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Education and Training

Electrical-Electronic and Control Education in Marine Engineering Operations: A Novel Educational Model for Turkey

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Abstract

According to the development gained from past to present on main and auxiliary marine engines, it is obvious that most of the developments are occurred in the electronics and control systems. Therefore, graduates of marine engineering operations have to be well qualified to the electric & electronics, control and automation subjects. On the other hand, there is a new certification standard named electro-technical officer who is formed in STCW convention (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers). This convention organized by IMO (International Maritime Organization) in Manila, capital of Philippines at 25.06.2010 which was signed by Turkey as well (Web 3). Hence, contents of electric & electronics and control courses in marine engineering operations undergraduate programs should be updated correspondingly to new features. In this paper, marine engineering operations electric, electronic and control study in Turkey and other countries is analyzed and a new educational model is proposed.

Keywords: Maritime , Electrical-Electronic, Education, Marine Engineering

1. Introduction

According to the recent advances in technology, engine control systems have developed and they became more autonomous. In this pattern, there are important differences between MC type main engine launched by MAN B&W in 1982 and “common rail” type engine used today(Web 1). There are two electronic control units (ECU) installed on common rail system and these control unit monitor the high pressure pumps according to RPM (Web 2) (see Fig.1).

Similarly in newly built ships, solenoid valves unit in separators is controlled by automatic controller made by Mitsubishi which is seen on fig.2 whereas total discharge controlled manually in old ships (Mitsubishi Selfjector Genius-Series Instruction Manual). In addition, by developing engine room control and monitoring systems, engine data such as lubricating oil – fuel pressure and temperature can be observed from control room or even chief engineer’s and other engineers’ cabins (Kokkulunk, 2009). Regarding these examples, developments on engine technologies have occurred on control and automation and engine rooms have changed to unmanned system. Consequently, marine engineer officers must have

the enough knowledge and skill about electric-electronics and control technologies. For this purpose, study courses should include related technologies.

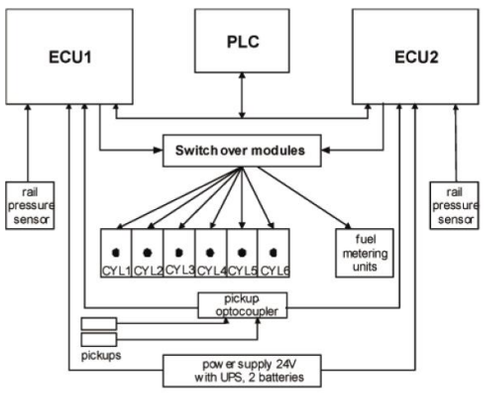

Fig. 1. Electronical controller (Common Rail) (Web 2)

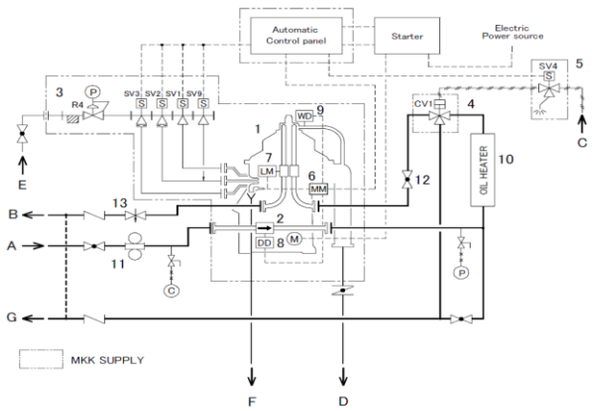

Fig. 2. Typical Purifying System Configuration

In this pattern, there have been various studies about maritime educations. Mazzarino studied the effects of new technologies on seafarer. He asked ship owners, marine equipment sellers, harbor administrators some questions in several countries like Finland, Norway, Italy etc. According to this report, adapting to new technologies will have brought integration, interoperability and mobility to maritime industry (Mazzarino, 2000). Furthermore, in maritime education, students have to develop their practical skills before working on ships. (Teel, 1988). Unsalan cited career of marine engineers lasts about 40 years hence given education have to be shaped according to expected developments (Unsalan, 2009).

Classical marine engineering instructions are given at IMO Model course 7.02 and 7.04 in late period of 20th century (Unsalan, 2009). However, this model courses have to be revised with the developing technology. In this respect, education and certification requirements of electro technical officer has determined in STCW meeting held in Manila, in 25.06.2010 (Web 3).

Unsalan claim that knowledge and skills for electric, electronic and control systems is necessary for marine engineering profession (Unsalan, 2009).

Gierusz declared that, in STCW 95 convention, electrical, electronic and control lectures inclusion for marine engineering education are among the essentials as appropriate for IMO requirements (Gierusz, 1998).

