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NECESSITY OF MECHATRONICS KNOWLEDGE IN MARINE ENGINEERING EDUCATION

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Abstract. Improvements in the electronics and sensing technologies show its influence on industry and ship systems. The more recent ships are built with newer electronic technology and automation systems which reduce the necessity of man power while increasing the reliability of the system. However, these ships are manned with the marine engineers and officers who have very limited knowledge of electronics and electronic control systems which are generally called mechatronics systems. It is clearly foreseen that the mechatronics education will be a must for the new generation of marine engineers. The curriculum of the marine engineering education should be updated considering this deficiency. In this paper, the new mechatronics laboratory of ITU Maritime Faculty will be introduced. The hands on education and training capabilities of the laboratory, the equipment and instruments, and the experimental facilities will be explained. Its effect on marine engineering education and its benefits to marine engineers will be discussed.

Key words: marine engineering, education, mechatronics, mechatronics laboratory

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1 INTRODUCTION

Recently, multidisciplinary studies have become more important for technological and scientific improvements. Most of the universities and institutions try to initiate new organizations for collaborative and multidisciplinary studies and bring the scholars together. One of the most outshining multidisciplinary areas is mechatronics.

The term “mechatronics” was first introduced by a Japanese company in 1969 [1]. One of the definition for mechatronics is; “Mechatronics is the synergetic integration of mechanical engineering with electronics and intelligent computer control in the designed manufacturing of industrial products and processes” [2].

The improvements of electronic equipment and systems make many applications feasible which were possible only in theory. For example, common rail system for internal combustion engines is actually a very old system. However, it is very popular these days because it became feasible with the electronic control systems. The improvement in sensing technologies has also very important role. Today it is possible to find various sensors which are very accurate and precise. Besides they are endurable to very rough conditions.

The mechatronic systems are everywhere in our world. Most of the systems are integrated with sensors, actuators and electronic control systems. The mechatronics is established as a new discipline named “Mechatronics Engineering”. In this department, basics of mechanical engineering, electrical/electronic engineering and computer science are taught. However, it is also a problem for other engineering disciplines to learn mechatronics knowledge. Therefore, the engineers of other disciplines like civil engineering and mechanical engineering also need to know about these systems. This results in the necessity of updating the curriculum of these disciplines including mechatronics knowledge.

2 MARINE MECHATRONIC SYSTEMS

Mechatronics is very important also for the marine engineering department. Marine engineering is very close to the mechanical engineering. However, marine engineers are focused more on operation of complex mechanical systems. The new build merchant ships are equipped with more mechatronic systems. These systems on board ship are not as complicated as robotic systems. It doesn't include very complex sensing systems, rigid body dynamics etc. These mechatronic systems are mostly based on electronic control systems using simple sensors. Electric motor controls, tank level controls, pressure and temperature controls, and

fuel control of engines are some of the instances of mechatronics systems on board ship.

Selection of the sensors and electronic control systems suitable for the marine systems has vital importance. The environmental conditions of ship should be taken into consideration. The ship is navigating in a very dynamic environment. The parameters such as ship movements (rolling, pitching, yawing), high vibration, humid, sea salt, oil mist, and high temperature should be considered and suitable sensors and electronic control units should be chosen. There are mainly two types of control units for industrial systems: Microcontroller systems and PLC (Programmable Logic Control) control systems. PLC control systems are more preferable for ships due to their suitability to above mentioned ship environment.

Another part of mechatronics for maritime sector is marine robotics. This is more complex and more specialization is needed. In this case, the integration and synergy of different disciplines is needed. Another point is that in this case mechatronic system design is carried out and it is not only operation of existing systems. Most of the marine robotics studies are focused on remote controlled and autonomous vehicles such as autonomous underwater vehicles, autonomous surface vehicles and remotely controlled underwater and surface vehicles.

3 MECHATRONICS EDUCATION FOR MARINE ENGINEERS

The electronics, computers, and information technologies are growing very fast and they take place in our everyday life. Therefore there is a gap between the knowledge of engineers educated with classical curriculum and the expected skills at the related sector.

This problem can be considered in two different perspectives: the curriculum of mechatronics engineers and the curriculum of other disciplines. There are many studies investigating the mechatronics and developing a curriculum for mechatronic engineers [3, 4, 5, 6, 7]. Study [3] investigated the mechatronics education in Nordic and Baltic Countries. They concluded that the mechatronics education in these countries is focused on local industry and they educate the engineers to work for offshore oil industry. In other words, they narrowed the wide area of mechatronics education and made it easier and more applicable.

There are also studies which investigate about the integration of mechatronics courses to other disciplines such as mechanical engineering [8, 9, 10]. In the study [9] the authors proposed a microcontroller system laboratory for supporting mechanical engineering course. In [10] development of supporting mechatron-

Table 1 The courses supporting mechatronics knowledge at ITUMF

Course Code	Course Name	Credit	Theory	App	Lab
BIL 106 E	Intr. to Scientific and Engineering Computing	3	2	2	0
GMI 201	Marine Electro-technology	2,5	2	0	1
GMI 222	Marine Electronics	1,5	1	0	1
GMI 341 E	Automatic Control Systems	2,5	2	0	1
GMI 427 E	Mechatronics	2	2	0	0
GMI 412 E	Hydraulic and Pneumatic Control of Systems	2	2	0	0

Table 2 Proposed courses related to mechatronics

Proposed Courses	Credit	Theory	App	Lab
Digital Control Systems and Signal Processing	3	3	0	0
Digital Electronics	2	1	1	0
Programmable Logic Control (PLC)	2	1	0	2
Microprocessors	2	1	0	2

ics courses for mechanical engineering students is presented. They proposed two additional classes which are "Introduction to Mechatronics" and "Mechatronics System Design".

