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A Study on Development of Educational Model of Subjects of Electric, Electronic and Control for Marine Engineer in Accordance with STCW 2010 Amendments

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Abstract : *This paper presents a novel educational model of subjects of electric, electronic and control for marine engineer in accordance with STCW 2010 amendments. In accordance with STCW 2010, contents of such courses in marine engineering operations of undergraduate programs in maritime university should be updated correspondingly to new features. In order to propose the model, this paper analyses and reviews subjects on electric, electronic and control in STCW convention compared to STCW 1995. Also, in this paper, subjects of electric, electronic and control in marine engineering operations in Korea and other countries are analyzed and a new educational model is proposed. in theoretical perspective and practical perspective.*

Key Words : *STCW, Marine engineer, Electric, electronic and control, IMO, Maritime university*

1. Introduction

International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (hereinafter refer to 'STCW Convention') was adopted at 7 July 1978 and entered into force at 28 April 1984. Since the enforcement of the convention, the convention have been modified through two comprehensive revisions. Recent revision of the convention have been dealt with under six STW meetings of International Maritime Organization(IMO) during last 4 years (2006 ~ 2010). Taking into account STCW 95, it had not been reflected on development of contemporary new technology and rapid advancement in the maritime industry, but also it had inconsistencies, improper interpretations and outdated provisions in itself. Hence, IMO have decided to amend the convention at 37th STW sub-committee (Gorken et al., 2008).

With such reasons, it has been mainly revised in term of subjects of electric, electronics and control in Chapter III of the STCW Convention. Also, As Japan's proposal in IMO, electro-technical officers was newly developed in the STCW 2010 amendments(Gorken et al., 2011).

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This paper provides the comparison of requirements and related standards between Chapter III of STCW 95 and 2010 amendments. It shows current educational situation of maritime university toward subjects of electric, electronics and control in 5 each countries. In closing, this paper proposes new educational model which will be adapted to current industry in accordance with STCW 2010 amendments.

2. Analysis on subjects of electric, electronics and control in STCW 2010

2.1 Differences on STCW 2010 with STCW 95

There are some differences of specification of minimum standard of competence for officers in charge of an engineering watch listed in Table A-III/1 at operational level between STCW 95 and 2010. Among them, Table 1 provides newly amended contents(IMO. 2010)

Table 2 describes newly amended contents in 'Function: electrical, electronics and control engineering at the management level' of STCW Code A-III/2(IMO 2010).

2.2 Analysis between STCW 95 and 2010

In the STCW 95 Code, There was only one standard:

Table 1. Contents of newly amendment of A-Ⅲ/1 of STCW Code

STCW 2010	
Competence	Knowledge, Understanding and Proficiency
Maintenance and repair of electrical and electronic equipment	Safety requirements for working on shipboard electrical systems, including the safe isolation of electrical equipment required before personnel are permitted to work on such equipment Maintenance and repair of electrical system equipment, switchboards, electric motors, generator and DC electrical systems and equipment Detection of electric malfunction, location of faults and measures to prevent damage Construction and operation of electrical testing and measuring equipment Function and performance tests of the following equipment and their configuration: .1 monitoring systems .2 automatic control devices .3 protective devices The interpretation of electrical and simple electronic diagrams

Table 2. Contents of newly amendment of A-Ⅲ/2 of STCW Code

STCW 2010	
Competence	Knowledge, Understanding and Proficiency
Manage operation of electrical and electronic control equipment	Design features and system configurations of automatic control equipment and safety devices for the following: .1 main engine .2 generator and distribution system .3 steam boiler Design features and system configurations of operational control equipment for electrical motors Design features of high-voltage installations Features of hydraulic and pneumatic control equipment
Manage troubleshooting restoration of electrical and electronic control equipment to operating condition	Troubleshooting of monitoring systems Software version control

"Operate alternators, generators and control systems". There are additional one competences in the STCW 2010 Code such as "Maintenance and repair of electrical and electronic equipment" as in Table 1(Wyszkowski and Mindykowski, 2012). Under the Knowledge, Understanding and Proficiency, KUP, it is possible to find out new content 1) safety requirements for working, 2) maintenance and repair of electrical system equipment, switchboards, electric motors, generator and DC electrical systems and equipment, 3) detection of electric malfunction, 4) electrical testing and measuring equipment, 5) performance tests of monitoring systems, automatic control devices and protective devices as well as 6) interpretation of electrical and simple electronic diagrams.

In STCW 2010 Code, there were two additional competence at the management level.

Marine engineer at the management level are not obliged to operate or maintain and repair of electrical, electronic and control equipment. They have to manage operation and troubleshooting of electrical and electronic control equipment watchkeeping engineers have to operate and maintain the equipment.

