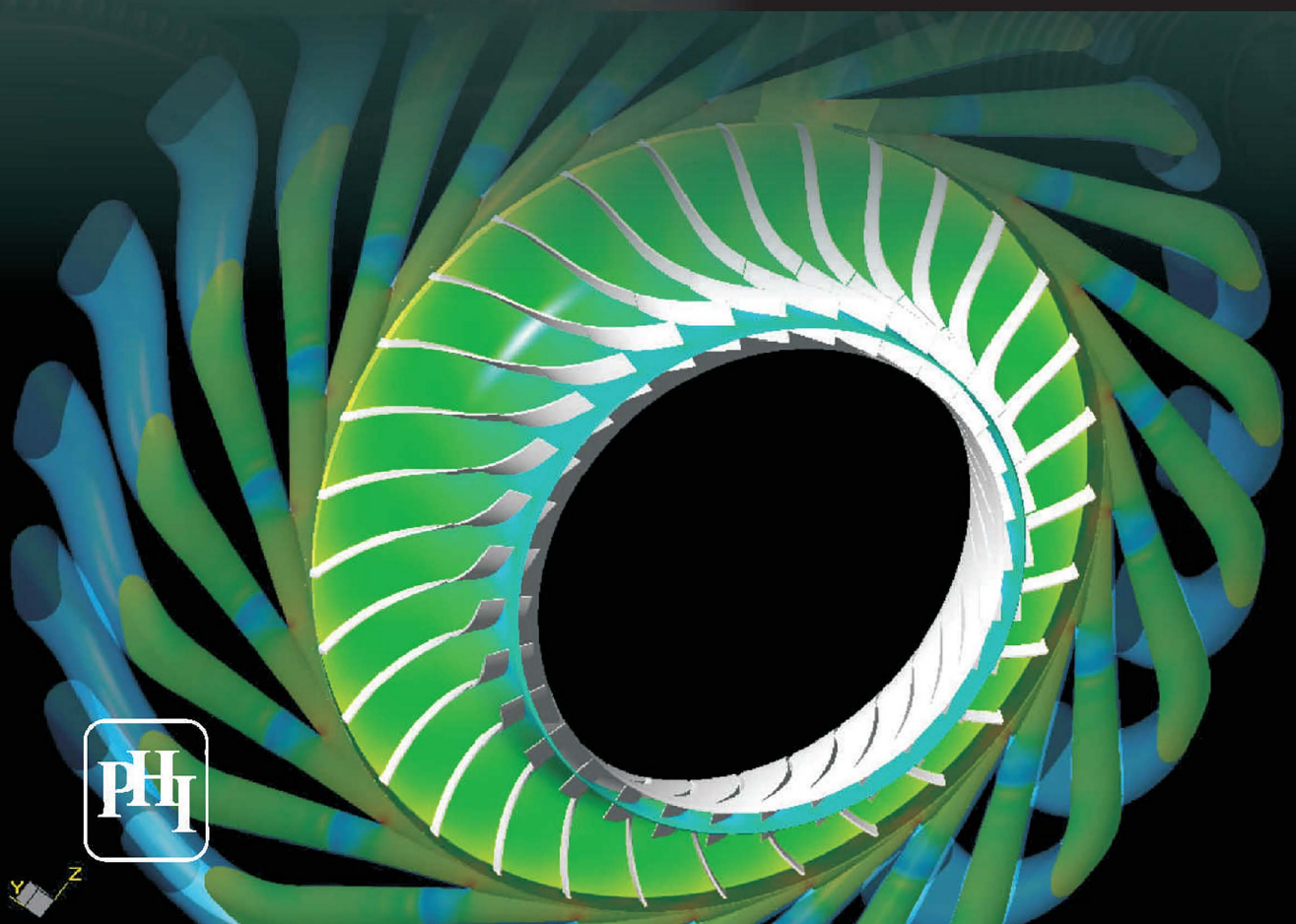


Eastern
Economy
Edition

Fundamentals of

Turbomachinery

B.K. Venkanna



Fundamentals of Turbomachinery

Fundamentals of **TURBOMACHINERY**

B.K. VENKANNA

Professor

Department of Mechanical Engineering
Basaveshwar Engineering College
Bagalkot

PHI Learning Private Limited

New Delhi-110001
2009

FUNDAMENTALS OF TURBOMACHINERY

B.K. Venkanna

© 2009 by PHI Learning Private Limited, New Delhi. All rights reserved. No part of this book may be reproduced in any form, by mimeograph or any other means, without permission in writing from the publisher.

ISBN-978-81-203-3775-6

The export rights of this book are vested solely with the publisher.

Published by Asoke K. Ghosh, PHI Learning Private Limited, M-97, Connaught Circus, New Delhi-110001 and Printed by Rajkamal Electric Press, Plot No. 2, Phase IV, HSIDC, Kundli-131028, Sonapat, Haryana.

To my wife

Swati

*for her unflinching support in every walk of my life
and standing by me during my hard times*

Contents

<i>Preface</i>	<i>xv</i>
<i>Acknowledgements</i>	<i>xvii</i>
1. Introduction to Turbomachines	1–57
1.1 Introduction	1
1.1.1 Solids	1
1.1.2 Liquids and Gases	1
1.2 Fluid Machines	2
1.3 Functional Classification of Fluid Machines	2
1.4 Turbomachines	3
1.5 Parts of a Turbomachine	3
1.6 Comparison between Positive Displacement Machines and Turbomachines	5
1.7 Basic Laws and Equations	6
1.7.1 Continuity	6
1.7.2 Steady Flow Energy Equation (First Law of Thermodynamics)	6
1.7.3 Entropy (Second Law of Thermodynamics)	8
1.8 Types of Turbomachines	9
1.9 Turbines	10
1.10 Pumps and Compressors	10
1.11 Fans and Blowers	10
1.12 Dimensionless Parameters and Their Physical Significance	11

