A history of TMM-MMS in Italy

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Abstract

In this paper a brief account of historical development of TMM in Italy is presented by discussing main aspects with peculiarities of Italian frames by using significant illustrative examples of personalities and works. This historical background is the base for the current activity of the Italian community working on MMS as linked also to IFToMM. Research, teaching, and application development on MMS are today carried out by teams in 32 Italian Universities with success both within national frames and with international collaborations.

Keywords: History of TMM, History of Kinematics, Italian Developments

1 Introduction

National associations and university teams state the identity of a discipline and corresponding community as well as they are the core for activity in discipline developments. Indeed the history of a discipline is very often the history of a community with people and works that are developed to define and further develop the discipline and community yet, [1]

TMM (Theory of Machines and Mechanisms) has been identified at the beginning of 19-th century all around the world with local and national communities working in university frames but also very successfully at professional levels with enhancements of Technology through up 20-th century as a fundamental base for Industrial Revolution and Modern Technology. TMM has evolved and at the end of 20-the century it has been better identified as MMS (Mechanism and Machine Science) since the more broad and extended meaning and activity of the disciplines on Machines and Mechanisms. Similarly IFToMM, the International Federation for TMM has been renamed as IFToMM, the International Federation for Promotion of MMS in 1998, [2]. Nowadays IFToMM community represents the international body at world level identifying the community and activity that is related to MMS, [3]. IFToMM member organizations at territory level are the units that are based on national associations and university teams with links and participations from industrial world working on MMS. Italy IFToMM is one of these units with national characters but with international links in its activity and identity.

The characters of Italian community are outlined in this paper by looking at its history with the people, who have been their main representatives and also promoters. Since the beginning of engineering developments Italian community has been very active by producing personalities and achievements that not always are known outside Italy and therefore they are not recognized within the international frames and in history of engineering at large. This paper is an attempt to fill this gap to give proper merit to Italian community within the history of mechanical

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engineering and to present the today community with such a historical background.

2 Italian Community on MMS

The today Italian community working on MMS is mainly identified by the university teams that are aggregated in GMA, the national Italian Group on Mechanics of Machinery (that is the English word for 'GMA, Gruppo Italiano di Meccanica Applicata alle Macchine), [4]. GMA is composed by teaching staff in Italian universities working in fields of MMS as indicated by Italian law in the academic sector 'SSD ING-IND 13, Meccanica applicata alle machine' for the Ministry for University. Currently the group composed by 196 professors in 32 universities and other 10 retired professors.

The aim of GMA is stated in its constitution at article 2 as to promote and coordinate the scientific research within MMS in national and international frames; to be the body for interactions for law requirements on research and teaching issues; to facilitate collaborations and interactions among the GMA members and other institutions and societies; to facilitate membership of GMA members in other bodies and teaching initiatives mainly in each Italian University; to stimulate divulgation of Italian MMS at national and international levels.

According to the Italian Law DM 4-10-2010 the sector is aimed to develop cultural and professional aspects that are related with the study of mechanical systems through methodologies from theoretical mechanics. The mechanical systems of interest are those in which motion and power transmission are fundamental for their operation, such as the traditional machinery but also innovative systems in all applications like robots, biomechanical devices, and nano-machines. Interactions are also aimed for research, teaching and applications such as in Mechatronics, Vibration technology, and Tribology. The research activity and professional formation are linked to the teaching activity thorough courses at the different levels of the university formation with characters of basic courses like Mechanics of Machinery, Vibrations, Simulation of Mechanical Systems; specialist courses like Mechanics of Robots, Control of Mechanical Systems, Functional Design of Mechanical Systems, Mechatronics, Tribology, Fluidic Systems, Mechanics of Vehicles, Mechanics of Automatic Machines.