It is interested to compare the competences and knowledge, understanding proficiency of engineer and electro-technical officers in the wake of the STCW 2010 Code.

With such short comparison of two competencies, it leads to conclusion

- Marine engineer is just obliged to know on how to operate, maintain and repair all electrical, electronic and control systems onboard the ship.

- Electro-technical officers have to know how to monitor, maintain and repair the systems and how to operate only generators and distribution systems including power system in excess of 1,000 volts, computer networks, bridge navigation equipment and ship communication system, deck machinery and cargo-handling equipment as well as safety systems of hotel equipment(Wyszkowski and Mindykowski, 2012).

3. Analysis and review in current marine institutes

In chapter 3, it analyses and review only subjects of electrical, electronic, and control in all marine engineering subjects in current marine institutes. From Table 3 ~ 13, it basically explains credits on subjects in general marine engineering. If there are additional subjects in electrical engineering as major, it is described in each Table.

Table 3. Korea maritime and ocean university (KMOU)

Subjects	Credit
Sequence control	2.0
Electrical engineering	3.0
Computer programming	2.0
Control engineering	2.0
Electronics engineering and digital engineering	3.0
Electronic and electrical lab	2.0
Fundamental practice of electronic and electric Ⅰ	3.0
Fundamental practice of electronic and electric Ⅱ	3.0
Practical electrical operation Ⅰ	3.0
Practical electrical operation Ⅱ	3.0
Electrical machinery	2.0
Power engineering (Major)	3.0
Electronic material (Major)	3.0
Applied micro processor (Major)	3.0
Energy engineering (Major)	3.0
Circuit theory (Elective)	3.0
Electronic circuit (Electives)	3.0
Semiconductor engineering (Elective)	3.0
Measurement engineering (Elective)	2.0
Energy engineering (Elective)	3.0
Applied PLC(Elective)	3.0

Table 4. Mokpo national maritime university (MMU)

Subjects	Credit
Electrical engineering	3.0
Electronic engineering	3.0
Sequence control	3.0
Control engineering	3.0
Electric machine	2.0
Computer programming (Major)	2.0
Electromagnetic (Major)	3.0
Circuit theory (Major)	3.0
Digital engineering (Major)	2.0
Measurement engineering (Major)	2.0
Microprocessor (Major)	2.0
Electrical control measurement practice (Major)	2.0
Electrical design (Elective)	3.0
Electronic circuit (Elective)	3.0
Digital control (Elective)	3.0
Power electronic (Elective)	3.0
Sensor and sensor process (Elective)	3.0
Application of microprocessor (Elective)	3.0
Application of sequence control (Elective)	3.0

3.1 Republic of Korea

As shown in Table 3, students studying in general marine engineering in KMOU are required to have 29 credits(KMOU, 2014).

Other students studying in electrical engineering as major have to be qualified 12 credits more. As elective subjects, students can have 17 credits in KMOU(KMOU, 2014).

As shown in Table 4, students studying in general marine engineering in MMU are required to have 14 credits.

Other students studying in electrical engineering have to be qualified 16 credits more. As elective subjects, students can have 21 credits in MMU(MMU, 2014).

3.2 USA

Students in CMA are obliged to study 20 credits given in as Table 5(CMA, 2015).

Table 5. California maritime academy (CMA)

Subjects	Credit
Electrical circuits	3.0
Electrical circuits lab	1.0
Electronics	3.0
Electronics lab	1.0
Electrical machinery	3.0
Electrical machinery lab	1.0
Automation	3.0
Automation lab	1.0
Power engineering technology	3.0
Power engineering technology lab	1.0

In Table 6, it is recognised that the college provides 19 credits for students studying in marine engineering(SUNY maritime college, 2015).

Table 6. SUNY maritime college

Subjects	Credit
Electrical engineering I	3.0
Electrical engineering II	3.0
Electrical engineering III	3.0
Electronics I	4.0
Marine electrical system	3.0
Analog controls	3.0

As shown in Table 7, it is recognised that the college provides 19 credits for students studying in marine engineering (SUNY maritime college, 2015).

Table 7. SUNY maritime college (Major in electrical engineering)

Subjects	Credit
Electrical engineering I	3.0
Network analysis	3.0
Electronics I	4.0
Electromagnetic fields	3.0
Power electronics	3.0
Electronics II	4.0
Electric machines	3.0
Electric drives	4.0
Electrical design I	1.0
Computerized control systems	3.0
Control systems theory	3.0
Electrical design II	4.0
Marine electrical system	3.0

MMC provides 13 credits to students as required subjects and have 6 credit of elective subjects as Table 8(MMC, 2015).

