ENGINEERING THERMODYNAMICS

Published @ 2017 Trieste Publishing Pty Ltd

ISBN 9780649092925

Engineering thermodynamics by James Ambrose Moyer & James Park Calderwood

Edited by Trieste Publishing Pty Ltd.
Cover @ 2017

www.triestepublishing.com

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FIRST EDITION
FIRST THOUSAND

NEW YORK
JOHN WILEY & SONS, Inc.
London: CHAPMAN & HALL, Limited
1915

Stanhope Press
F. H. GILSON COMPANY
BOSTON, U.S.A.

PREFACE

For years there has been an important demand for a text-book on thermodynamics which would be brief and concise, but at the same time so clearly written as regards explanation that students of *average* ability in our large technical schools could read it without difficulty. A professor of thermodynamics wrote recently as follows: "I like the idea of making the text largely self-explanatory. Too many books require the reading of several lines between every two lines of the text." This book has been prepared to meet this demand and in writing it the authors have kept in mind these requirements. Further, it has been the idea of the authors to make this book particularly suitable for use in the larger technical schools where it is possible to give special courses on the subjects of steam turbines, pneumatic machinery, internal combustion engines, refrigeration and pumping machinery. Usually in the courses on these subjects the advanced and special theory of thermodynamics as it relates to each of them is taken up with completeness. At present there is too much duplication of subject matter in the large volumes on thermodynamics now available, which are made to include the descriptive matter and the applications of these special subjects.

The authors are particularly indebted to Professor Roy B. Fehr of The Pennsylvania State College for invaluable assistance and criticisms in the preparation of this work. Acknowledgments are due also to President Ira N. Hollis of Worcester Polytechnic Institute; Professor Lionel S. Marks of Harvard University and Massachusetts Institute of Technology; Professor H. C. Anderson of the University of Michigan; Dr. S. A. Moss of the General Electric Company; Dr. William Kent of Montclair, N. J.; Professor A. M. Greene of Rensselaer Polytechnic Institute; Professor A. L. Westcott of University of Missouri; Professor A. A. Atkinson of Ohio University; and Professors J. A. Bursley and C. H. Fessenden of the University of Michigan, for assistance in various ways.

A book on applied thermodynamics published privately by the late Professor H. W. Spangler and with the preparation of which one of the authors was intimately associated has been consulted freely in the preparation of the last chapters. This book, as a whole, includes many of Professor Spangler's ideas as regards subject matter to be included in a book of this kind.

Acknowledgment of the services of Messrs. W. M. Sides and H. J. Hartranft of State College, Pa., is due for assistance in preparation and proof-reading.

J. A. MOYER
J. P. CALDERWOOD

STATE COLLEGE, PA.,
August, 1915.

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SYMBOLS

A = area in square feet.
B.t.u. = British thermal units (= 778 ft. lbs.).
C_p = specific heat at constant pressure in B.t.u. per pound per degree.
C_v = specific heat at constant volume in B.t.u. per pound per degree.
C = a general constant in equations of perfect gases.
D = degrees of superheat.
E = external work in B.t.u. per pound; also sometimes used to express efficiency, usually as a decimal.
E_a = available energy in B.t.u. per pound.
F = force in pounds.
H = heat per pound in B.t.u.*
H_{sup} = total heat of superheated steam, B.t.u. per pound.
I_H = total internal energy of steam (above 32° F.) in B.t.u. per pound.
I_L = internal energy of evaporation of steam in B.t.u. per pound.
J = reciprocal of mechanical equivalent of heat = $\frac{1}{778}$ (use becoming obsolete).
K = specific heat in foot-pound units.
L = latent heat of evaporation in B.t.u. per pound.
M = mass (pounds).
P = pressure in general or pressure in pounds per square foot.
Q = quantity of heat in B.t.u.
R = thermodynamic constant for gases; for air it is 53.3 (in foot-pound units per pound.)
T = absolute temperature, in Fahr. degrees = $460 + t$.
V = volume in cubic feet, also specific volume and velocity in feet per second.
W. E. = Wärme Einheit = kilogram calorie.
W = work done in foot-pounds.
a = area in square inches.
c = constant of integration.
d = distance in feet.
e = subscript to represent base of natural logarithms.
g = acceleration due to gravity = 32.2 feet per second per second.
h = heat of the liquid per pound in B.t.u. (above 32° F.).
k = a constant.
log = logarithm to base 10.
$\log_e$ = logarithm to natural base e (Naperian).
n = general exponent for V (volume) in equations of perfect gases, also sometimes used for entropy of the liquid in B.t.u. per degree of *absolute* temperature.

* In steam tables it is total heat above 32° F.