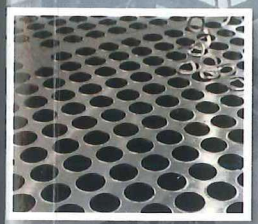
Industrial Production

The Manufacture of Mechanical Products

5th revised edition



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Foreword

This is the first English translation of the text book Industrial Production, based on the fifth Dutch edition compiled by an editorial committee consisting of Prof. Dr. Ir. H.J.J. Kals, Ir. Cs. Buiting-Csikós, Ir. C.A. van Luttervelt, Ir. K.A. Moulijn, Ir. J.M. Ponsen and Ir. A.H. Streppel, all lecturers in production engineering. The final editing was done by this committee under the ultimate responsibility of the undersigned.

The book has already been used for a number of years by lecturers at the Delft University of Technology, University of Twente and many other institutions of higher education in the faculties of mechanical engineering, aeronautical engineering, industrial design and industrial engineering & management science.

This book finds its origin in the effort to improve the quality and effectiveness of education in production engineering at the university and university of applied sciences level. Another important objective of the book is to improve the image and profile of the broad field of production engineering.

During the compilation of this book, the following considerations played an important role:

- Providing knowledge at a level appropriate to students of technical universities and universities of applied sciences who have no prior knowledge of the field.
- Providing a context that expresses the importance of production engineering within the disciplines concerned with the design and manufacture of products.
- Presenting knowledge that takes into account the needs of the industry and devotes ample attention to decision making and other important aspects of technical management.

The book gives a broad and substantial introduction to the extensive field of production engineering and covers fundamental subjects in the areas of manufacture, assembly, materials, material treatments, production machines, quality, costs and the most important aspects of technical and organisational management in an industrial environment. It also contains an introductory chapter on product and production development, with special attention paid to material and process choices.

A series of authors contributed to the book's contents. In addition to the members of the editorial committee itself, the following authors contributed in their specific fields of expertise: Dr Ir. J.P. Baartman, Dr. Ir. J.H. Dautzenberg, Ing. F. Langereis, Ir. Th. Luijendijk, Dr. Ir. D. Lutters, and Dr. Ir. M. Tichem.

The content of all delivered manuscripts has been thoroughly reviewed by the editors and, where necessary, adapted and expanded. During the preparation, much attention was devoted to the aligning of the content, but also to the presentation of the separate texts and chapters. The same applies to the figures, the presentation of which was arranged by Ir. A.H. Streppel and Ir. Cs. Buiting-Csikós. The responsibility for the preparation and content lies entirely with the editors of the final draft.

In addition to the authors and the members of the editorial committee, many others have contributed to this book. My special thanks go to Prof. Dr. Ing. Habil. B. Karpuschewski, Prof. Dr. Ir. R. Akkerman and Ir. P.J.M. Wentzel.

The editors welcome any comments and suggestions that may lead to the improvement of future editions. The address of the editorial committee is:
Redactie Industriële Productie, p/a Ir. Cs. Buiting-Csikós, TU Delft, Faculteit Industrieel Ontwerpen, Landbergstraat 15, 2628 CE Delft, the Netherlands.

Enschede, the Netherlands, March 2016

Prof. Dr. Ir. H.J.J. Kals

Reader's Guide

This book was developed through a collaboration of lecturers from Delft University of Technology, the University of Twente and the Engineering Department of Inholland University of Applied Sciences in Haarlem. Within these institutions, instructors felt a need for a book to support the introductory lectures and practicals in the area of production engineering.

The design of the book included consideration of the industry's growing need for recent engineering graduates who are both experienced in solving problems in the field of design and production and who have knowledge of the integral process of product manufacturing.

The book is limited to the production technologies used in the production of **discrete products**: these are distinctly separate and countable products that are separately distinguishable (whether already assembled or not) and which have a functionally recognisable geometry. Products of the chemical industry (e.g. gasoline) or the food industry (e.g. sugar) are not considered here. Another characteristic of discrete products is that they are movable. Therefore, construction works of any kind also fall outside the scope of this book.

As a result of trade and competition on a global scale, the importance of production engineering as a multidisciplinary field has significantly increased over the past decades. At the same time, the fierce competition has led to extensive reorganisations of large businesses in particular, which aim at reducing scale (business units), outsourcing and achieving 'flat' organisations (lean production). When outsourcing production, it remains important that product designers have and maintain a good knowledge of the possibilities of production technologies and the requirements to be imposed on the product design based on those possibilities. Smaller businesses are especially confronted with the increasing importance of technological knowledge.

