MECHATRONICS IN THE DEPARTMENT OF ELECTRICAL ENGINEERING OF THE UNIVERSITY OF PASSO FUNDO

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Abstract. *The purpose of this article is to present the Mechatronics teaching that is implemented in the Department of Electrical Engineering at the University of Passo Fundo (UPF), Rio Grande do Sul, Brazil.The implementation has been done through a modification of a traditional electrical engineering curriculum. The modified curriculum is presented and the skills, needed in Mechatronics and which are currently lacking in most professional engineers, are discussed.*

Keywords*: higher education, mechatronics*

1. Introduction

The term Mechatronics was introduced about 25 years ago by Ko Kikuchi, later president of the Yashkawa Electric Company, Tokyo, Japan. The advances of microelectronics during two last decades make possible to manufacture millions of microprocessors and microcontrollers. It permitted to implement digital control not only in large scale system, but in consumer electronics and even in toys. During this period, new power electronic components, high capacity memory chips and advanced architecture microprocessors have been developed. This way, Mechatronics became a method of analysis and design of advanced products and processes. Answering to this requirement of the market, universities in the developed countries have started to teach Mechatronics in the undergraduate and post-graduate level courses.

In Brazil some universities offer Mechatronics education too, that became possible after the approval of the Resolution 1694, of 5 of December of 1994, by the Brazilian Ministry of Education. In 1999 the Federal Advice of Engineering, Architecture and Agronomy adopted the Resolution 427, which gave to a discrimination of Engineering of Control and Automation. The curriculum of these courses includes, in accordance with the normative documents, such disciplines as Industrial Systems and Administration of Production Systems. In our opinion, this situation placed in fact the symbol of equality between Mechatronics, on one side, and Industrial Automation and even FMS (Flexible Manufacturing System), on the other, that does not reflect the current trends in the Industry.

2. What is Mechatronics?

There are many definitions of Mechatronics. The authors of this article believe that the most correct one was given by the Industrial Research and Development Advisory Committee of the European Community. The definition stands that Mechatronics is “a synergistic combination of precision mechanical engineering, electronic control and systems thinking in the design of products and manufacturing processes" (Acar and Parkin, 1996) Analyzing this and others existing definitions of Mechatronics, one can conclude that the main components of the Mecatrônica are: Mechanics, Automatic Control, and Electronics and Computer Science. Moreover, the combination of these components is not only mixture, but yes a synergistic union. The word "synergistic" means that the components fortify ones to the others and the final result, or either, the product or process of this union is better that a simple addition of contributions of each component.

The Mechatronics approach includes modeling and numerical simulations already in the initial stages of the projects, aiming significant time-to-market and designing cost reduction. The use of modern techniques of rapid prototyping permits to accelerate design process even more (Popovic and Vlacic, 1999).

One more comment is that Mechatronics has to concentrate on product and process design and delegate the questions of manufacturing to Production Engineering.

Traditionally, the companies which act in the field of electromechanical area possess a departmental organization. There are departments of mechanical engineering, electronic engineering and computer engineering. Specialists with traditional formation, after its admission, start to work in accordance with his capacity, qualification and "rules of the game". These last ones represent the reality of the company from the bureaucratic point of view. This reality represents one of the obstacles which make the new products design difficult. Each department has its proper politics and tactical goals, which not always coincide with the strategic objective, that is, to design a good product and to conquer the market.

Another obstacle is that the traditional specialists of the different departments possess different formation, so the discussion of the design problems turns very difficult. Therefore, to prevent this type of difficulties and to accelerate the development of projects, it is indispensable to have a coordinator who understands all the problems and, moreover, is necessary to break bureaucratic barriers. The Mechatronics approach consists accurately of this. The Mechatronics approach is in first place an organizational measure. It is necessary to work in team and this team has to join all the specialists involved in the project. And more, the specialists of this team must be accustomed to work in group and have an adequate formation. This last one is a great problem of superior technological education nowadays.

