TRENDS IN PRODUCT DEVELOPMENT: CONCURRENT ENGINEERING AND MECHATRONICS

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Abstract: *This paper presents the most significant contemporary trends in new industrial product development: concurrent engineering (CE) and mechatronics (M). Author defines what CE and M are, emphasizing what connections are between these two concepts, and which are the ways of integration in CE and M. The main conclusion of this paper is that both these two concepts have known a strongly development in 1975-1985's, when Information and Communication Technologies (ICT) was in full swing of development. The influence of ICT is undoubted, but, from this point of view, there are differences: if M could not be implemented in the absence of the ICT, communication and computational technologies are not strictly necessary for the implementation of CE.*

Key words*:* industrial product development; electromechanical engineering;

1. INTRODUCTION

In the real world, mechanical engineering and electrical engineering are inextricably entwined. Every electrical device is also a mechanical device designed for its electrical properties and manufactured in a factory of mechanical machines and many mechanical devices are partly electrical and most are made by machines that are electrically powered and electrically controlled. Electromechanical **(**EM) engineering is interdisciplinary and deals with devices and systems combining electrical and mechanical phenomena. This art has been growing for over a century, but only recently, for less then 40-45 years, under the impact of Information and Communication Technologies **(**ICT**),** EM has a new name mechatronics (M**).** An older term, than M, that is applied to the engineering design philosophy of cross-functional cooperation in order to create products that are better, cheaper and more quickly brought to the market is concurrent engineering(CE**)**.

In the last 50-60 years, several well established industrial paradigms are undergoing dramatic shifts: A first shift has been produced from traditional sequential engineering toward what is called now concurrent engineering. The second paradigm shift of interest here has to do with how meta-product and the production machinery are evolving, in order to cope with, to fast, changing customers'tastes, present day products being increasingly personalized. The way to cope with this problem is to design and build products and meta-products in terms of plug/and play compatible modules. The mechatronics framework can be a guide to optimize the design of the modules and to provide suitable interfaces at all levels**,** as well between the modules or the machines as with the outside world (task programming, man-machine interface a.s.o.).

2.WHAT CONCURRENT ENGINEERING AND MECHATRONICS ARE?

Although there are no well accepted definitions, most authorities would probably concur that CE integrates the new product development process to allow participants making upstream decisions to consider downstream and external requirements. All functional aspects of a product - a component, a machine or a machine system for our purposes – have to be considered simultaneously, from the very beginning of the design cycle, and confronted with the capabilities offered by the different engineering disciplines and their interactions.

The ideas of CE are traceable continuously from the beginning of the XXth century till now. My belief is that CE ideas have existed all along and have always been applied by companies that were using a sophisticated approach to product development.

The first paper, I know from the literature on the management of the design process, that has put the accent on the relationship between the design department, manufacturing and other function as an essential function of engineering design lasts from 1904 year [1]. The papers published, later, pointed out some of the ideas were used in pre-war projects in some companies and how CE ideas were applied during the Second World War. After the Second World War, the application of CE ideas became significantly less prevalent until these ideas have been rediscovered during the late 1970's-early 1980's.

M is a methodology used for the optimal design of electromechanical design and for the integration of the electronic control systems in mechanical engineering. The term M was first introduced in Japan by a Yaskawa Electric Enterprise engineer in 1969 as a combination of "mecha" of mechanisms and "tronics" of electronics. A trademark rights were granted in Japan in 1972 [2]. But, in 1982, as the use of the word mechatronics became soon to popular, Yaskawa Electric Enterprise released all rights concerning this trademark.

In the 80's years, of the XXth century, information technology **(**IT**)** was introduced in EM field and, in the 1990's years, in the field of mechatronics, the communication technology has been introduced, connecting the conventional mechatronics products in the networks.

In the present, mechatronics, synergetic and inventively, combines mechanical engineering with electronics and intelligent computer control (the hard and soft knowledge) in the design and manufacture of products and processes, in order to conceive a product and/or a technological process whose compounding elements have intelligently, in real time, controlled movements or developments [3].

3. CONNECTIONS BETWEEN CE AND M

We have to think that, in the past, machine and product design had, almost exclusively, been the preoccupation of mechanical engineers (Fig.1). Solutions to controlling and programming problems were added by control and software engineers, after the machine already had been designed. This sequential-engineering approach invariably resulted in sub-optimal designs.

Under the impact of information and communication technologies (ICT), machine design has been profoundly influenced by the evolution of microelectronics, control engineering and computer science.