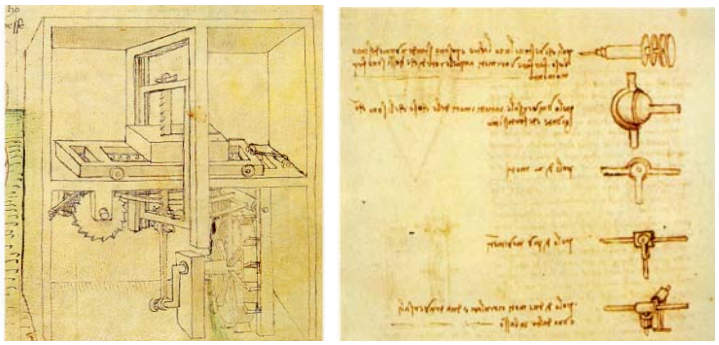
GMA has links with several international bodies and one specific sector of GMA is IFToMM Italy as related to the international communities for MMS.

3 Early Works and Backgrounds

An early discipline with a corresponding community was developed since Renaissance because of increasing need of machinery that was indeed conceived, designed, built, and operated mainly by early professionals of machine design and architects, [5]. Since then research and development were started with new solutions that still have contents of modern interests, like the example in Fig.1. First studies were elaborated by Francesco di Giorgio and Leonardo da Vinci to give a theoretical basis and the dignity of a scientific discipline to machine design. Thus, first personalities were recognized even by the society as professional designers, science designers, practitioners, and architect users like Filippo Brunelleschi, Mariano di Jacopo (il Taccola) (1382-1458?), Francesco di Giorgio, and Leonardo da Vinci,

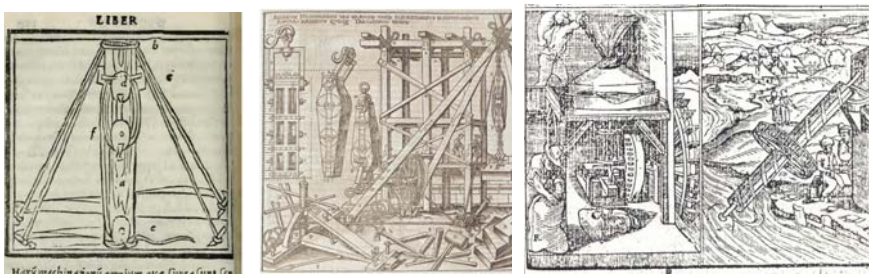
among many others, Fig.3, [5].

Machine design attracted also humanistic scientists by looking at the antique machines in classical treatments from the Greek-Roman literature that was discovered, like the case of Vitruvius's work. This interest gave also the possibility to enhance machinery because of discussions for interpretation and redraws of the described machines, Fig.2. Thus personalities from Academy were attracted to the field up to give a scientific approach to machine design. Relevant in this developments are Guidobaldo Del Monte and Galileo Galilei, Fig. 3 among many others.



a) b)

Figure 1: Early mechanism designs, [5]: a) automatic saw machine by Francesco di Giorgio; b) catalogue of basic joint components by Leonardo da Vinci.



a) b) c)

Figure 2: Treatise on Roman machines by Vitruvio as reconsidered by: a) Fra' Giocondo in 1511; b) Cesare Cesariano in 1521; c) Daniele Barbaro in 1584.

a) b) c) d) e)

Figure 3: Early founders of Italian MMS: a) Filippo Brunelleschi (1377-1446); b) Francesco di Giorgio (1439-1501); c) Leonardo da Vinci (1452-1519); d) Guidobaldo Del Monte (1545-1607); e) Galileo Galilei (1564-1642).

In particular, Guidobaldo del Monte used the Archimedes' approach to study the mechanics of machinery mainly as a humanistic discovery of achievements from Antiquity, but still with an eye to practical problems of the time. Galileo Galilei elaborated the Mechanics of machines with more clarity and practical purposes within a technical interest since he approached the subject within his teaching activity at University by giving the first course 'Le Mecaniche' on Mechanics of machinery in the years 1593 – 1604 at Padua University. The notes of this course is a first textbook on TMM; it gives a classification of machinery; it gives formulation for operation and design of machines with a unique principle, [6].