The curriculum of marine engineering education is very close to the mechanical engineering. Almost all of the engineering courses such as thermodynamics, heat transfer, mechanics, material science, fluid mechanics, strength of materials etc. are identical. Therefore, marine engineering curriculum already has a strong background of mechanical side. There are also courses which are related or supporting mechatronics such as: automatic control, programming languages (C++, Matlab) etc. However, it is not sufficient for marine engineers due to increase of mechatronics systems on board ship. The marine engineers should have technical skills and expertise in these systems. Therefore, it is necessary to improve the marine engineering course by developing some courses which will support the mechatronics knowledge and skills. In the study [11], the importance of mechatronics for marine engineers is discussed and some new courses are proposed.

The marine engineering education at ITU Maritime Faculty is discussed here and the necessary courses which will be more suitable for supporting marine engineers' mechatronics knowledge are proposed. The existing courses which are related to mechatronics at ITUMF are shown in Table 1.

In BIL106E course, one of the programming languages such as C++, Matlab and Fortran is being taught. Marine Electro-technology course is based on the basic electrical engineering knowledge, electromagnetism, and basics of electrical machines and classical control of electrical machines. Marine Electronics course includes basic electronics knowledge as semiconductors,

diodes, transistors etc. Control theory is the main topic of Automatic Control Systems course. Hydraulic and pneumatic control systems are also very important part of mechatronics systems and it is the topic of GMI 412E course. In the Mechatronics course the basics of mechatronics systems, sensors and actuators are being taught. Another important point is the credits of the courses. It sufficiency of the number of hours for theory and laboratory and total number of hours should be considered, too.

As we can see there are many courses related to mechatronics but there are still some deficiencies which should be included in the curriculum. The missing parts are mainly electronic control systems, integration of hydraulic and pneumatic systems with electronic systems (electro-hydraulic, electro-pneumatic), signal processing, PLC and microcontroller systems. In Table 2 the proposed courses are listed. These courses are planned to be selective courses.

4 THE NEW MECHATRONICS LABORATORY AT ITUMF

There are various laboratories at ITUMF related to mechatronics. These are:

- Electro-technology/Electronics Laboratory
- Automatic Control Laboratory
- Hydraulic/Pneumatic Laboratory

These laboratories are sufficient for classical control of electrical machines, basics of electricity and electronics and classical hydraulic/pneumatic courses. However, the electronic control of these systems can-



Figure 1 PLC Training Set at ITUMF Mechatronics Laboratory

not be carried out. Therefore a new mechatronics laboratory is developed. In this laboratory mainly PLC control systems are preferred because mostly these systems are used on board ship as explained in Section 2. Besides, also a microcontroller training set is included due to its importance.

The PLC Training set is shown in Figure 1. It consists of a PLC controller and application modules. The PLC controller can be used alone or with application modules. A Siemens S7-1200 series CPU 1214C model PLC is used in the set. There are 8 digital inputs and 6 digital outputs. There are 6 pieces of relay outputs for

Image of Module	Name of Module/ Applications	Image of Module	Name of Module/ Applications
	Asynchronous Motor Application Module/ Speed and control applications of Asynchronous Motor with PLC		Pressure Control Simulation Model/A compressed tank's pressure measurement and control applications, PLC applications for real analog and digital signal simulations
	DC Motor Application Module/ Speed and control applications of DC Motor with PLC		Traffic Signalization Simulation Module/ Traffic signalization applications
	Sensor Applications Module/ PLC applications with sensors		Graphic Based Touch-Screen Operator Panel Module/ Input/output applications with operator panel and PLC
	Level and Pump Simulation Module/The pump and tank's fluid level measurement/control, PLC applications for real analog and digital signal simulations		

Figure 2 Application Modules of PLC Training Set



Figure 3 Microprocessor Training Set and Application Modules

digital outputs. The digital outputs can be selected – PLC output or relay output- via a selector switch. For analog applications, there is potentiometer and adjustable frequency oscillator in the PLC Training Set.

The application modules of the PLC training set are shown in Figure 2.

In Figure 3 the microprocessor training set with PIC16F877 microcontroller and application modules are displayed. The application modules are:

- 1) Step Motor Experiment Module
- 2) Display and LED Experiment Module
- 3) Heat Control Experiment Module
- 4) Elevator Experiment Module
- 5) BreadBoard Experiment Module
- 6) I2C-PWM-LCD – UTLRASONIC Experiment Module
- 7) DIP-DAC Experiment Module

5 CONCLUSIONS

Most of the control systems on board ship are being replaced with mechatronics systems very rapidly. The necessity of mechatronics knowledge is clear. The marine engineers should have the mechatronics knowledge and skills to be able to carry out their jobs. Therefore, the curriculum of marine engineering education should be updated including courses related to mechatronics. The laboratory environment is also very important for better understanding of the systems by hands on experiments. In this paper we introduced the new mechatronics laboratory at ITU Maritime Faculty. This laboratory is equipped for education of marine engineers and equipment is chosen suitable for this purpose.

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