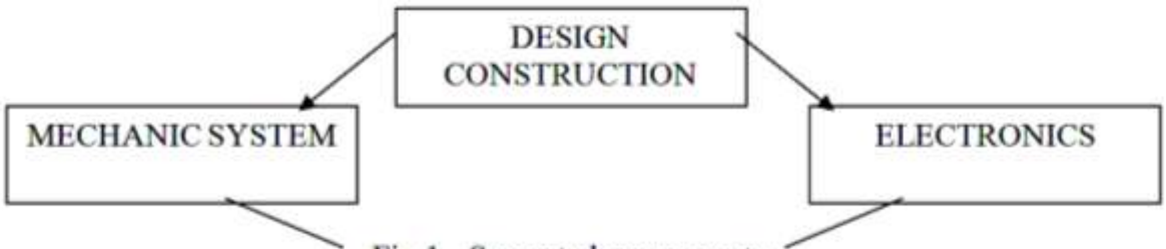


Fig.1 - Separated components

What is needed, as a solid basis for designing high performance machine, is a synergetic cross-fertilisation between the different engineering disciplines involved: mechanical engineering, microelectronics, control engineering, computer science. This is exactly what M is aiming at. (Fig.2).The hype created around these new technologies has provoked an overshoot in the opposite direction. Mechanics were no longer considered important and every problem–possible inadequate as mechanics–start be considered that it could be solved only by smart control algorithms and software.

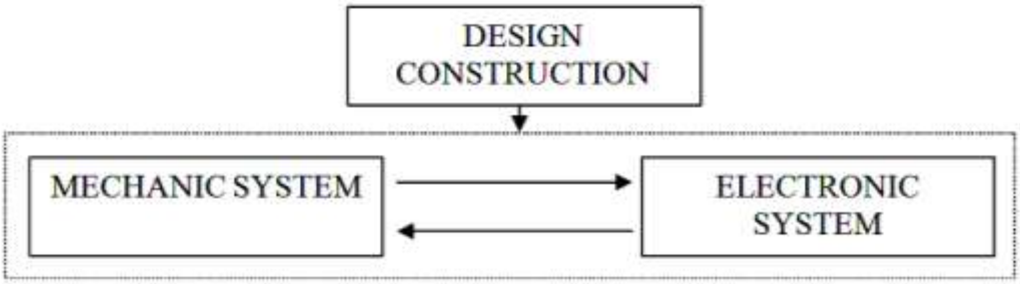


Fig.2- Mechatronic overall system

In my opinion, whatever the power of control engineering and ICT, even today, somebody cannot turn poor mechanics or poor electronics into a good machine.

4. WAYS OF INTEGRATION IN CE AND M

Ways of integration in CE and M are different. In CE, the ways are organisational while in M these ways are technical (hard or soft).

From the beginning of the XX's century, in the CE, several organizational methods have been proposed, to accomplish the integration:

- Requiring approval by other departments;
- Establishing a liaison department that is responsible for co-ordinating the activities of other departments.
- Joining all interested parties into one cross-functional team using job rotation to ensure that functional cross-pollination occurs.
- Using *job rotation* to ensure that functional cross-pollination occurs [4].

It is possible to offer a number of conjectures as to why CE did not become the dominant product development strategy earlier than 1980's [5]:

- There have been changes, in the last two-three decades of the XXth century, in technology that may have made a CE approach, both more possible and more necessary. It is conceivable that these changes in the technology have increased the need for CE.
- Current communication and other enabling computation technologies have lowered the costs of cross-functional co-operation, thereby encouraging such behaviour. The new ICT enable the rapid exchange of information and the application of a range of analytical framework that are necessary in cross-functional work. In the same time, it's a reality that a number of firms had applied CE before the advent of the modern's technologies.
- A functionally separated organisation makes it difficult to implement CE mechanisms. There were several difficulties that might have caused hierarchical, functional organizations to discourage the types of cross-functional cooperation associated with CE earlier than 1980's.

In the last 50 years have appeared multiple ways that the educational and training systems of the XXI century may have foiled the earlier development and spread of CE ideas:

- During the first half of the XX century engineering education has been focused on engineering practice, which should have focused students' attitudes on product development issues;
- Emphasis in the last 50 years within engineering education has been strongly on engineering science rather than applied fields.