3. Mechatronics at the UPF

At the University of Passo Fundo (UPF), to choose a strategy of education in Mechatronics, the curriculums of the already existing courses in Brazil and abroad had been analyzed. Thus, in the undergraduate level, the curriculums of the UNICAMP (UNICAMP, 2005), the University of Brasilia (UnB, 2005), the UFSC (UFSC, 2005) and the PUC-RS (PUC-RS, 2005) had been analyzed. Of the foreign universities, the curriculums of the State Electrotechnical University (St. Petersburg, Russia) (Vodovosov, 1995), the Ohaio State University (Rizzoni and Keyhani, 1995), the University of California (U.S.A.), California Polytech (U.S.A.), City University of Hong Kong, University of Linz (Austria) (University of Linz, 2005), University of Berkeley (U.S.A.), University of Adelaide (Australia), among others, had been analyzed.

The analysis performed has induced the idea that, in the ideal case, the specialist in Mechatronics must dominate enough all the four of the areas that compose the base of the Mechatronics, which are Digital Automatic Control, Mechanics, Electronics and Computer Science. But in practice it is impossible to form such specialist elaborating one curriculum as a simple sum of the four curriculums of these areas, because the undergraduate course would last between 10 and 12 years. Yet more, assuming that this specialist has been formed, it seems to be quite impossible the situation of periodic changing of the area. Taking in consideration all these arguments, we at UPF have adopted another objective, that is, not to form an universal specialist who possesses solid knowledge in the all the four basic areas, but yes a specialist who possesses knowledge necessary and enough to participate in teams of project.

Adopting this philosophy, the formation task becomes viable and is reduced to elaboration of an adequate curriculum. The main idea is to form professionals that, in the future, could act as leaders of project teams or as participants of those teams, specializing itself in one of the four basic areas.

Modern market is highly dynamic and competitive, so the teams of design engineers have to adopt the Mechatronics methodology as a long term strategy because it suggests new solutions for many technical problems and guarantees that new products will be able to conquer its space in the market.

In 2001, the curriculum of the Electrical Engineering Department of the UPF was modified to offer two areas of specialization on the undergraduate level. These two areas were “Electronics and Telecommunications” and “Mechatronics”. The duration of the course is five years and the degree schemes are identical for the first two years. The specialization begins on the 5th semester. All students must take subjects amounting to 240 credits (1 credit = 15 hours).

The specialization in Mechatronics includes such traditional electrical engineering disciplines as Mathematics (38 credits), Physics (16 credits), Chemistry (4 credits), Electro technique (20 credits), Electric Circuits (16 credits), Programming in C language (8 credits), Analog/Digital and Power Electronics (36 credits), Classical and Modern Automatic Control (14 credits), and Microprocessors (6 credits). Moreover, some new discipline had been added. These disciplines are: Statics (4 credits), Kinematics and Dynamics (4 credits), Strength of Materials (4 credits), Applied Mechanics (4 credits), Metrology (2 credits), Digital Control (theory + laboratory, 6 credits), Hydraulic and Pneumatic Systems (2 credits), Robotics and Industrial Automation (4 credits), Mechatronics Design (2 credits) and Machine Design (4 credits). The time diagram of these new disciplines is shown in Fig.1. The discipline Mechatronics Design is lectured on the 9th semester and introduces the Mechatronics design approach to products and processes development. The program of this discipline includes revision of dynamic systems modeling and simulation, sensor interfacing, advanced electrical motor control, introduction to real-time control and case studies. The case studies introduce internal combustion engine modeling and MATLAB/Simulink simulation, electronics rocking chair design and impact matrix printer analysis.

The curriculum modification was accepted by the students and there are almost equal divisions of the classes between the two areas of specialization.

The comparison of the mechatronic curriculums of some Brazilian universities is presented in Tab. 1. In Tab. 1, the columns show the percentages of each the mechatronics areas in the total of classes, when the Mechanical area includes all the traditional mechanical courses and Robotics; Basics includes mathematics, physics, chemistry and drawings. In Tab. 1, the curricular period of training was not entered. Analyzing Tab. 1, it‘s difficult to give the preference to one of the curriculum structures, because, as was mentioned above, Mechatronics is a very ample area so the successful teaching should be implemented only giving a emphasis on one of the main components of Mechatronics. For example, at PUC-RS the Mechatronics education has been initialized on Mechanical Engineering Department, therefore that it has more mechanical engineering courses than any other university in Tab. 1.

Table 1. Structures of Mechatronics Education at some Brazilian Universities.

