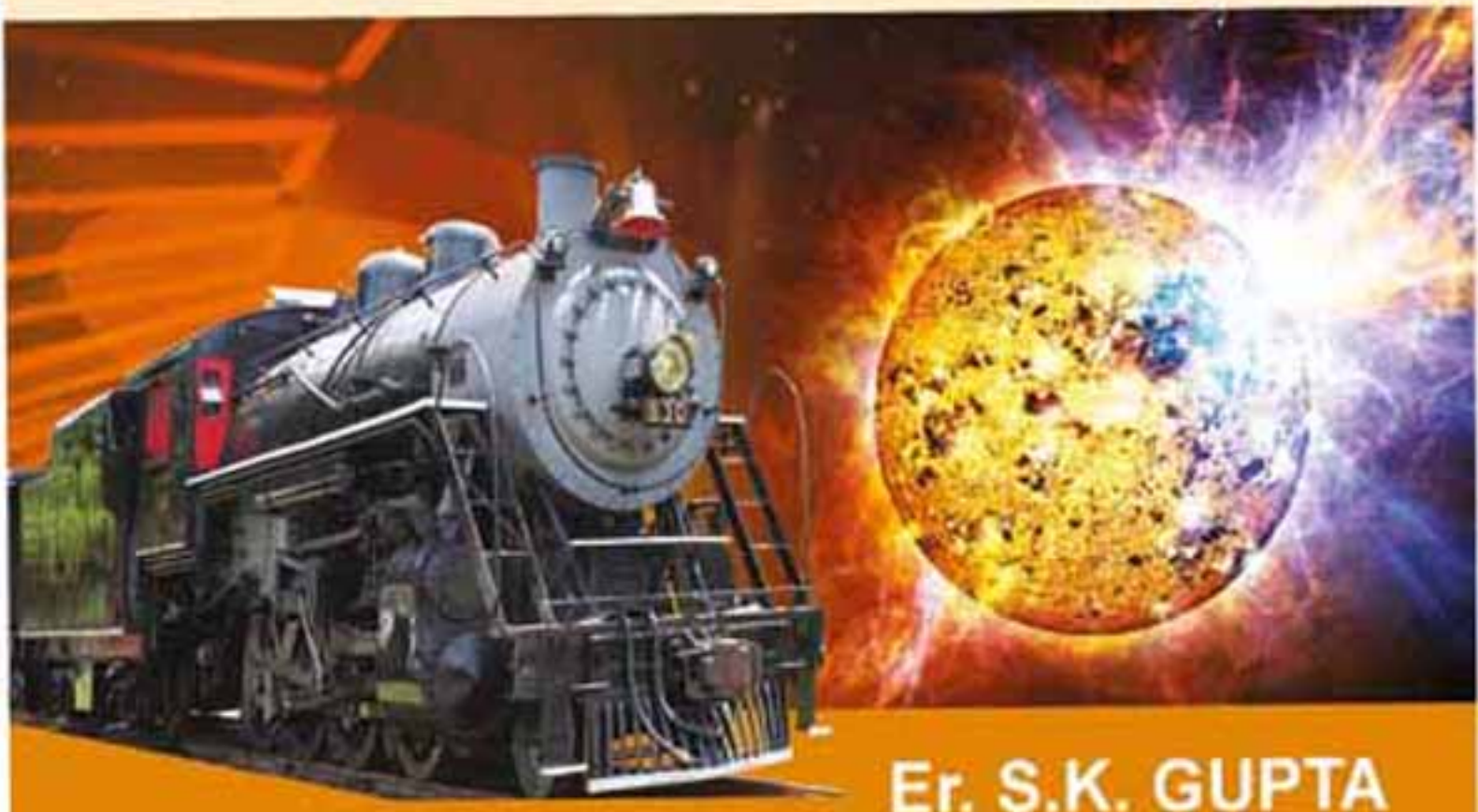
ENGINEERING THERMODYNAMICS

[For the Students of all branches of B.E./B.Tech.]



Er. S.K. GUPTA

S. CHAND

Engineering Thermodynamics

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First Edition 2013

ISBN : 81-219-4270-5 **Code :** 10 589

PRINTED IN INDIA

By Rajendra Ravindra Printers Pvt. Ltd., 7361, Ram Nagar, New Delhi -110 055
and published by S. Chand & Company Pvt. Ltd., 7361, Ram Nagar, New Delhi -110 055.

Preface

This standard treatise titled as **'Engineering Thermodynamics'** is intended for the use of students of B.E./B.Tech. of all Indian and Foreign Universities. The subject matter is presented in the most concise, to-the-point and lucid manner. The book contains well-graded examples, most of which are taken from the recent examination papers of Indian and Foreign Universities. In order to make more useful for the students, Highlights for Quick Revision before examination and Objective Type Questions with Answers are added, at the end of each chapter.

My sincere thanks are due to the Management Team and Editorial Staff of S. Chand & Co. Pvt. Ltd., New Delhi, for taking their keen interest in bringing the book in a very short time.

Though utmost care has been taken to check mistakes, yet it is difficult to claim perfection. The author will, therefore, acknowledge any errors, omissions and suggestions for the improvement of the book and will be incorporated in the next edition.

