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KALPAKJIAN

Third Edition

Manufacturing Engineering and Technology

THIRD EDITION

SEROPE KALPAKJIAN

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To
Claire, Kent, and Kimberly

About the Author

Professor Serope Kalpakjian has been teaching and conducting research in manufacturing processes at the Illinois Institute of Technology since 1963. After graduating from Robert College (with High Honors), Harvard University, and the Massachusetts Institute of Technology, he joined Cincinnati Milacron, Inc., where he was a research supervisor in charge of advanced metal-forming processes. He has published numerous papers in technical journals and is the author of several articles in the *Encyclopedia of Materials Science and Engineering*, the *McGraw-Hill Encyclopedia of Science and Technology*, and the *Mark's Standard Handbook of Mechanical Engineers*. He is a co-founder and former co-editor of the *Journal of Applied Metalworking* (now the *Journal of Materials Shaping Technology*) and a former associate editor of the *Journal of Tribology*. He currently serves on the editorial boards of *Manufacturing Review*, the *Journal of Manufacturing Systems*, the *Journal of Engineering Manufacture*, and the *Encyclopedia Americana*.

He is also the author of four books: *Mechanical Processing of Materials* (Van Nostrand, 1967); *Manufacturing Processes for Engineering Materials* (second edition, Addison-Wesley, 1991), which received the M. Eugene Merchant Manufacturing Textbook Award in 1985; *Lubricants and Lubrication in Metalworking Operations* (with E. S. Nachtman; Marcel Dekker, 1985); and *Manufacturing Engineering and Technology* (third edition, Addison-Wesley, 1995), which received the M. Eugene Merchant Manufacturing Textbook Award for its first edition in 1990. He has also edited *Tool and Die Failures: A Source Book* (ASM, 1982). He is a Fellow of the American Society of Mechanical Engineers, ASM International, and the Society of Manufacturing Engineers, and is a full member of the International Institution for Production Engineering Research (CIRP). He is a founding member and a past president of the North American Manufacturing Research Institution of the Society of Manufacturing Engineers (NAMRI/SME).

The author has received a number of awards, including citations by the Forging Industry Educational and Research Foundation for best paper (1966) and the Society of Carbide and Tool Engineers (1977); the "Excellence in Teaching Award" from the Illinois Institute of Technology (1970); the "Centennial Medallion" from the American Society of Mechanical Engineers (1980); and the international "Education Award" from the Society of Manufacturing Engineers (1989).

P R E F A C E

Valuable suggestions and constructive criticism from numerous colleagues at various institutions, as well as the rapid progress in various areas of manufacturing, have led to the preparation of this third edition. While a comprehensive state-of-the-art text has been my most important goal throughout this effort, my ambitions continue to encompass two additional aims: to motivate and to challenge students. The text presents topics with a balanced coverage of relevant fundamentals and real-world practices, so that the student develops an understanding of the important and often complex interrelationships among the many technical and economic factors involved in manufacturing.

This new text basically follows the same introductory nature, format, organization, and balance as the second edition. It has retained its emphasis on (a) the influence of materials and processing parameters in understanding manufacturing processes and operations; (b) design considerations, product quality, and manufacturing cost factors; and (c) the domestic and global competitive context of each manufacturing process and operation, highlighted with illustrative examples.

Study aids include the following:

- Presentation of each topic within a larger context of manufacturing engineering and technology, using extensive schematic diagrams and flowcharts.
- Analogies, discussions, and problems designed to stimulate the student's curiosity about consumer and industrial products and how they are manufactured.

- Emphasis on the practical uses of the concepts and information presented.
- Extensive reference material, including numerous tables, illustrations, graphs, and bibliography.
- Numerous illustrative examples to highlight important concepts and techniques.
- Summary tables comparing advantages and limitations of manufacturing processes.
- A summary, list of key terms, and concise description of current trends at the end of each chapter.

What Is New in This Edition

In response to comments and suggestions by numerous reviewers, several major and minor changes have been made throughout the text. A page-by-page comparison with the second edition will show that literally thousands of changes have been made for improved clarity and completeness. Information has been updated, some illustrations and text have been replaced with new ones, some material has been rearranged, and more cross-references have been cited. There are more than 1,600 questions and problems, about a quarter of them new to this edition. In addition, as shown below, certain topics have been expanded or added (opening page numbers in parentheses):

- Design for manufacturing, assembly, disassembly, and recycling (1163)
- Environmentally conscious design and manufacturing (33)
- Lean production and agile manufacturing (32)
- Assembly systems (1160)
- High-speed machining (688)
- Ultraprecision machining (689)
- Hard turning (689, 809)
- Machining and turning centers (759)
- Machining data (669, 705, 731)
- Tool materials (669, 731)
- Polishing with magnetic fields (816)
- Biodegradable plastics (219)
- Processing of composite materials (556)
- Artificial neural networks and fuzzy logic (1207)

- ISO 9000 standard (1074)
- Product liability and safety (1109)

Expanded coverage of technological advances includes abrasive machining, computer simulation of manufacturing processes and systems, instrumentation, laser beams in manufacturing, nanophase ceramics, rapid prototyping, semisolid metalworking, surface texturing, and tool-condition monitoring. Although every effort has been made to present a balanced view of all aspects of manufacturing engineering and technology, special emphasis has been placed on material-removal processes and machines, the topic of Part IV. The revision and updating of this part of the text to include recent developments and trends reflects a recognition of the sustained importance of this topic in textbooks.

Additional new features include the following:

- Division of the end-of-chapter questions and problems into four categories: review questions, qualitative problems, quantitative problems, and synthesis and design.
- Several new examples to reflect contemporary applications, such as synthetic ivory piano keys, an all-aluminum automobile, and grinding vs. hard turning.

Audience

Like the first two editions, this edition has been written for students in manufacturing, mechanical, industrial, and metallurgical and materials engineering programs. It is hoped that by reading and studying this book, students will come to appreciate the vital nature of manufacturing engineering as an academic subject that is as exciting, challenging, and important as any other engineering and technology discipline.

Acknowledgments

This text, together with the first two editions, represents a total of seven years of effort. It could not have been written and produced without the help of many people. It gives me great pleasure to acknowledge the assistance of the following in the preparation and publication of this third edition.

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S. K.

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