University	Basic	Mechanical	Electrical	Automatic Control	Computer Science
PUC-RS	38,6%	32,9%	15,7%	7,1%	5,7%
University of Brasilia	34%	18,6%	19,3%	12,9%	15,2%
UNICAMP	25,7%	26,5%	29,4%	6,4%	12%
Federal University of Santa Catarina	27,8%	18,4%	25,7%	13,1%	15%
University of Passo Fundo	29%	16,4%	40%	11%	3,6%

4. Final project

Final project is a compulsory discipline and must be attended as partial fulfillment of the requirements of the degree of electrical engineer. Traditionally, the electrical engineering undergraduate students choose for the final project some kind of pure electronic design involving analog/digital/microprocessor and power electronics. Last years, at UPF, such projects involved smart electronic instrumentation, Hi-Fi audio amplifiers and intelligent lighting systems.
The introduction of the Mechatronics specialization area conditioned some modifications of the themes chosen by the students for his graduate projects. There is a tendency to design prototypes which involve some kind of mechanical subsystem. As the most interesting example of this tendency we consider the design of an automatic accessory prototype which can be used with a tractor for applying chemical substance on soy plantation. The accessory includes two pulverizes whose altitude is controlled automatically in a closed loop manner using two ultrasonic sensors. This project has involved some structural calculation, mechanical part design and implementation and digital controller design. Moreover, a pulverizer prototype with automatic electric drive was fabricated and tested (Bonfante, 2004). Some images of the tractor are shown in Fig.2 and Fig.3.

5. Discussion

The implementation of the two specialization, or areas, in the Department of Electric Engineering at UPF appears to be a viable alternative to traditional electrical engineering curriculum. Mechatronics at UPF has been implemented in the Department of Electrical Engineering so the program of this area is essentially electronic one. The modifications of the original curriculum aim to introduce some relevant topics of the Mechanical Engineering permitting for the student easy integration to design teams afterwards.

Our experience of teaching Mechatronics at UPF permits to observe the following: 1) the students have no sufficient skill to perform design and implementation of closed-loop controlled systems. The sequence of the automatic control disciplines is viewed as an obstacle to avoid; 2) the students prefer to build and test each design concept instead of performing some type of modeling and simulation. The only exception is the simulation with Pspice software, which can permit to adjust circuits parameters via brute-force approach; 3) students rely on computers too much and easily learn how to use any software, but the correct and critical interpretation of the simulation results is lacking; 4) the majority of the students does not learn mathematics and this conditions the others abovementioned problems. Almost the same set of educational problems was appointed in (Mechatronics, 2001).

The problem with the mathematics teaching is the most serious, because the mathematics is almost always taught by mathematicians and not by engineers. Mathematics disciplines lecturers should emphasize more the practical aspects and show how to apply the theories to engineering practice. At UPF, the Mechatronics students are stimulated to apply some mathematics calculations when studying electrical circuits, linear systems and automatic control. Nevertheless, the programs of the mathematics disciplines should be revised one more time.

