Mechanisms and Machine Science 19

Juan Carlos García-Prada
Cristina Castejón *Editors*

New Trends in Educational Activity in the Field of Mechanism and Machine Theory

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Preface

Proceedings of ISEMMS

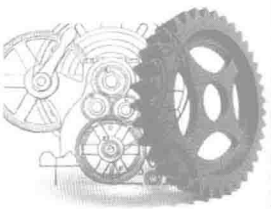
Education is of primary interest for any academic community. This symposium is the first of a series that is organized by Permanent Commission (PC) for Education of IFToMM, the International Federation for the Promotion of Mechanism and Machine Science (MMS). IFToMM has addressed attention to Education of MMS since its beginning in 1969 with discussions and plans in several frames. After many years and several attempts, the IFToMM Executive Council has supported the organization of ISEMMS, IFToMM Symposium on Education of MMS since 2010 thanks to the efforts by Prof. Juan-Carlos García-Prada in his position of PC chair. The team at the Carlos III University in Leganés, Spain, as coordinated locally by Prof. Cristina Castejón did a great job attracting several interesting contributions in the many aspects of MMS Education. Authors from all around the world have presented their views and information about current situations and possible future perspectives.

I am sure that this ISEMMS will be the start of a successful series of conference events where the PC activity can be worked out in the visibility of its achievements in coordinating the IFToMM community in the several aspects of MMS education, as asked during my IFToMM Presidency. Nowadays more than in the past, there is a need to share and discuss the current problems in MMS education with the aim to give solutions and to identify proper trends for a modern worldwide common vision that will consider MMS still a core area in Engineering formation within Technology developments for Society enhancement.

This is to congratulate the organizers and authors for this book giving an overview of problems and situations on MMS Education with several points for future discussions and possibilities of improvements of our future.

Leganés, June 2013 Marco Ceccarelli

Introduction



ISEMMS 2013

1st International Symposium on the Education in Mechanism and Machine Science

June 13 & 14, 2013, Madrid, Spain

The First International Symposium on the Education in Mechanism and Machine Science (ISEMMS 2013) is the first event of a promising series of symposiums focused on Mechanism and Machine Science (MMS) education. In the 1970s of the last century, Prof. Artobolevsky proposed a first seminar about 'Education in MMS'. Today, many years after this pioneer seminar, the Permanent Commission (PC) of Education of IFToMM has established these new series symposium. This first conference has been held at Madrid on June 13–14 of 2013.

The aim of the ISEMMS symposium is to establish a forum where teachers and researchers interchange experience in the field of MMS.

We have received 44 abstracts by authors from all around the world. After the review process 32 contributions were selected for presentation and publication in this book. The program of ISEMMS 2013 has included technical sessions with oral presentations, two plenary sessions and social activities that enhanced to share experiences, discussions and let all the participants to start new collaborations among them. The contributions cover topics related with new trends and experiences, mechanical engineer curricula, methodology and virtual labs.

We would like to express grateful thanks to the members of the steering committee for ISEMMS 2013 who have collaborated for the success of the symposium, especially Professors Pietro Fanghella, Joerg Bauer and Olga Egorova.

We thank Universidad Carlos III of Madrid (UC3M), IFToMM, AEIM (Spanish Association of Mechanical Engineering) and the Mechanical Department of UC3M for the financial support for the ISEMMS 2013.

We thank to the members of MAQLAB research team for the great effort they have made during the preparation and holding of the symposium. They have done a very good job.

We also thank Natalie Jacobs and Anneke Pot (Editorial board of Springer) for the editorial support of this book.

And finally, we would like to acknowledge the invaluable support of Marco Ceccarelli during the first stages of this symposium and the continuing help to achieve with success the ISEMMS 2013.

We thank the authors for their excellent and interesting contributions. We think the works presented in this book will be of interest for the MMS educators community and the ideas, experiences and developments presented shall enhance the quality in this main area.

Juan Carlos García-Prada
Cristina Castejón

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Part I
Mechanism and Machine Science in the Mechanical Engineer Curricula

Historical Accounts on the Figure of Engineers and Academic Mission for their Formation

Marco Ceccarelli and Roberto Bragastini

Abstract The mission of academic formation of mechanical engineers is strongly connected with role of their profession in the society. This has evolved from practitioner on field to a science teaching through a slow evolution. This paper is an attempt to outline the main aspects of historical developments as well as current critical issues in recognizing a significant role to mechanical engineering and its academic formation. In particular, the paper presents an historical evolution of the understanding of engineers figure and consequently it outlines the mission issues in a modern academic formation.

1 Introduction

Today the figure of engineers suffers of considerable reduction of significance and influence in the society when compared with respect to the great reputation in the past. Even more is the reduction of authority for mechanical engineers.