1.13	Dimensional Analysis	11
1.13.1	Fundamental Quantities	11
1.13.2	Secondary Quantities or Derived Quantities	11
1.13.3	Dimensional Homogeneity	11
1.14	Buckingham's π -Theorem	12
1.15	Procedure for Applying Buckingham's π -Theorem	12
1.16	Application of Dimensional Analysis to a General Fluid Flow Problem	14
1.16.1	Physical Significance of π Terms	17
1.17	Application of Dimensional Analysis to Turbomachines	19
1.18	Significance of π Terms	21
1.18.1	Capacity Coefficient or Flow Coefficient or Specific Capacity or Discharge Coefficient	21
1.18.2	Head Coefficient or Specific Head	22
1.18.3	Power Coefficient or Specific Power	22
1.18.4	Reynold's Number	23
1.18.5	Effect of Reynold's Number	23
1.18.6	Specific Speed	24
1.18.7	Definition of Specific Speed	25
1.19	Examples	26
	<i>Important Equations</i>	54
	<i>Review Questions</i>	56
	<i>Exercises</i>	57

2. Energy Transfer in Turbomachines

58–157

2.1	Euler Turbine Equation	58
2.2	Alternate Forms of Euler Turbine Equation	61
2.3	Components of Energy Transfer	62
2.4	The Steady Flow Equation of the First Law of Thermodynamics	63
2.5	Degree of Reaction	64
2.6	General Analysis of a Turbomachine	65
2.6.1	Effect of Blade Discharge Angle β_2 on Energy Transfer and Degree of Reaction	65
2.7	General Analysis of Centrifugal Pumps and Compressors	69
2.7.1	Effect of Blade Discharge Angle on Performance	69
2.7.2	Theoretical Head Capacity Relationship	69
2.8	General Analysis of Axial Flow Compressors and Pumps	76
2.8.1	General Expression for Degree of Reaction	76
2.8.2	Velocity Triangles for Different Values of Degree of Reaction	81
2.9	General Analysis of Turbines	83
2.9.1	Utilization Factor (ϵ)	83
2.9.2	Axial Flow Turbines	85
2.9.3	Radial Flow Turbines	92

