A text book of engineering thermodynamics

Lucke Charles Edward

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BY

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AN ABRIDGMENT OF

ENGINEERING THERMODYNAMICS

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PREFACE

This Textbook of Engineering Thermodynamics has been prepared to meet the requirements of technical schools desiring a briefer treatment of the subject than that contained in the original "Engineering Thermodynamics," by Charles E. Lucke, of which this book is an abridgment.

Since Rankine's time the science of thermodynamics has been highly developed and has become of great importance in the formulation of modern physical chemistry and its correlated branches in engineering. Thermodynamics, *per se*, is not concerned with any physical substance, it is rather a theory of energy in relation to matter.

Engineering thermodynamics, while making use of those principles of pure thermodynamics which may help to solve its problems, must rely on a great mass of facts or relations that have not attained the dignity of thermodynamic laws. Its field includes a portion of that of pure thermodynamics, but it extends far beyond the established provinces of that subject and reaches to the interpretation of all pertinent principles and facts for purely useful purposes. One of the most promising applications of engineering thermodynamics is to be found in the establishment of limits of possible performance of heat apparatus and machines. These limits show what might be expected of a steam engine, gas engine or refrigerating machine when its mechanism is quite perfect; thus they become standards of reference, and a measure of improvements yet possible. These methods and practices are also applicable to the analysis of the operating performance of complete plants to discover the amount of energy being lost, how the total amount is divided between the different elements of the apparatus, which of the losses can be prevented and how, and finally which are unavoidable. In this book the treatment has followed that of the larger work, based upon the application of the laws of pure thermodynamics, modified by conditions of practice, to guide computation on thermal problems which deal with physical substances under actual conditions of operation.

The subject is divided into three general parts: Part I deals with the conditions surrounding the doing of work without any consideration of heat changes; Part II, with heat gains and losses by substances without reference to work involved; and Part III, transformation of heat into work or work into heat in conjunction with changes in the condition of substances. The first part applies to the behavior of fluids in the cylinders of compressors and engines. The second part is concerned with the development of heat

by combustion, its transmission from place to place, and the effect on the physical condition of solids, liquids and gases with their mixtures, solutions and reactions. The third part is fundamental to the efficient production of power by gases in internal combustion gas engines or compressed-air engines, and by steam or other vapors in steam engines and turbines, and likewise to the production of mechanical refrigeration by ammonia, carbon dioxide and other vapors.

The nineteen chapters of the book treat these three Parts accordingly. The first six chapters deal with work without any particular reference to heat; the next six chapters, with heat, without any particular reference to work; while the last seven are concerned with the relation between heat and work.

After establishing in the first chapter the necessary units and basic principles governing work, the second chapter proceeds to the determination of the work done in compressor cylinders, which is followed by a discussion of the available work in engine cylinders in terms of all the different variables that may determine the work for given dimensions of cylinder or for given quantities of fluid. Chapters VII to IX, Part II, are devoted to the qualitative and quantitative heat content of substances and their physical-chemical state; the remaining portion of Part II relates to heating by combustion and discusses fuels, furnaces, gas-producers and steam boilers. In Part III the general relations between heat and work are presented, and the thermal efficiencies of steam, gas, and compressed-air engines are deduced. The flow of expansive fluids and the performance of refrigerating systems are discussed in the last two chapters.

Throughout the entire work there have been established a series of working formulas derived from a few simple principles having in view maximum clearness and utility, and the resulting equations have been presented in such form as to be readily available for numerical substitution, either directly or by the use of derived charts. This permits the solution of quite involved thermodynamic problems with very little labor or time, although it has necessarily required the expansion of the subject over a considerable number of pages, but it is confidently believed that the saving of time thus gained in facilitating numerical solutions more than justifies the presentation.

The book treats in the same consistent manner all the important related subjects which are frequently administered in a technical school under different courses. It is hardly expected that teachers of Thermodynamics will use the entire text; rather it is assumed that those portions will be selected which will best articulate with other related subjects, serving more or less as a basis for them. In this way the present text can be made to supplement courses on gas power, compressed air, steam engines and turbines, steam boilers and power plants, refrigeration, chemical engineering, laboratory practice and research.

The text includes many tables and diagrams which are essential to the proper presentation of the subject, but in order to save space most of the

tables and working charts which appear in the original work on Engineering Thermodynamics have been omitted from the present book. These with some additions are published in a separate volume as a Handbook of Thermodynamic Tables and Diagrams.

The authors desire to express their obligations to Mr. E. D. Thurston, Jr., whose invaluable help is gratefully acknowledged, and to Mr. T. M. Gunn for aid on part of the work.

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