As it can be seen, the content of maritime education must be changed and expanded correspondingly with developing technology. With electro-technical officer education and certification regulations, decreed in Manila Conference, first signals of this change has been given. In this case, several maritime schools course contents, has been studied and a model has been evaluated for marine engineering education.

Electric, electronics, control lectures and credits of maritime schools are compared in section 2. A model is suggested for universities that giving marine engineering education in Turkey, in section 3.

2. Electric - Electronics Courses in Marine Engineering Operations Education

2.1 Turkey

Marine engineering education providing universities in Turkey are Istanbul Technical University, Yıldız Technical University, Dokuz Eylul University, Rize University, Piri Reis University and Zirve University. Electric, electronic and control lectures and credits for Istanbul Technical University, Yıldız Technical University and Dokuz Eylul University which are the top scored university according to the 2010 University Entrance exam, are given in Table 1 (Web 4).

Table 1. Electric, electronic and control courses in Turkish Maritime Universities

Institutions	Course names	Credits
ITU Maritime Faculty, Marine Engineering (Web 5)	Marine Electrotechnics	3
	Marine Electronics	2,5
	Automatic Control Systems	2,5
	Mechatronics &Digit.Cont.Syst. (Elective)	3
YTU Naval Arch. & Maritime Faculty, Marine Engineering Operations (Web 6)	Marine Electrotechnics	2
	Marine Electronics	2
	Automatic Control Systems	2,5
	Digital Control Systems (Elective)	3
Dokuz Eylül University, Maritime Faculty, Marine Engineering (Web 7)	Marine Electrotechnology	3
	Marine Electronics	2,5
	Automatic Control Systems	2,5

2.2 The rest of the world

Different from Turkey with maritime faculties, there are maritime universities giving marine engineering education in the world. According to IAMU (International Association of Maritime Universities) members general map, this universities and faculties are : Asia/Pacific (India, Australia, China, Philippines, Japan,

Korea, Vietnam), European Union (Romania, Denmark, France, Estonia, Poland, UK, Germany, Holland, Bulgaria, Spain, Finland, Sweden), Americas (Canada, USA), Africa/Central Europe (Russia, Egypt, Georgia, Turkey, Iran, Ukraine, Ghana, Croatia) (Web 8). Electrical, electronic and control courses of different institutions in these areas are given in table 2.

Table 2. Electric, electronic and control in maritime schools in the world

Institutions	Course names	Credits	Name of the Universities	Course names	Credits
The California Maritime Academy (USA), Marine Engineering Technology (Web 12)	Electrical Circuits	3	The State University of New York (USA), Marine Engineering - Engine License (Web 16)	Electrical Engineering I	3
	Electrical Circuits Lab	1		Electrical Engineering II	3
	Electronics	3		Electrical Engineering III	3
	Electronics Lab	1		Analog Controls	3
	Electrical Machinery	3		Marine Electrical Systems	3
	Electrical Machinery Lab	1		Electronics I (Elective)	4
	Automation	3			
	Automation Lab	1			
Massachusetts Maritime Academy (USA), Marine Engineering (MMA Curriculm, 2011)	Electrical Machines	3	University of Cantabria - Escuela Tecnica Superior de Nautica (Spain), Degree in Marine Engineering (Web 13)	Electronics	6
	Electrical Machines Lab	1		Automation	6
	Electronics	3		Electricity and Electrical	6
	Electronics Lab	1		Electric Boat (optional)	6
University of Rijeka, Faculty of Maritime Studies (Croatia), Marine Engineering (Web 14)	Marine Electricity	5	Arab Academy for Science & Technology and Maritime Transport (Egypt), Marine Engineering (Web 10)	Electrical Engineering Fundamentals	3
	Boat Electrical Appliances	3		Marine Control Systems	3
	Shipboard Electrical Systems	4		Marine Electrical Engineering	3
	Automation of Ship Operation	5		Electrical Machines	3
	Fault Diagnosis	3		Digital Design & Intro. to Microprocessor	3
	Shipboard Power Systems (Elective)	3		Automatic Control Systems	3
	Marine Auto Control (Elective)	4		Electrical Ship Design	3
Nikola Vaptsarov Naval Academy (Bulgaria), Maritime Officers Engineering (NVNA Curriculm, 2011)	Control Systems Technical	5	Gdynia Maritime University (Poland), Marine Maintenance Engineering(Web 9)	Fundamentals of Electrotechnics& Electronics I	4
	Electrical Power Systems	5		Fundamentals of Electrotechnics&Electronics II	2
	Medium Voltage	2		Fundamentals of Control Engineering & Robotics	4
	Electric Drives	2			

