

CIRP - The International  
Academy for Production  
Engineering

Luc Laperrière  
Gunther Reinhart  
*Editors*

CIRP

Encyclopedia of  
Production  
Engineering



 SpringerReference

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# CIRP Encyclopedia of Production Engineering



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Production Engineering  
Luc Laperrière • Gunther Reinhart  
Editors

# CIRP Encyclopedia of Production Engineering

With 1145 Figures and 85 Tables

 Springer Reference

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## Preface

Mankind has a long and successful history of continuously adapting to its changing environment. One of the key elements of this adaptation process is the development of precise skills to design, shape, and repeatedly produce objects with various materials that also evolve: from stone to bronze, from iron to steel, from composite to nano materials, the quest never ends. As a result of this long evolution process, today we live in a world of global production: in 2012, for the first time, over 60 million cars were produced worldwide, and over 415 million mobile phones were produced only in the first quarter of 2013! Needless to say, the total production of all goods worldwide has simply become intractable.

It is the thesis of this encyclopedia that in a sustainable world, the knowledge about good design practices, materials, and manufacturing technologies used to produce goods should be easily available and shared. Production engineering is a fast evolving area, and the production map on our little planet, now a global village, has recently undergone very important changes. New technologies are being deployed while manufacturing strategies are constantly changing. Global production networks and supply chains are created and international co-operation is quickly evolving.

Change is certainly not new, but the speed at which it takes place is. Not surprisingly, the technical vocabulary in this engineering domain also experiences significant expansion. New concepts in the fields of design, optimization, control, and management of processes, machines, and systems continuously emerge, thereby increasing the importance of communication and the need for a rigorous and unified technical terminology.

But one must remember that knowledge, rather than being spontaneous, is an incremental concept. Therefore, right from the beginning, the vision behind this encyclopedia was to bring a good balance between fundamental concepts and new emerging ones. In fact, a good proportion of the terms in this first edition is a result of the continuous monitoring and update of established concepts upon which new ones are derived. As such, this encyclopedia is an evolving product where current authors will continuously update their essays based on new technical or economical information, while at the same time new authors will continuously be appointed to write about new emerging topics. It is the main objective behind the *CIRP Encyclopedia of Production Engineering* to provide authoritative, exhaustive, fast, and easy access to such precious, fast evolving information.

The target audience includes researchers, engineers, managers, graduate students, and many others whom day to day work gravitates around production engineering technologies in the global market.

CIRP has a long history of standardizing the terminology for technical terms. Since 1962, CIRP issued a number of trilingual dictionaries of production engineering in English, French, and German. Not surprisingly, technical terms are sometimes interpreted differently in their conceptual contexts in the three languages. The dictionaries took account of this by including both definitions of the terms and, in some cases, explanatory illustrations. In this way, CIRP realized one of its fundamental aims, i.e., to enable correct translation of production engineering terms and to contribute to a clear, unambiguous professional communication in the three languages. Throughout the years, some dictionaries were extended to include Danish, Finnish, Norwegian, Swedish, Italian, Spanish, Portuguese, Chinese, and Turkish translations.

In 2007, CIRP and Springer discussed the idea of creating an electronic web version of the dictionaries, referred to as E-dictionaries, where such things as animations, equations, and cross-links to other relevant terms could be included to further enhance the understanding of the definition of each term. As a natural extension, the idea of expanding the definitions into essays was next discussed. At that time both parties started to refer to the work as an encyclopedia.

In 2009, a pilot project involving 15 essays, 5 in each section of Forming, Cutting, and Assembly, was initiated. Later on that year, a wiki platform was developed and improved by Springer staff according to the feedback and comments provided by CIRP. After the platform was judged to be at an acceptable level of functionality, Editors in Chief and Section Editors were appointed and Authors were invited to start using the platform to submit the 15 pilot essays. A successful demo took place at the CIRP general assembly in Boston in August 2009. From then on, the Editors in Chief created a list of 256 most relevant technical terms to include in the first edition of what is now called the *CIRP Encyclopedia of Production Engineering*. It contains more than 1300 pages, available both in print and online, organized around 11 chapters:

- Abrasive Processes
- Assembly
- Cutting
- Design
- Electro-Physical and Chemical Processes
- Forming
- Life Cycle Engineering
- Machines
- Precision Engineering and Metrology
- Production Systems and Organizations
- Surfaces

Certainly, the most fundamental aspect behind the *CIRP Encyclopedia of Production Engineering* is quality of content. This comprehensive work involves the contribution of more than 200 authors from all around the

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world, mostly CIRP fellows, associates, corporates, or affiliates considered as leading authorities in their field. A thorough review process of each essay was established under the leadership of each of the 11 Section Editors. We hope the reader finds it as useful referring to it as it was a great experience for us building it.

Professor Luc Laperrière  
Professor Gunther Reinhart  
Editors in Chief



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## A word from CIRP

The International Academy for Production Engineering Research, also known as CIRP<sup>1</sup>, is the world leading organization for production engineering research and is at the forefront of design, optimization, control, and management of processes, machines, and systems for manufacturing. CIRP promotes research and development among its members from Academia and Industry to contribute to the global economic growth and well being of society. In this context, one of the most fundamental roles of CIRP as a global organization is to ensure as far as possible that the terminology used be standardized and common across all nations of the earth.

To date, the main publications of CIRP have been the *CIRP Annals* (Manufacturing Technology) and the *CIRP Journal of Manufacturing Science and Technology*. The *CIRP Annals* are published under ISI standards each year in two volumes: Vol. I, with refereed papers presented during the CIRP General Assembly as well as Vol. II with refereed keynote papers. The *CIRP Journal of Manufacturing Science and Technology* is published each year in four volumes. CIRP also publishes the trilingual Dictionaries of Production Engineering. Beside these main publications, a Newsletter is published twice a year, as well as CIRP Internal Documents and Reports from CIRP General Assemblies available on the CIRP website ([www.cirp.net](http://www.cirp.net)). Finally, the Proceedings of CIRP Conferences are available online on the Procedia CIRP website.

Six years ago, the CIRP Terminology Committee decided to follow a totally new pathway in answer to the new age of advanced communications technology, to the advancing internet-age, and to the cloud capabilities. As an outcome of the work undertaken, an online platform was launched in 2012 for the provision of authoritative, exhaustive, fast, and easy access to terms, definitions, and a whole set of information in the field of production/manufacturing engineering. The *CIRP Encyclopedia of Production Engineering* is now launched and represents the natural extension of the current CIRP Dictionaries of Production Engineering. This Encyclopedia consists of a list of essays that describe each term with definitions, theory, and applications. It is available both in print and on a website ([www.springerreference.com](http://www.springerreference.com)). The definitions are based on the current

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<sup>1</sup>The acronym CIRP comes from the French appellation of the Academy, namely Collège International pour la Recherche en Productique), headquartered in Paris

The CIRP Encyclopedia covers the state-of-art of advanced technologies, methods and models for production, production engineering and logistics. While the technological and operational aspects are in the focus, economical aspects are addressed too. The definitions and short explanations for a wide variety of terms were reviewed by the CIRP-Community, representing the highest standards in research.Â CIRP is the world leading organization in production engineering research and is at the forefront of design, optimization, control and management of processes, machines and systems. The Academy has restricted membership based on demonstrated excellence in research and has some 550 academic and industrial members from 40 industrialized countries.