Er. S.K. Gupta

Contents

1

BASIC CONCEPTS

1.1 INTRODUCTION

The subject *Thermodynamics is defined as the science which deals with the study of energy in its various forms or types. It may also be defined as the science which deals with the conversion of heat into mechanical energy. The science of thermodynamics is used often by engineers and technologists in very practical design problems and in problems of the operation of large or complicated systems.

1.2 SCOPE AND APPLICATIONS OF THERMODYNAMICS

The scope of applied thermodynamics is restricted to the study of heat and work and the conversion of one into the other. The applications of thermodynamics are found in the measurement of temperature and humidity in the air, as in the design of a heating or air conditioning system. The engines of automobiles, trucks and tractors are designed by using the concept of thermodynamics.

* The literal meaning of thermodynamics is heat-force action and it deals with matter and interaction between quantities of matter.

Jet engines and rockets are analysed by using the principles of thermodynamics. The central thermal plants, captive power plants based on coal, nuclear power plants, gas turbine plants and chemical process plants are fully dependent on the Laws of Thermodynamics. Thus, a good knowledge in thermodynamics is very necessary for an engineer so that he can use fundamental ideas of thermodynamics and applications of those ideas to engineering problems.

1.3 WORKING SUBSTANCE

A substance through which the conversion of heat into work and *vice versa* takes place, is known as *working substance*. It should be capable of changing its volume, so the working substances are, in general, fluids. Air and steam are the commonly used working substances.

1.4 PURE SUBSTANCE

A substance whose chemical composition is both homogeneous and constant is known as *pure substance*. In other words, it is a homogeneous substance whose molecular structure does not vary. A pure substance exists in three phases, *i.e.* solid, liquid and gas. Water or steam or a mixture of water and steam are examples of pure substances as they have the same molecular or chemical structure through its mass. Air in liquid and gaseous form is another example of pure substance.

1.5 MACROSCOPIC AND MICROSCOPIC APPROACH

The behaviour of a matter may be studied by the following two approaches:

1. *Macroscopic approach*. The term macroscopic is used in regard to large units which is visible to the naked eye. In the macroscopic approach, a certain quantity of matter is considered without taking into consideration the events occuring at the molecular level. In other words, macroscopic approach to thermodynamics is concerned with gross or overall behaviour of matter. This is called *classical thermodynamics*.

In order to understand clearly the macroscopic approach of thermodynamics, let us consider the pressure that a gas exerts on the walls of its container. This pressure is average value of pressures exerted due to the collision of all the molecules made on a unit area. We are not concerned with the action of individual molecules from the macroscopic point of view. We measure the force on a given unit area by using a pressure gauge. There are certain properties like temperature and volume which can be expressed as macroscopic quantities.

In the *microscopic approach,* the matter is considered to be composed of particles and each particle having a certain position, velocity and energy, at a given instant. Such a study which is concerned directly with the structure of the matter, is known as *statistical thermodynamics*.

It may be noted that all the results of classical or macroscopic thermodynamics may be derived from the statistical or microscopic study of matter.

1.6 MASS AND WEIGHT

The mass of a system is a measure of quantity of matter as well as property of matter called inertia. In S.I. system of units, the mass is expressed in kilogram (briefly written as kg). Though the mass is related to weight, yet both these terms are different. Weight refers to the force exerted by gravity on mass. It may be noted that mass of a body or system does not change but the weight of a body changes from place to place. In S.I. system of units, the weight is expressed in newton (briefly written as N). Mathematically, the relation between the mass (m) and the weight (W) of the body is

$$m = W/g \quad \text{or} \quad W = m.g$$

where m is in kg, W is in newton and g is the acceleration due to gravity whose value is taken as 9.81 m/s^2.

Note: From the above discussion, we see that weight of a body of mass m kg, at a place where gravitational acceleration is 'g' m/s^2 is mg newton.

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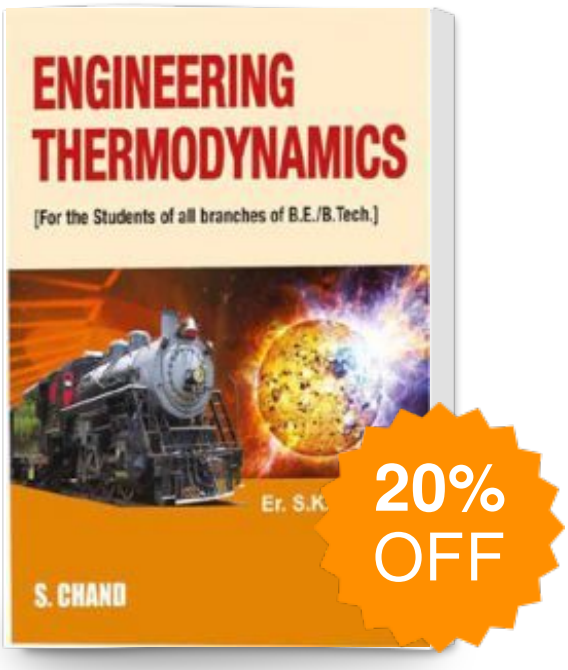

Publisher : SChand Publications ISBN : 9788121942706 Author : Er. S.K. Gupta