Francesco di Giorgio was the first, who elaborated a handbook on design and operation of machines, as specifically for pumping systems. Only much later the topics was accepted for printed publications in the form of treatises/handbooks such as theatrum maquinarum mainly with aims of dissemination of technical skills of the authors. This is a tradition that was persistent along the centuries and it is still today used in the catalogues and handbooks, [7].

Beside increasing attention to practical aims of mechanism design, a mathematization of machine performance was also developed even with very theoretical approaches. An example of the high of those studies can be represented the work by Giulio Mozzi (1730-1813) on Screw Theory, [8].

In 18-th century regular courses on Mechanics were given at Universities with sections that were somehow directed to machine design. Illustrative examples are the significant works by Alessandro Vittorio Papacino d'Antonj in Turin, Ruggero Boscovich in Milan, Guido Grandi in Pisa, Paolo Frisi in Milan and Pisa.

Emblematic is the personality of Paolo Frisi (1728-1784), who was professor at Universities of Milan and Pisa, where he addressed great interest to kinematic aspects of Mechanics. He also encouraged the study and work of his pupils and particularly, Giulio Mozzi, who published in 1763 a fundamental work, [8], that can be considered the base of modern Screw Theory, [9]. Frisi is believed to have been the first to have formulated correctly the composition of instantaneous rotations as reported in [10].

Reasons for reduced significance of Italian works within international frames can be identified in:

- several small kingdoms before Italy unification
- efforts to obtain a unified culture and organization after Italy unification
- the 19-th century is considered a recent past in the Italian culture

The cultural influence of Italian Universities was reduced so that in the 19-th century they were not considered centres of excellence as they were in the past. Nevertheless, specific developments were obtained and original contributions proposed.

4 Developments in 19-th century

19-th century is the Golden age of TMM, which was the basis for Industrial Revolution with the development of better and better machinery with strong mechanical structure and kinematic performance. Significant Italian personalities of a large community disseminated in the country can be recognised in first half of the century in Giuseppe Antonio Borgnis, Carlo Ignazio Giulio, Gaetano Giorgini; and in second half of the century in Ernesto Cavalli, Domenico Tessari, Lorenzo Allievi, and Francesco Masi, [11].

Giuseppe Antonio Borgnis extended Monge's view by including a description of machine components in terms of "receptors, modificators, frames, regulators, and operators"; but then he catalogued the existing machines also by referring to practical uses,. His Encyclopedic work in 9 volumes, [12]**,** was used as reference first modern technical handbook by practicing engineers along the whole 19-th century and not only in Italy. Borgnis completed the encyclopedic work with publication of the "Dictionnaire de Mecanique appliquèe aux arts" in 1823. This is a brilliant synthetic dictionary with technical terminology for Mechanical Science.

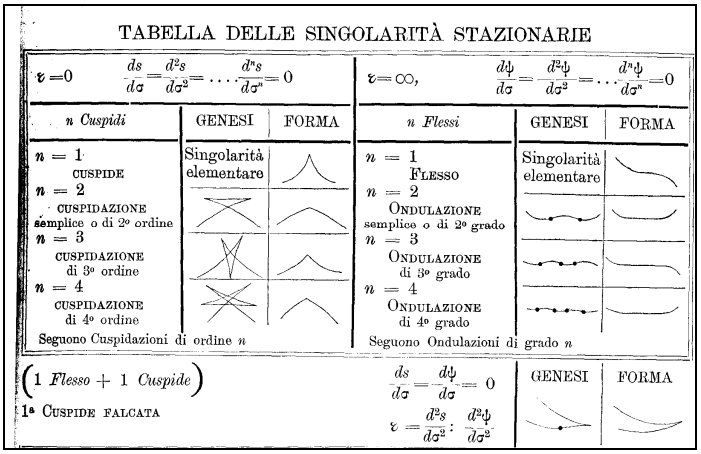
Since 1831 Carlo Ignazio Giulio was professor of Pure and Applied Mathematics at University of Turin. In 1845 he was one of the founders of the School of Engineering in Turin, where he gave class on early modern Kinematics by using his textbook 'Lezioni di meccanica applicata alle arti'. It is to be noted that it was only after the publication of the masterpiece by Ampere who introduced the term and discipline of Kinematics in 1834 that specific courses on Kinematics were started all around Europe. Poncelet gave a first course in 1838 at the Sorbonne in Paris, and in 1845 Giulio started its classes at the School of Engineering in Turin with analysis algorithms and synthesis criteria by using preferably arguments based on Descriptive Geometry, but also graphical procedures are outlined with clear explanation.