What are the motivations of such a less attraction to science and technology in this modern time that nevertheless is dominated by the success of engineering?

The problem has been attached and still is attached at several levels and with different views in these last years and a considerable literature is already published on the topic. Strong attention is address within formation (University) frames and professional applications, even with discussion of reform proposals.

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This paper is an attempt to explain the current situation by looking at the historical evolution of the figure and task of engineers as understood within a technical community whose authors are members with different experiences and perspectives. Thus, the authors have discussed and illustrated the significance and success of engineers though significant examples over the time, with the aim to stress the cultural importance of engineers in the society with a vision for better life quality as consequence of a proper merit and consideration of engineers activities.

2 On the Term of Mechanical Engineer

The figure of mechanical engineers can be understood when mechanical issues are understood by looking at the corresponding terminology that can be summarized by referring to IFToMM definitions [6, 11, 12]:

- Machine: Mechanical system that performs a specific task, such as the forming of material, and the transference and transformation of motion and force.
- Mechanism: System of bodies designed to convert motions of, and forces on, one or several bodies into constrained motions of, and forces on, other bodies.

A modern term MMS (Mechanism and Machine Science) has been adopted within the IFToMM Community to better indicate the complexity of modern machines as:

- Mechanism and Machine Science: Branch of science, which deals with the theory and practice of the geometry, motion, dynamics, and control of machines, mechanisms, and elements and systems thereof, together with their application in industry and other contexts, e.g. in Biomechanics and the environment. Related processes, such as the conversion and transfer of energy and information, also pertain to this field.

Interesting is the evolution of machine definition that can be summarized thought the following significant examples:

- By Marcus Pollione Vitruvius (he lived in first century B.C.) in De Architecturaliber X, translated and discussed by Daniele Barbaro in [2]: "A machine is a combination of materials and components that have the capability of moving weights";
- By Galileo Galilei in Le Mecaniche [8]: "A machine is a means by which a given weight will be transported to a given location by using a given force";
- By Paolo Branca in [4]: He described machines by stressing "the operation as consumption of motor power and changes of weights in functions of time history, cost and operator skill";
- By Jacob Leupold in [16]: He treated the description of machines and mechanisms referring to "their aim of modifying motion rather than just the construction of machinery";

- By Josè Maria de Lanz and Augustin de Betancourt in [15]: "In agreement with Gaspar. Monge, we consider as elements of machines the devices than can change the direction of the movements...the most complicated machines are only combinations of those capable of single movements";
- By Robert Willis in [22]: "I have employed the term Mechanisms as applying to combinations of machinery solely when considered as governing the relations of motion. Machinery as modifier of force";
- By Franz Reuleaux in [19]: "A machine is a combination of bodies capable of withstanding deformation, so arranged as to constrain the (mechanical) sensible forces of nature to produce prescribed effects in response to prescribed input motions";
- By Francesco Masi in [17]: "Hence we name: as mechanism a kinematic chain that has been fixed on one of its components; as machine a mechanism whose components make mechanical work";
- By Gabriel Koenigs in [14]: "A machine is recognized as an assembly of resistant bodies that are constrained reciprocally and are under the action of natural forces. If you abstract from forces, the remaining of a machine consists of bodies and constraints. This is a mechanism";
- By Richard S. Hartenberg and Jacques Denavit in [10]: "The term machine is associated with the use and transformation of force, and although motion is varying degree is encountered in a machine, the idea of force dominates. Mechanism, on the other hand, definitely conjures up the idea of motion, and while forces do exist, they are relatively small and unimportant compared with the exploitation of motion";
- By Joseph Edward Shigley and John Joseph Jr Uicker [13]: "A machine is an arrangement of parts for doing work, a device for applying power or changing its directions. It differs from a mechanism in its purposes. In a machine, terms such as force, torque, work, and power describe the predominant concepts. In a machine, though it may transmit power or force, the predominant idea in the mind of the designer is one of achieving a desired motion";
- By IFToMM, the International Federation for the Promotion of Machine and Mechanism Science [12]: "A machine is a mechanical system that performs a specific task, such as the forming of material, and the transference and transformation of motion and force; and a mechanism is a system of bodies designed to convert motions of, and forces on, one or several bodies into constrained motions of, and forces on, other bodies".

More specifically the meaning and role of (mechanical) engineers have evolved from the different perspectives.

