THE NATURE AND PROPERTIES OF ENGINEERING MATERIALS

Third Edition

Zbigniew D. Jastrzebski

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Lafayette College

JOHN WILEY & SONS
New York · Chichester · Brisbane · Toronto · Singapore

Library of Congress Cataloging in Publication Data:

Jastrzebski, Zbigniew D.
The nature and properties of engineering materials.

Includes bibliographies and index.
1. Materials. I. Title.

TA403.J35 1987 620.1'1 86-24673
ISBN 0-471-81841-0

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1 0

TABLE 3 SI derived units with special names

Quantity	*SI Unit*			
	Name	Symbol	Expression in Terms of Other Units	Expression in Terms of SI Base Units
Frequency	hertz	Hz		s^{-1}
Force	newton	N		$kg \cdot m/s^2$
Pressure	pascal	Pa	N/m^2	$kg/(m \cdot s^2)$
Energy, work, quantity of heat	joule	J	$N \cdot m$	$kg \cdot m^2/s^2$
Power, radiant flux	watt	W	J/s	$kg \cdot m^2/s^3$
Quantity of electricity, electric charge	coulomb	C	$A \cdot s$	$A \cdot s$
Electric potential, potential difference, electromotive force	volt	V	W/A	$kg \cdot m^2/(A \cdot s^3)$
Capacitance	farad	F	C/V	$A^2 \cdot s^4/(m^2 \cdot kg)$
Electric resistance	ohm	Ω	V/A	$kg \cdot m^2/(A^2 \cdot s^3)$
Conductance	siemens	S	A/V	$A^2 \cdot s^3/(m^2 \cdot kg)$
Magnetic flux	weber	Wb	$V \cdot s$	$kg \cdot m^2/(A \cdot s^2)$
Magnetic flux density	tesla	T	Wb/m^2	$kg/(A \cdot s^2)$
Inductance	henry	H	Wb/A	$kg \cdot m^2/(A^2 \cdot s^2)$

TABLE 4 SI prefixes[a]: Decimal multiples and submultiples of SI units

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{-1}	deci	d	10	deka	da
10^{-2}	centi	c	10^2	hecto	h
10^{-3}	milli	m	10^3	kilo	k
10^{-6}	micro	μ	10^6	mega	M
10^{-9}	nano	n	10^9	giga	G
10^{-12}	pico	p	10^{12}	tera	T
10^{-15}	femto	f	10^{15}	peta	P
10^{-18}	atto	a	10^{18}	exa	E

[a] Prefixes may be attached to many of the units given in Tables 1, 2, 3 and 7. For example, kPa (kilopascal) = 10^3 Pa, MJ (megajoule) = 10^6 J, nm (nanometer) = 10^{-9} m.

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To my wife

IRENA

PREFACE

Since publication of the second edition there have been numerous advances in both Materials Science and Materials Technology that have exerted considerable impact on the development of new materials and improvement of existing materials. These advances have greatly contributed to our better understanding of fundamentals and theoretical concepts on which the growth and development of materials depend.

The purpose of this third edition is to incorporate these changes into the text to provide a more comprehensive and integrated treatment of the present state of Materials Science and Engineering. This is achieved by effective integration of theoretical principles resulting in a balanced coverage of all types of engineering materials—metals, ceramics, and polymers. The organization of the book and the treatment of the basic concepts are such that after the first seven chapters the order and the subsequent coverage of the material may be adjusted to whatever the course requires or time permits.

This edition, like the previous ones, is intended for engineering and science students both at the sophomore or junior level and is based on a knowledge of general chemistry, physics, and calculus. The book will also serve professional engineers and scientists who seek a basic understanding and knowledge of the nature and properties of the varied engineering materials in their current work or a stepping-stone for more advanced studies in the area of specific materials problems.

This revision offers an account of important concepts that will enable the reader to become familiar with the basic principles involved in manufacturing processes, in engineering applications, and in limitations and failures of the various materials. Some new topics have been introduced and the old ones

updated; some material had to be eliminated or deemphasized because its importance has diminished. The questions and problems at the end of chapters have been expanded, revised, and supplemented with additional illustrative problems. References at the end of each chapter have been thoroughly revised and brought up to date. A number of additional microphotographs have been added. All of the detailed changes can be examined from the Table of Contents. Chapters 3, 4, 5, 7, 8, 9, 10, 11, and 14 have undergone major changes in their organization and/or contents to include all major advances in Materials Science and Materials Technology. The remaining chapters required only minor changes.

SI units are used as the main units but they are accompanied by English engineering units and other customary units in parentheses. Most tables, drawings, and figures contain both SI units and the other frequently used units. The names of the units, their symbols, notations, and, more important, conversion factors are tabulated on the front-end and back-end papers.

Appendices at the end of the book now contain seven tables which provide a very informative summary of the important properties of metals, plastics, and rubbers as used in varied engineering applications. All of these tables contain both SI units and the other frequently used engineering units.

I thank my colleague Robert R. Jones for providing most of the microphotographs that appear in this edition, and John C. Duke, Jr., Virginia Polytechnic Institute and State University, Robert H. Doremus, Rensselaer Polytechnic Institute, and Jay M. Samuel, The University of Wisconsin, for their assistance in reviewing the manuscript. My sincere thanks are also due Elizabeth Bullock for her typing and her great assistance in preparing this manuscript.

Zbigniew D. Jastrzebski

ABOUT THE AUTHOR

Dr. Zbigniew D. Jastrzebski is Professor of Chemical Engineering (Emeritus) at Lafayette College, Easton, Pennsylvania. He received his Dipl.Ing. and D.Sc. degrees from the Technical University of Warsaw, where he was an Assistant Professor from 1935 to 1939. In 1939 he became a consultant for the Scientific Department and Research Laboratories at Kabul, Afghanistan. His scientific activities were interrupted for three years while he was a member of the Polish Army under British command. In 1946 he became associated with the Polish University College in London where he became Professor and Head of the Chemistry and Chemical Engineering Department and Vice-Principal of the College. In 1953 he joined Lafayette College.

Although his teaching, research, and industrial experience cover a broad and diversified area, his main interests have been in the field of Materials Science and Engineering. He has published numerous papers and books and has been a consultant on corrosion and engineering materials for industry and research institutions. The first edition of his book *The Nature and Properties of Engineering Materials*, published in 1959, marked a new approach to teaching Materials Engineering from the scientific point of view. He was also conducting intensive four- and/or five-day courses for scientists and professional engineers under the auspices of the Center for Professional Advancement, both in this country and abroad. Professor Jastrzebski is a member of the American Institute of Chemical Engineers, the American Society for Engineering Education, the Polish Institute of Arts and Sciences in America, Polonia Technica, and other scholarly and social organizations. He was the recipient of many awards for superior teaching and research, was named John Markle Professor, and was listed in *Who's Who in America* and *World Who's Who in Science*.

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