2.10	Condition for Maximum Utilization: Axial Turbine	93
2.10.1	Reaction Turbine	93
2.10.2	Impulse Turbine	95
2.11	Optimum Blade Speed Ratio (ϕ_{OPT}) for Different Types of Turbines for Maximum Energy Transfer $(W.D.)_{max}$	97
2.11.1	Reaction Turbine	97
2.11.2	Impulse Turbine	97
2.12	Examples	97
	<i>Important Equations</i>	152
	<i>Review Questions</i>	155
	<i>Exercises</i>	157

3. Thermodynamics of Fluid Flow and Thermodynamic Analysis of Compression and Expansion Processes 158–246

3.1	Velocity of Sound or Sonic Velocity	158
3.2	Mach Number	161
3.3	Classification of Fluid Flow	161
3.4	Stagnation and Static Properties	162
3.4.1	Static State	162
3.4.2	Stagnation State	162
3.4.3	Stagnation Enthalpy (h_0)	162
3.4.4	Stagnation Temperature (T_0)	163
3.4.5	Stagnation Pressure or Total Pressure (p_0)	163
3.4.6	Stagnation Density (ρ_0)	164
3.4.7	Stagnation Velocity of Sound (a_0)	164
3.5	Compression Process	165
3.5.1	Isentropic Efficiency or Adiabatic Efficiency or Isothermal Efficiency or Compression Efficiency	166
3.5.2	Overall Isentropic Efficiency, Stage Efficiency, Comparison and Relation between Overall Efficiency and Stage Efficiency	168
3.5.3	Polytropic Efficiency or Infinitesimal Stage Efficiency (η_p) of a Compression Process	171
3.5.4	Constant Stage Pressure Ratio	174
3.5.5	Preheat Factor (PF)	176
3.6	Expansion Process	176
3.6.1	Isentropic Efficiency or Adiabatic Efficiency or Expansion Efficiency	176
3.6.2	Overall Isentropic Efficiency, Stage Efficiency and Comparison and Relation between Stage Efficiency and Overall Efficiency for Expansion Process	179
3.6.3	Polytropic Efficiency or Infinitesimal Stage Efficiency (η_p) of an Expansion Process	182

3.6.4	Multistage Machine with Constant Stage Pressure Ratio	185
3.6.5	Reheat Factor for Expansion Process (RF)	188
3.7	Examples	188
	<i>Important Equations</i>	239
	<i>Review Questions</i>	243
	<i>Exercises</i>	245

4. Centrifugal Compressors and Pumps **247–347**

CENTRIFUGAL COMPRESSORS

4.1	Working Principle, Components and Description	247
4.2	Work Done and Pressure Rise	248
4.2.1	Enthalpy–Entropy Diagram	252
4.2.2	Overall Pressure Ratio	253
4.2.3	Limiting Inlet Velocity	255
4.3	Pressure Coefficient (ϕ_p)	255
4.4	Blade Angles at Eye Root and Eye Tip	256
4.5	Eye Conditions for an Impeller	257
4.6	Influence of Impeller Blade Shape	258
4.7	Slip Factor (σ)	259
4.8	Power Factor (ϕ)	260
4.9	Prewhirl and Inlet Guide Vanes	261
4.10	Diffuser	262
4.10.1	Vanless Diffuser	262
4.10.2	Determination of Diffuser Inlet Angle, Width and Length of the Diffuser Passages	263
4.10.3	Width of the Impeller Channel	264
4.11	Surging of Centrifugal Compressors	265