Estonian Maritime Academy (Estonia), Marine Engineering (Web 11)	Electrical Engineering	3	University of Transport in Ho Chi Minh City (Vietnam), Marine Engineering (Web 15)	Electrical Machineries and circuits	3
	Electronics	2		Basic Electronics	2
	Marine Electrical Equipment	4,5		Electrical Plants	3
	Basics of Auto. Contr & Elements of Auto. Cont. Sys.	1,5		Automation and control 1	2
	Automatic Control - Tools and Systems	2,5		Automation and control 2	3
	Operation and Maintenance of Marine Electrical Equip.	2,5			

2.3 A Comparison between the cases in Turkey and abroad

By analyzing the situation in the world, highest numbers of the courses in electronics and control systems are given in California Maritime University. Besides, every course in California Maritime University is supported by laboratory lectures (see Table 3 and Fig 4). Turkey universities have the lowest course share with respect to the application in other countries.

Table 3. Comparison of course numbers and credits

Institutions	**No. of courses**	**Credits**	**Total Credits of the Program**	**% of Credits**
Istanbul Technical University (TR)	4	8	164,5	4,9
Yıldız Technical Universitesi (TR)	4	6,5	159	4,1
Dokuz Eylül University (TR)	3	8	175	4,6
Massachusetts Maritime Academy (USA)	4	8	126	6,3
Gdynia Maritime University (Poland)	3	10	195	5,1
Arab Academy for Science & Technology and Maritime Transport (Egypt)	7	21	185	11,4
Estonian Maritime Academy (Estonia)	6	16	160	10,0
Nikola Vaptsarov Naval Academy (Bulgaria)	4	14	236	5,9
The California Maritime Academy (USA)	8	16	161	9,9
University of Cantabria - Escuela Tecnica Superior de Nautica (Spain)	4	18	258	7,0
University of Rijeka, Faculty of Maritime Studies (Croatia)	7	20	179	11,2
University of Transport in Ho Chi Minh City (Vietnam)	5	13	187	7,0
The State University of New York (USA)	6	15	164	9,1

By comparing the ratio of related lectures to whole credits, the highest ratio is seen in Arab Academy for Science & Technology and Maritime Transport and University of Rijeka. These universities are followed by the California Maritime Academy and Estonian Maritime Academy (see Fig. 3, Fig. 4). The highest ratio belongs to University of Rijeka and The State University of New York when the selective lectures are taken into account.

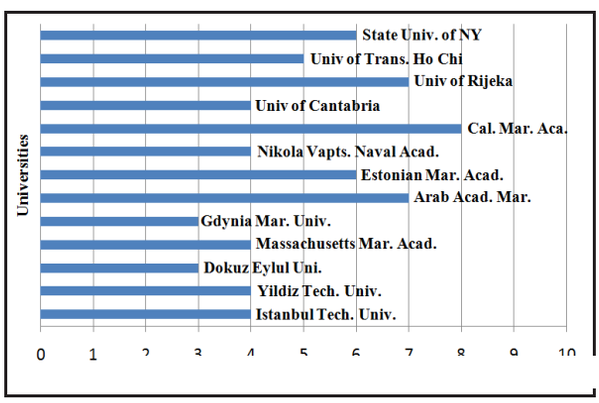

Fig. 3. Number of courses in different institutions.

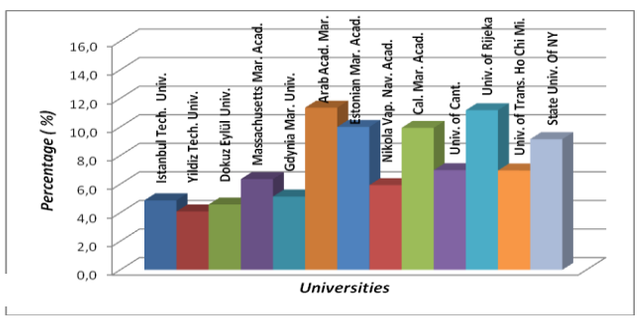

Fig. 4. Credit percentages

3. A Proposal

Electronic and automation systems are generally used for energy transmission, communication, propulsion, monitoring and control purposes in ships. Hence, in undergraduate program, marine engineers are required to pass 3 credits of theoretical and 1 credit of laboratory hours for the subjects of interest (see Table 4)

Table 4. Suggested Lectures and Credits

Theoretical Lectures (Credits)	**Laboratory Lectures (Credits)**
Marine Electrotechnics (3 Credits)	Marine Electrotechnics Lab. (1 Cr.)
Marine Electronics (3 Cr.)	Marine Electronics Lab. (1 Cr.)
Marine Automatic Contr. Sys. (3 Cr.)	Marine Automatic Cont. Sys. Lab. (1 Cr.)
Control Systems (3 Cr.)	Control Systems Lab. (1 Cr.)

