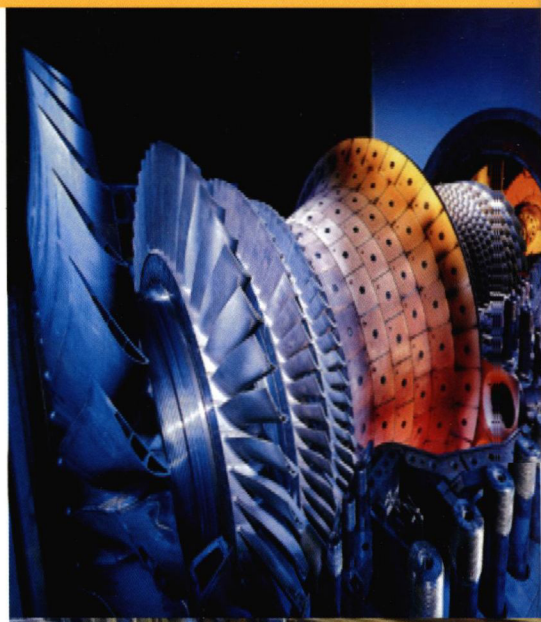
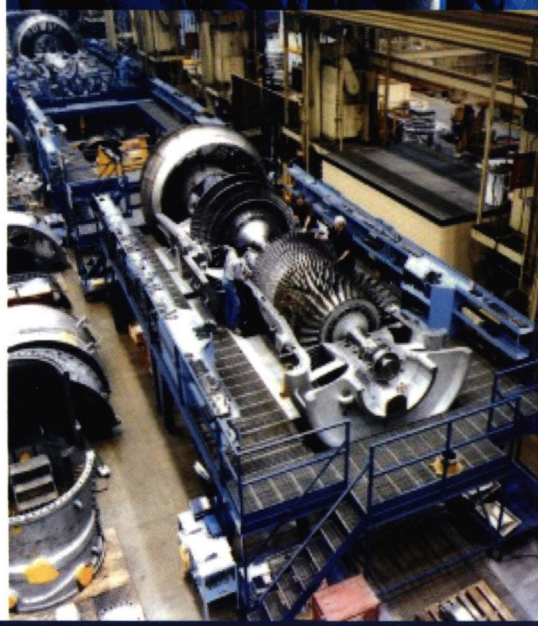
2nd Edition

THEORY AND PRACTICE IN GAS TURBINES





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New Academic Science

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(SECOND EDITION)

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Preface

Various mechanical devices have been built to produce power for industrial and societal needs. Reciprocating engines with its sliding components have the problems of balancing, and cause considerable vibrations. Hydroelectric power from turbines using water is a great resource and still a significant contributor to satisfy the world's energy needs, but potential sites are limited. Steam power plants are a mainstay for producing electric power, with larger units developing 1000 MW at 40 per cent thermal efficiency. Steam power plants, however, require high-pressure steam at elevated temperatures. Expensive steam generating equipment of large bulk is needed, and installation may stretch over lengthy time periods. Steam turbines are also commonly used in nuclear powered aircraft carriers and submarines. Gas turbines enjoy the major advantage of compactness in size since the water-to-steam step is eliminated by directly using the combustion gases for driving the turbine.

Developments in related areas such as system control, super alloys and fuel combustion have made great strides in gas turbines operating at high thermal efficiency while minimizing exhaust pollutants. Modern turbo-machines rely on marvelous devices, instruments, and fly-by-wire control systems to ensure smooth and trouble-free operation at all times. Instead of manipulating an array of switches, valves, and mechanisms of the various electrical, hydraulic, pneumatic, and mechanical actuators, the pilot or the operator in charge of the engine instructs a computer of his intentions. The central processing unit of the computer activates the necessary protocol and issues command instructions to achieve the desired objective.

This book is written to meet the needs of students in engineering colleges and practicing engineers in a large number of industries where turbo-machines are used. In keeping with its mostly introductory nature, and to primarily focus on physical principles, no attempts are made to add computational methods for prediction of flow through the turbo-machine. Where possible, electronic spreadsheet type of calculations is used in example problems to calculate flow characteristics and related cycle design parameters.

The book is split into two parts. The first part focuses on the fundamentals of thermodynamics, fluid flow mechanics, physics and thermodynamic cycles. The second part explores the design features and operating practices of gas turbines. The first chapter of part I provides historical insights and trends in the development of gas turbines. The second chapter delves into thermal and fluid flow dynamics, the third chapter into considerations of physics, and the fourth and fifth chapters develop cycle designs for shaft power and to propel aircrafts. In the second part of the book, chapter six further explores thermodynamic cycle and mechanical design of power generation turbines, chapter seven of aviation engines, and chapter eight of aero-derived engines. Attention is focused on components such as fan and radial and axial compressors in chapter nine, combustors in chapter ten, and turbines in chapter eleven. The twelfth and thirteenth chapters delve into performance evaluation and enhancement of gas turbines, and chapter number fourteen considers exhaust emissions, noise and vibration control of gas turbines.

A list of symbols is provided mostly to facilitate identification with commonly used parameters in the equations and the associated text. However, because of the considerable number of topics, the corresponding variables are adequately defined within each section. Oftentimes it is found necessary within the sections to redefine many of the symbols for convenience and better understanding of the subject matter. Thus, the list of symbols may be used only as a general guideline.

Selected references and bibliography are provided at the end of each chapter. Some solved problems and exercises are also included to stimulate the mind and to act as catalyst for analytic thinking. I gratefully remember and appreciate past students of the course on this topic who have sent in comments and reported errors, and express my hope that those who work with this treatise will do likewise. I am profoundly indebted to Mr. Mark Belloni of General Electric Company for performing a vast amount of computational work and for valuable advise on the text and layout of the book. I greatly appreciate comments provided by Dr. Ahmad Kamel and Mr. George Robinson of Siemens-Westinghouse Power Corporation for checking the problems and reading the proof.

Orlando, FL **A.S. Rangwala**

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