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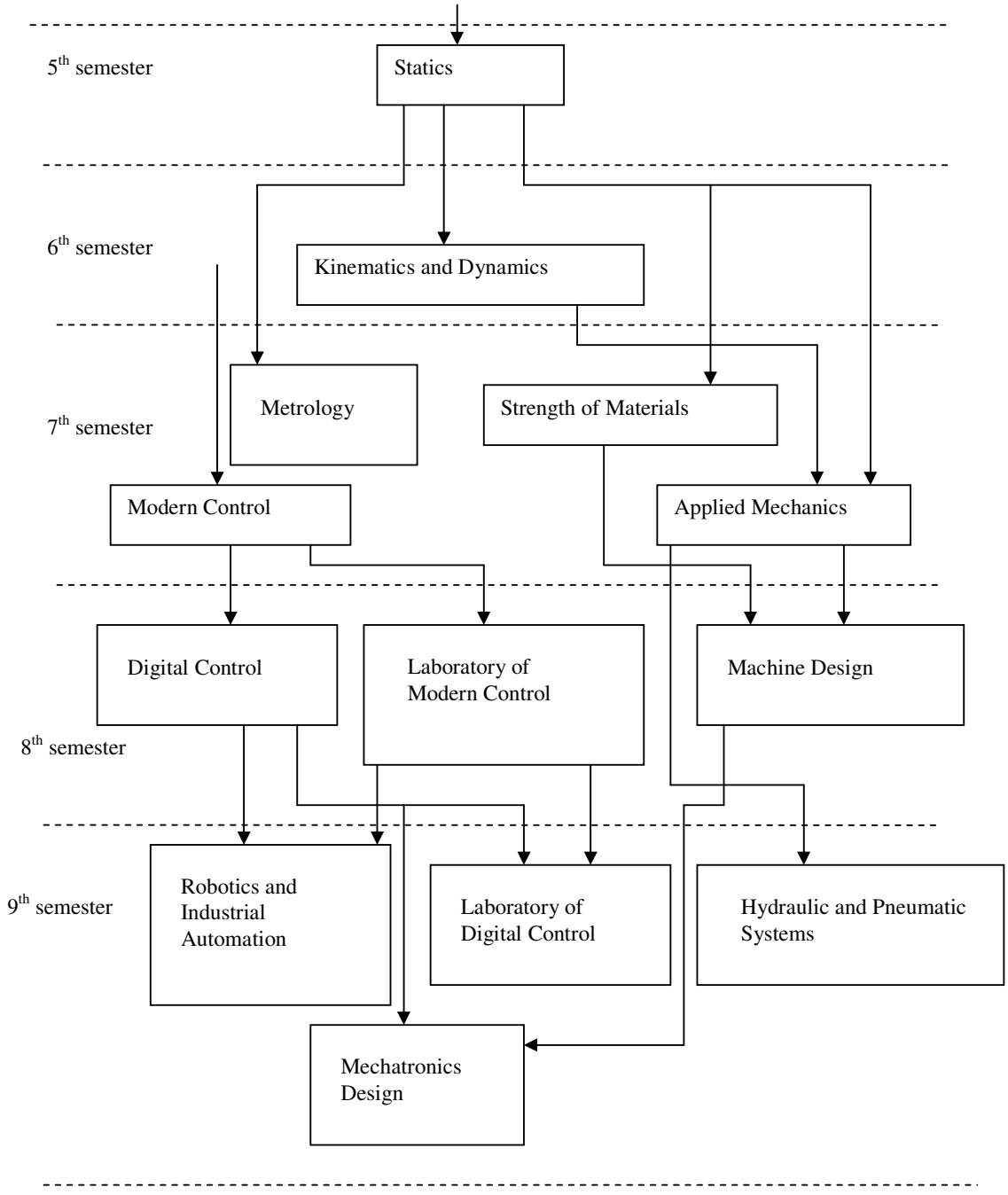

Figure 1. New disciplines offered for the area of Mechatronics.

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Figure 2. Back view of the tractor with systems prototype.

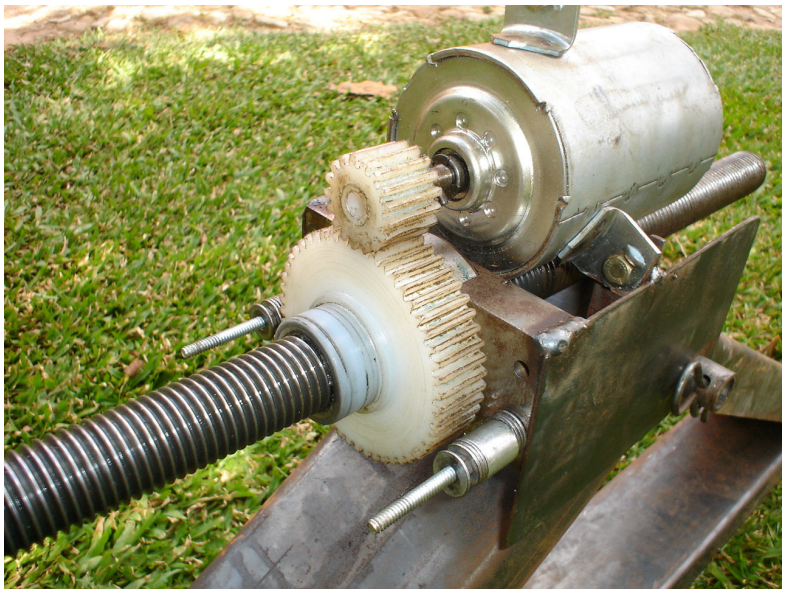

Figure 3. Detail of the mechanism.

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7. Responsibility notice

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