Besides textbooks, in Italy like in other European countries, there was a tradition to present research results at Academies both with oral and written contributions in theoretical studies with no mention to practical applications or mechanical design of mechanisms. A brilliant Italian example is the paper 'Intorno alle proprietà geometriche dei movimenti di un sistema di punti di forma invariabile' by Gaetano Giorgini, who in 1836 published that fundamental work for Screw Theory where he demonstrated contemporarily to Chasles the existence of Screw Axis in a modern way. He also proposed a rigorous early modern formulation for the study of spatial Kinematics. Gaetano Giorgini was pupil at Ecole Polytechnique together with Michels Chasles, who was his lifetime friend, and later he became Senator of recent established Italian Kingdom.

In the second half of the 19-th century there were established Schools of Engineering in most of the Italian Universities, but it was only after the Decree of 3 July 1879 that the course "Kinematics Applied to Machinery" was introduced on a regular basis in the curricula of industrial engineers, [11].

In Turin, following the work by Lagrange and Papacino, courses on TMM were given by Carlo Ignazio Giulio, Galileo Ferraris, Domenico Tessari, Scipione Cappa. Other contributions were given by Elia Ovazza (who seems to be the first female engineer and TMM teacher in Italy), and Mario Panetti. In Milan, after Ruggero Boscovich relevant Academic personalities can be recognised in Ernesto Cavalli and Gian Antonio Maggi. Other works are those by Ugo Ancona, Giusto Bellavitis, and Ernesto Padova. In Bologna, after Gaetano Giorgini, Domenico Chelini, and Francesco Masi gave significant contributions on TMM. In Rome works in TMM were written by Ugo Cerruti and Carlo Saviotti. A short contribution was given by Lorenzo Allievi, who nevertheless published a masterpiece, [13], on planar kinematics after giving lectures for only one year, [14], Fig.4. In Napoli, an important personality on Mechanics at large was Giovanni Battaglini and in the field of TMM Dino Padelletti reached a good reputation. In addition, some professors were involved in promoting the academy and specifically TMM in more than one University also with the aim to establish a common academic frame in the recent unified Italian nation (achieved in 1861). An emblematic example is Ernesto Cavalli

who taught in Milano, Livorno, Pisa and Napoli, as reported in [11].



a) b)

Figure 4: a) Lorenzo Allievi (1856-1941); b) a classification of coupler curves from "Cinematica della Biella Piana" published in 1895.