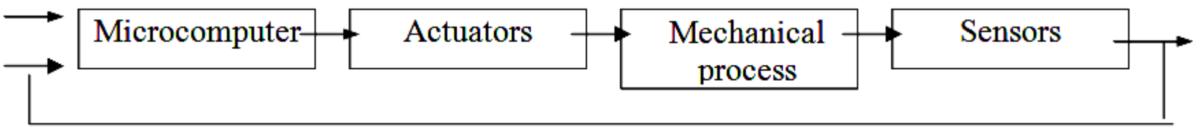
There may have been changes in the strategic environment that have led to an increased need for and acceptance of CE ideas in recent years. Competition increasingly focuses on lead-time, which leads to increased benefits for CE organisations.

The principles of integrated CE that action now are:

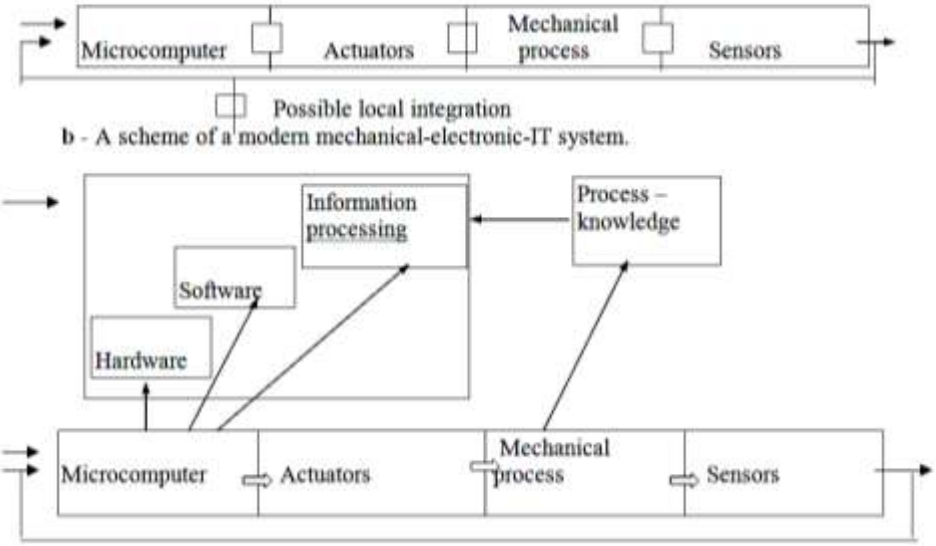
- manufacturing and functional design constraints need to be considered simultaneously (Fig.3a);
- combining of people with different functional backgrounds into a design team is a useful way to combine the different knowledge based;
- engineering designers must bear in mind customer preferences during the design process;
- time to market is an important determinant of eventual success in the market.

The integration within a mechatronics system can be performed in two kinds:

- integration of components (hardware integration) results from designing the mechatronic system as an overall system and imbedding the sensors, actuators and microcomputers into the mechanical process (Fig.3b).
- integration by information processing (software integration) (Fig.3c).



a – A scheme of a (classical) mechanical-electronic system;



- Fig. 3 -

c - Integration of information processing (software integration) is mostly based on advanced control functions.

Software integration supposes that, besides a basic feedback, an additional influence may take place through the process knowledge and corresponding information processing. This means a processing of available signals in higher levels, and includes the solution of task like supervision with fault diagnosis, optimisation, and general process management [6].

The respective problem solutions result in real-time algorithms which must be adapted to the mechanical process properties, for example, expressed by mathematical models in the form of static characteristics, differential equations etc.

From the foregoing discussions, it can be appreciated that special considerations have to be given to education and training of the technical personnel of the 21st century that will have to function (and do reliably so due to safety reasons) in an environment that is so complex and technologically very dense. A number of institutions have therefore started designing special undergraduate and graduate level programs in mechatronics. In mechatronics, the key areas of technology are; drives and actuators, sensors and instrumentation systems, embedded microprocessors systems and engineering design [7].

5. CONCLUSIONS

▪ Both the M and the CE have been strongly developed in 1980's, when ICT was in full process of development. The influence of **ICT** is undoubted. But there is a difference:

- M could not be implemented in the absence of ICT;
- CE was well influenced by ICT that include Computer Aided Design/ Computer Aided Manufacturer systems, integrated database, electronic communication tools etc. But communication and computational technologies are not strictly necessary for the implementation of CE**.**

▪ Ways of integration in M. and CE are different. In M these ways are technical (hard or soft) while in CE, the ways are organisational;

▪ M is emerging as a CE thinking framework in the process of designing complex machines.

▪ M is still in a competitive stadium of development, but it has a bright future and will grow steadily into the XXI century.

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