A consequence is that the demand for engineers has shifted significantly from large companies (which previously hired the vast majority of recent engineering graduates) to medium-sized and small companies. At the same time, graduates need to have an increasingly broad education because there are fewer opportunities for education and training within companies. This explains the growing demand for recent engineering graduates with sufficient operational knowledge of the field and a good understanding of the needs of the industry.

The increasing relocation of production activities from the traditional industrial countries to emerging industrial countries does not diminish the need for production engineering education in the former countries. New products, manufacturing technologies and means of production are still mainly developed in the traditional industrial countries and the need to educate future designers and business experts in this field is only increasing.

This book is intended to offer a broad overview. Given the nature and scope of the field, it is impossible to achieve any form of completeness in a text book. The broad scope includes subjects such as important manufacturing technologies, along with a discussion of subjects such as the most common processes for material processing and assembly or tooling. It also discusses related aspects of technical production, such as quality, costs and the organisation of production. The connection between product development and production development is also discussed extensively. In addition, the book focuses on issues of decision making in a production environment.

The book is primarily aimed at students of mechanical engineering, aeronautical engineering, industrial design and related disciplines taught in higher education. It is also suitable for other disciplines, such as technical business administration and business information technology, where a basic grasp of manufacturing and production processes is essential.

In addition to the material offered here, it will be necessary to elaborate on one or more of the covered subjects, depending on the field of study or specialisation. For disciplines such as Industrial Engineering and Management Science, the depth of the material related to the technical subjects will be sufficient. It is also possible to skip particular parts, either because they are considered less important, or because they will be discussed in more detail later in the course.

Apart from its use in education, the editors see possibilities for using the book as a reference work for designers, structural engineers and production engineers who, in addition to their business-related knowledge and experience, demand a general and structured overview of the field and the technologies applied in that field.

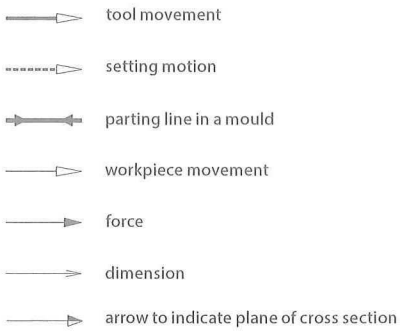
How to use this book

The book is suitable for self-study. To that end, quite a few practice questions are included. Some of these questions are designed to encourage students to become actively engaged with the subject and are therefore less suitable as examination questions. The answers given to these questions are not the only correct ones, but provide an indication of the right line of thought. Other questions would qualify as examination questions.

Only start answering the questions when you have a thorough grasp of the subject. First try to answer them without referring back to the text in the book. If you fail at this repeatedly, you have not sufficiently mastered the material. Study the text further and try to imagine which questions you can expect. Then try to answer the questions again. After answering, go back to the text to check whether you got it right. Only use the answers in the back of the book to confirm your conclusions. In addition to answering the exercise questions, it is strongly recommended that you practise making drawings (a skill that every engineer must possess).

Nowadays, in all kinds of project-based education, there is often a need for much more information on particular subjects than is presented in this book. To meet this need, carefully selected literature references have been included in each chapter. References to specialist literature have been left out intentionally. It is recommended that educational institutions include the works from these reference lists in their libraries.

Various types of arrows occur in the drawings, each with their own meaning:



Technical terms are printed in bold typeface in the places where they are introduced. A list of keywords can be found at the end of the book.

Note on the decimal point

To maintain conformity of the equations and numbers in the Dutch and English editions of this publication, this English edition uses decimal commas instead of decimal points, and full stops (dots) as grouping separators. For example, two thousand is printed as 2.000 and two and a half as 2,5.

The editors wish you the best of luck in studying this book and hope that the knowledge you acquire will contribute to a greater interest in the field.

The editors

Content

As a result of trade and competition on a world scale, production technology has strongly gained importance. This holds not only for the actual manufacturing processes, but also for the technical business management, with subjects such as process planning, production control, cost control, and the organisation of the production company as a whole. This textbook provides an overview of these subjects, with the industrial application as a starting point.

The book concentrates on the production of mechanical products. Most manufacturing processes are discussed, such as those for shapeless materials (e.g. casting, sintering, and additive manufacturing), forming and machining processes, and special manufacturing processes (e.g. electro-chemical, laser and water-jet processes). Subjects such as dividing, joining, heat treatment, surface treatment, assembly, quality assurance, and environmental effects have also been included.

The book includes an introductory chapter on materials, while relevant material behaviour is discussed in relation with the various processes. Attention is paid to the large influence that product development has on the cost price, and to the selection challenges in production environments. These subjects are discussed in particular in a concluding chapter on product and production development.

Industrial Production has been developed as a textbook for mechanical engineering, aviation engineering, industrial design, business management and similar studies in scientific and higher vocational education.

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