Marine electrotechnics: The structure of matter and atom, the resistance-voltage-current concepts, measuring instruments, magnetism, electromagnetism, direct and alternating current, Kirchhoff's laws, passive and active electrical circuit elements, temporary regimes, RLC circuits, phasors, transformers, line calculation, ship network elements, protection systems, wiring board, on board the ship used in the production of electrical energy storage batteries and batteries, and ships in areas of direct current

machines, single phase and three phase alternating current basic information, alternators basics, the use of synchronous and asynchronous motors and boats, electrical safety on ships.

Marine Electrotechnics Laboratory: Measurement of DC voltage and DC current, AC voltage, frequency measurement, passive circuit elements and applications, electrical circuit laws (Ohm's and Kirchhoff's laws), RC, RL and RLC circuit experiments

Marine Electronics: Semiconductors, Diode, Diode Models and Applications, Bipolar and Field Effect Transistors, Amplifiers, Oscillators, Power supplies, digital electronics fundamentals, microprocessor-based systems, modulation techniques, modern technologies on ship communication

Marine electronics Laboratory : The diode characteristics, Rectifier Applications, Clipping, clamping and voltage multiplexer applications, the transistor characteristics, transistor biasing circuits, Zener diode characteristics, Zener Diode Regulator Circuit, Class A amplifier, Class amplifier, the RC phase-shift oscillator, astable multivibrator, Colpitts oscillator, crystal oscillator

Marine Automatic Control Systems: Actuators, and power transmission systems, sensors and measurement, data acquisition systems, relays, industrial data communication systems (field, "bus" systems), programmable logic controller, distributed control system (DCS), observer control and data acquisition (SCADA) system.

Marine Automatic Control Systems Laboratory: Magnetic Relay, Thermal Relay, Mechanical Magnetic Sensor (Reed Relay), Electronic Magnetic Sensor (Hall Effect Sensor), temperature sensors, optical sensors, pressure sensors, flow sensors, position sensors, PWM and motor control, usage of the data acquisition systems, PLC programming and system control

Control Systems: Control Systems, Dynamic Systems in ships (Diesel Engines, Boilers, Steam Turbine and Gas Turbine), Mathematical Modelling, Time Domain Analysis, Closed-Loop Control Systems, The root-locus method, Controller Design, Frequency response analysis, Stability analysis.

Control systems laboratory: Preparing simulations in computer by using mathematical analysis software like MATLAB is suggested for this laboratory lecture.

Learning provided by using visual and auditory skills, in theoretical lessons. But it is an incontrovertible fact that using tactual skills improve learning performance. However there should be laboratory lectures along with theoretically given lectures. Laboratory experiment Contents which should be practiced for this purpose is given below.

Ship Electro-technical Internship: According to Chapter III section STCW/CONF.2/33 which is published in 01.07.2010 (2010 Manila Conference), for marine engineers, the sum of workshop skill

training and approved seagoing service internship should be 12 months and this rule will be accepted unless one third of member countries or %50 of world's merchant shipping of ship's of 100 gross register tons owner countries would object. Also, it shall enter into force on 01.01.2012 (Web 17). For this reason, it can be suggested for new graduated marine engineers to make minimum 3 months shipyard or seagoing vessels internship in electric, electronics and control systems.

Conclusions

In this study, the condition of electric, electronics and control lectures in universities providing marine engineering education in Turkey and in the world has been examined and a new model for Turkey is suggested. Contents and credits of control lectures are found specifically insufficient. For this reason, the requirement of laboratory lectures and arranging the contents and credits of related courses is declared. Meanwhile, 3 months of practical training in shipyard or aboard of seagoing vessels is suggested.

Marine Technology is enhancing rapidly. Hence; electric, electronic and control education have to be shaped according to the expected future technology. For this reason, basic electric, electronic and control system knowledge, which is generally given in existing lecture contents, is important to adapt new technologies. Regarding to the rising importance of automation and remote control in new ships, increasing contents and numbers of these lectures will be appropriate. Integration of contents to ship systems is also important.

Whilst the technical diagnostic is recently done by control systems in vessels, these systems may not monitor the whole system or can give incorrect results. Hence, it is useful for marine engineers to have enough knowledge to set basic level circuits at least, in case of diagnosing the faults in the electronic systems. In this point, the importance of adding extra laboratory lectures and allow time for practical applications is inevitable. In addition, minimum 3-months-electro technical internship can be suggested for marine engineering students inside the totally 12 months trainee period according to the STCW Manila Amendments.

In conclusion, simulation practices about mechanical faults are commonly used in marine studies. By developing these kind of simulations for electronic and control systems new engineers can experience and learn more about fault and problems that they may occur in the future. In addition it is required to develop automation simulators and additional practical courses for the student along with engine room simulator, which is commonly used in many universities around the world.

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