussinesq Approximation	49
5.2	Models Based on Boussinesq Approximation	50
5.2.1	Mixing Length Models	50
5.2.2	One Equation Model	53
5.2.3	Two Equation Models	56
5.3	Limitations of Boussinesq Approximation	56
5.4	Examples	56
5.5	Concluding Remarks	56
	References	57
6	$k-\varepsilon$ and Other Two Equations Models	59
6.1	Introduction	59
6.2	Standard $k-\varepsilon$ Model	59

- 6.3 Exact Transport Equations for k and ε 60
- 6.4 Modelled Transport Equations for k and ε 60
- 6.5 Features of the k - ε Model 62
- 6.6 Boundary Conditions. 62
- 6.7 Treatment of Wall 63
 - 6.7.1 Wall Functions Approach 63
 - 6.7.2 Low Reynolds Number Models 65
- 6.8 Example: Oscillatory Boundary Layers 67
- 6.9 Some Modern Variants of k - ε Model 67
 - 6.9.1 RNG k - ε Model 68
 - 6.9.2 Realizable k - ε Model 68
 - 6.9.3 k - ω Model 69
- 6.10 V2f Model. 70
- 6.11 Shear Stress Transport k - ω Model 72
- 6.12 Other Two Equation Models 73
- 6.13 Modifications to k - ε Model for Buoyancy Driven Flows. 73
- 6.14 Other Modifications 76
- 6.15 Concluding Remarks 77
- References 78

- 7 Reynolds-Stress and Scalar Flux Transport Model 81**
 - 7.1 Introduction 81
 - 7.2 Modeled Equations for Reynolds Stress Transport Model 81
 - 7.2.1 Modeling of Turbulent Transport 82
 - 7.2.2 Modeling of Pressure Strain. 83
 - 7.2.3 Modeling of Dissipation 83
 - 7.3 Exact Transport Equation for Scalar Flux 84
 - 7.4 Boundary Conditions. 84
 - 7.5 Treatment of Solid Walls. 85
 - 7.6 Features of Reynolds-Stress and Scalar Flux Transport Model 86
 - 7.7 Algebraic Stress and Scalar Flux Models. 86
 - 7.8 Examples. 87
 - 7.9 Concluding Remarks. 88
 - References 89

- 8 Direct Numerical Simulation and Large Eddy Simulation 91**
 - 8.1 Introduction 91
 - 8.2 Direct Numerical Simulation 92
 - 8.3 Large Eddy Simulation 93
 - 8.4 Subgrid Scale Models for LES. 95
 - 8.4.1 Smagorinsky SGS Model. 95
 - 8.4.2 Dynamic SGS Model 96
 - 8.4.3 Scale Similarity SGS Model 97

- 8.5 DNS vis-à-vis LES 97
- 8.6 Detached Eddy Simulation and Hybrid Models 97
- 8.7 Treatment of Walls in LES 98
 - 8.7.1 Wall Models That Use Equilibrium Laws 99
 - 8.7.2 Velocity and Temperature TBLE Wall Model 100
- 8.8 Initial, Boundary Conditions and Duration of Computations . . . 102
- 8.9 Concluding Remarks 103
- References 104

- 9 Some Case Studies 105**
 - 9.1 Heat Exchangers 105
 - 9.2 Stirred Vessels 107
 - 9.3 Flow in a Tundish Used in Steel Making 108
 - 9.4 Turbulent Plume 109
 - 9.5 LES and DES of Particle Deposition in a Human Throat 111
 - 9.6 Unsteady Cross Ventilation in Buildings 112
 - 9.7 Effect of Turbulent Prandtl Number on Film Cooling 113
 - 9.8 Flow Over Rough Walls with Suction 114
 - 9.9 Separated Convection Due to Backward Facing Step 114
 - 9.10 Concluding Remarks 114
 - References 115

- 10 Conclusions and Recommendations 117**
 - 10.1 Tackling Turbulence 117
 - 10.2 CFD Issues 119
 - References 119