Today in the Oxford dictionary [18] an engineer is defined from historical viewpoint as 'a designer and constructor of military works' and from general understanding as 'a person whose occupation is the design, construction and maintenance of works of public utility'. Similarly, from Italian UTET dictionary [21] in antiquity an engineer was a person, who designed and built any kind of devices and machinery, with particular mention to war machines and hydraulic systems. Today from

general understanding an engineer is a person, who with a formation on science and technology works for design, construction, and operation of systems, [9].

From the above few examples (and more can be noted as from other countries) it is remarkable that still today there is not a well focused understanding of the figure of engineers with a well identified role and activity, although is universally recognized the specific activity of engineers in developing systems for the needs of the society.

From legal viewpoint the situation is even more confused and still under definition, both at national and international levels, since the today large variety of engineering fields and their areas of implementations both in scales and natures of the objects they refer to. Other situations have complicated the situations. For example historically in Italy the legal definition of the figure of engineer has suffered a fragmentation due to the several kingdoms that were persistent for centuries and only the unification in 1861 imposed a need of a unique legal position that nevertheless was not easy to achieve and it still under reforming actions, due to also European constraints beside professional prerogatives and perspectives even on local conditions.

An understanding of the role and activity of engineers can be understood by looking at the epistemology of the term engineer. A short account is given in the following.

The term engineer was coined through an evolution from a word in Latin that was used at the end of the Roman empire at the end of fifth century up to a modern meaning that was established at the time of the Ecòle Polytechnique in Paris at the beginning of nineteenth century. Technical formation of engineers, as independent from military corps, was a need felt around the world for the demand of engineers in the developing technology since the early stages of Industrial Revolutions.

A specific term as 'ingeniator' appeared in eighth and ninth century in south France and north west Italy to indicate the profession of builders of apparatus. Just later the term evolved to 'engineor' and 'engineur' in south France, where as in north Italy it became 'encignarius'. In particular, a first mention of the term can be found in a legal act in Genova, Italy with the date of 19 April 1195 where the role of a cited Rainaldus is named as 'encignerius', [20]. Relevant is also an edict by Ludovico il Moro, duke of Milan who in 1492 prescribed that civil constructions must worked out by 'ingeniarii'.

3 Role and Activity of Mechanical Engineers

A historical survey of the role and activity of (mechanical) engineers over the time can be outlined by looking at emblematic personalities, but also without forgetting the many anonymous persons. In the following a short survey is reported to indicated main characters over the time.

Archimedes (287–212 B.C.) can be considered a first machine engineer with a very strong scientific activity [7], by combining theory (investigations) and practice (applications). Because of both aspects he had a great reputation also in the centuries after his death.

Francesco di Giorgio (1439–1501), although architect, was the typical Renaissance engineer. He dedicated lot of successful efforts in designing, constructing, and operating a large variety of machines for the enhancement of production and help of human labour, including automata for entertainment. Most of his machine designs were improvements of previous solutions, but several ones were products of his ingenuity with long-duration engineering source.

James Watt (1736–1814) is considered the first modern mechanical designer engineer since he improved and indeed made powerful the steam engine with proper mechanism designs completing an efficient motion and power transmission, with an empirical ingenuity that was later the base for advances in theory and practices of mechanisms and machines.

Augustin Betancourt [12] can be considered the first modern manager mechanical engineer since he used his knowledge and expertise on mechanical systems both in theory and design in developments for Industry frames in several countries (Spain, Frances, Russia) to give a supranational impression of the figure and role of engineers, with a great reputation and influence.

Franz Reuleaux [19] can be considered an emblematic example of modern scientist in MMS, who studied the many possibilities of mechanisms for machine design both by developing a general theory and applying it in practical industrial applications.

Ivanov I. Artobolevski [1] can be considered a modern mechanical MMS engineer, who has centred his activity on Mechanism Design to elaborate the successful most wide mechanism handbook as results of his activities in practical engineering based on theoretical works. His success as mechanism designer and inventor gave him a great reputation and role in many frames of the society both at national and international levels.

Corradino D'Ascanio (1891–1981) can be considered an emblematic example of engineer inventor of machines of current technology, since his creativity and MMS formation gave him the possibility to design and produce brilliant market-successful machines, like the scoter Vespa and first helicopter.

The above are examples of figures with significant activity in engineering with an influential role in the developments in Technology and finally in the society. But they have reached those goals also thanks to a multitude of anonymous engineers whose works has prepared and indeed stimulated those achievements. A specific large literature to which a reader can refer, is available, even with several different perspectives, on each of the above personalities and many more, with details of their legacy and contributions on technological developments and education enhancements.

4 On the Formation of Engineers and Mission of University

Today professional mechanical engineers are formed, even with a time sequence, within the frames of University, professional Unions, and enterprise training. Engineers receive formation with mainly information and theoretical backgrounds during University curricula; specific profession-oriented formation is offered within