In 1882, Ernesto Cavalli wrote a treatise "Fundamentals of Theoretical Kinematics" with modern views and methodologies; in 1890, Domenico Tessari wrote the book 'Kinematics Applied to Mechanisms" for teaching purposes as a theoretical treatise on kinematical properties of mechanisms with the aim to include existing devices and even new solutions that can be also of no interest for practical applications by using mainly descriptions and geometrical arguments in order to avoid complicated analytical expressions (as declared by Tessari); in 1883 Francesco Masi wrote "Manuale di Cinematica Applicata" within which he proposed a classification and numbering of mechanisms after Reuleaux (1875) approach with identification of up to 10,362,600 composed quaternary mechanisms. In particular, Francesco Masi (Guastalla 1852 – Bologna 1944), [15], gave relevant contributions that circulated successfully with a memory still persistent in Italian Schools of Engineering on Technical Drawing for Machinery, of great interest for Technical Colleges for many years; Friction and early Tribology, as a significant early development of modern Tribology for practical applications; and TMM and Mechanism Design. In 1897 he wrote book "Theory of Mechanisms" for teaching purposes within the course mechanics applied to machines, but very useful also for practising engineers, since it contains a well ordered collection of mechanisms and transmissions with outline of analysis and design algorithms. The book is divided in two parts, namely the first part treats planar motion of rigid bodies, including a brief account of screw motion for application to spatial gears; and the second part contains a significant classification of mechanisms and in-depth study of the collected mechanisms. After reviewing previous classifications of mechanisms by Monge, Willis, and Haton de la Goupillierre, in his book Masi proposed a novel symbolic notation for mechanisms by using composition of elementary mechanisms and kinematic pairs.

Beside the academy frames there were also development and achievements from singular scientists, professionals and industry managers, like for example the conceive and design of the first writing machine that was proposed as based on

mechanisms by the layer Giuseppe Ravizza (1811-1885) in Novara with a patent 'Cembalo scrivano' in 1846, with a credit by Olivetti only in 1927.

Following so strong tradition of the second half of 19-th, the field was growing during the first half of the 20-th century but with a scarce evidence due mainly to secret limits for war constraints. Then in 1950s the community has been revitalized with links to worldwide community as it is nowadays, but still preserving its identity and activity within national frames.

5 A History of Current GMA

GMA was founded in 1986 with a slight different name at Technical University of Milan under coordination of prof. Arrigo Vallatta and since the beginning it attracted all from the Italian MMS community. Then in 1989 at its first general assembly a constitution was approved and a first President was elected in the person of prof Vallatta with a two year term. The history of GMA can be summarized with the president sequence as:

- 1989-1991: prof. Arrigo Vallatta. (Milano)
- 1992-95 e 1996-2000: prof . Antonio Trentadue (Bari), with annual GMA conference from 1993 to 1998
- 2001- 2002 e 2003-2005: prof Sergio Della Valle (Napoli), with a GMA conference in 2004
- 2006-2007 e 2008-2009: prof. Guido Belforte (Torino) with annual GMA conference in 2006 and 2007
- 2010-2011: prof Aldo Rossi (Padova)

At the GMA conferences not only research subjects were presented but the community discussed the problems of the reforming activity imposed by the government both in the teaching and research systems.

Before GMA, the Italian TMM-MMS community was grouped within AIMETA, the Italian Society of theoretical and Applied Mechanics, that was funded in 1965, an still it is present in its activity within a biennial conference.

GMA has been active within IFToMM since the foundation of IFToMM with several officers and leaders, and today is well identified as IFToMM Italy with a well established activity in all prescribed aspects of participation, conference organization, publications, and collaborations. Similarly, members of GMA are active singularly or grouped in sub sections of other international bodies for international activity to link and promote the local achievements, like for ASME, IFAC, IEEE, EUROMECH, EUCOMES, RAAD.

In addition, an intense activity is still based within national frames within national programs for research and teaching, giving results of considerable relevance that sometimes are published only in Italian, like for example the book [16].

6 Conclusion

Early approaches can be recognized since Renaissance time both with practical designs and theoretical works. Afterwards, in 17-th and 18-th centuries there was a period of reduced significance mainly due to lack of visibility for the many kingdoms and different cultural frames within which nevertheless important achievements were reached, as for example the Theory of Screw motion by Mozzi in

1763 following the milestone works by Frisi in Pisa. Golden Age was experienced during the 19-th century because of the Industrial Revolution, but also because of the unification of the Italian nation, both theories and designs were produced within very fecundus university frames that are not well known abroad mainly for language barriers. In this paper main works are reviewed and main achievements are stressed as a background for the today community in Italy, which is present in 32 Italian Universities with activity in all the fields of MMS .

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