CENTRIFUGAL PUMPS

4.12	Introduction	266
4.13	Centrifugal Pumps	266
4.14	Working Principle	266
4.15	Main Parts of a Centrifugal Pump	267
4.15.1	Impeller	267
4.15.2	Casing	268
4.15.3	Suction Pipe, Foot Valve and a Strainer	268
4.15.4	Delivery Pipe	268
4.15.5	Delivery Valve or Check Valve or Regulating Valve	268
4.16	Classification of Centrifugal Pumps	268
4.16.1	According to the Working Head	268
4.16.2	According to the Type of Casing	269
4.16.3	According to Fluid Entrance to the Impeller	270
4.16.4	According to the Direction of Flow of Water through the Impeller	270
4.16.5	According to Number of Impellers	271

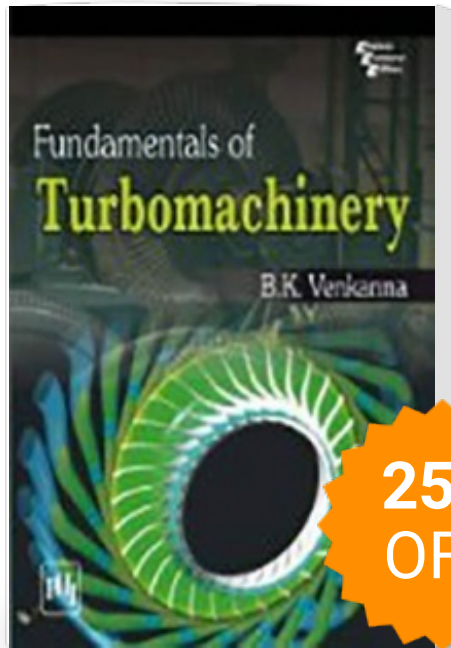
4.16.6	According to Liquid Handled	271
4.16.7	According to Specific Speed	272
4.17	Heads of a Centrifugal Pump	273
4.17.1	Static Head (H_S)	273
4.17.2	Manometric Head (H_m)	273
4.18	Efficiencies of Centrifugal Pump	274
4.18.1	Manometric Efficiency (η_{mano})	274
4.18.2	Mechanical Efficiency (η_m)	275
4.18.3	Hydraulic Efficiency (η_H)	275
4.18.4	Volumetric Efficiency (η_v)	275
4.18.5	Overall Efficiency (η_o)	275
4.19	Work Done by the Pump	275
4.20	Pressure Rise in Pump, Impeller and Manometric Head	278
4.21	Minimum Starting Speed	278
4.22	Multistage Pumps	279
4.23	Cavitation	279
4.24	Examples (Centrifugal Compressors)	280
4.25	Examples (Centrifugal Pumps)	315
	<i>Important Equations</i>	342
	<i>Review Questions</i>	344
	<i>Exercises</i>	344

5. Axial Flow Compressors

348–417

5.1	Introduction	348
5.2	Description and Principle of Operation	349
5.3	Stage Velocity Triangle	350
5.4	Work Done	352
5.5	Temperature and Entropy Diagram for a Stage of an Axial Flow Compressor	352
5.6	Overall Pressure Ratio per Stage (p_{R0})	354
5.7	Work Done Factor (ψ)	355
5.8	Flow Coefficient (ϕ)	356
5.9	Pressure Coefficient (ϕ_p)	356
5.10	Degree of Reaction (R)	356
5.11	Combined Velocity Triangles for Different Values of R	358
5.12	Radial Equilibrium Conditions	360
5.13	Air Angle Distribution	362
5.13.1	Free Vertex Flow	362
5.13.2	Constant Reaction Design	366
5.14	Examples	367
	<i>Important Equations</i>	413
	<i>Review Questions</i>	414
	<i>Exercises</i>	415

Fundamentals Of Turbomachinery



Publisher : **PHI Learning**

ISBN : **9788120337756**

Author : **VENKANNA, B. K.**

Type the URL : <http://www.kopykitab.com/product/7353>



Get this eBook