Table 8. Maine maritime college (MMC)

Subjects	Credit
Electrical power I	4.0
Electrical power II	3.0
Automation and control	3.0
Power control electronics	3.0
Enhanced electrical power (Elective)	3.0
Computer applications for power (Elective)	3.0

3.3 Spain

University of Cantabria provides 24 credits to students studying marine engineering and students can study 6 credits as elective subject as given Table 9(UC, 2015).

Table 9. University of cantabria (UC)

Subjects	Credit
Automatic control systems	6.0
Electronics	6.0
Electricity and electrical engineering	6.0
Electrical regulation and propulsion	6.0
Electric ship (Elective)	6.0

3.4 Turkey

As given in Table 10, it provides 9 credits to students studying marine engineering and students can study 3 credits as elective subject in ITU(ITU, 2015).

Table 10. Istanbul technical university (ITU)

Subjects	Credit
Marine electrotechnics	3.0
Marine electronics	2.5
Automatic control systems	2.5
Mechatronics & digital control system (Elective)	3.0

In Table 11, it is 8 credits for students studying in marine engineering which DEU provides(DEU, 2015).

Table 11. Dokuz eylul university (DEU)

Subjects	Credit
Marine electrotechnology	3.0
Marine electronics	2.5
Automatic control systems	2.5

As provided in Table 12, YTU requires 8 credits for students studying in marine engineering(YTU, 2015).

Table 12. Yıldız technical university (YTU)

Subjects	Credit
Marine electrotechnics	2.0
Marine electronics	2.0
Automatic control system	2.5
Digital control system (Elective)	3.0

3.5 Middle East

AAST provides 21 credits to students studying in marine engineering(AAST, 2015)

Table 13. AAST

Subjects	Credit
Electrical engineering fundamentals	3.0
Marine control systems	3.0
Marine electrical engineering	3.0
Electrical machines	3.0
Digital design & introduction to microprocessor	3.0
Automatic control system	3.0
Electrical ship design	3.0

3.6 Analysis of credits in maritime universities

Each maritime institutes has different hours per one credit.

Therefore, this paper considers only ratio of credits relating to subjects of electric, electronics and control as shown in Table 15.

As given in Table 14, KMOU, MMU and SUNY in electrical major just arranges over 20 % for electrical, electronic and control subjects.

Table 14. Comparison of credits in maritime institutes

Institutes	Credits	Total Credits	Percentage
KMOU	28	150	18.7
KMOU (Electrical Eng'r)	40	150	26.7
MMU	14	146	9.6
MMU (Electrical Eng'r)	30	146	20.5
CMA	20	161	12.4
SUNY	19	164	11.6
SUNY (Electrical Eng'r)	44	163	27
MMC	19	160	11.9
UC	24	240	10
ITU	8	164.5	4.9
YTU	6.5	159	4.1
DEU	8	175	4.6
AAST	21	185	11.4

3.7 IMO Model courses

IMO describes educational model course for each training course in accordance with STCW convention. Of them, marine engineers should be recommendably trained by formal education in accordance with the model course given by Table 15(IMO, 2014a; IMO, 2014b).

Table 15. Comparison of learning time between STCW 95 and 2010

Competence	Operational Level		Management Level	
	95	2010	95	2010
Marine Engineering	600	606	815	428
Electrical, Electronic and Control	160	400	121	288
	15.5 %	25.5 %	8.1 %	29.4 %
Maintenance and Repair	60	402	410	66
Ship and Person	211	161	138	196
Total	1031	1569	1484	978

Learning time to subject of marine engineering is almost same at operation level between STCW 95 and 2010. It has just 6 hour differences. but, in STCW 2010, the marine engineering subject is dramatically reduced from 606 hours to 428 hours with 178 hours differences.

As shown in Table 15, subject of electrical, electronic and control is highly increased 2.5 times at operational level and 2.4 times at management level.

Such increment means electrical, electronic and control subjects must be very important subject. Also, such subjects have to be reflected on education regime of maritime institutes. Except Korea maritime and ocean university(major in electric) and SUNY(major in electric), most of countries does not accepted those subjects.

This paper focuses on subject of maintenance and repair. The subjects is significantly increased from 60 to 402 hour with 6.7 times at operational level. Unlike operational level, subjects on maintenance and repair at management level is sharply decreased from existing 410 hours to 66 hours with 6.2 times. Changes of such learning hour on the subjects means contents on maintenance and repair should mainly be dealt with at operational level.

As for ship and person, learning hour at operational level is a bit reduced. But the hour at management level is a few increased.

4. Proposals

This paper recommends learning time and related subjects for first year student and second year student in Table 16 and subjects for third year student and fourth year student in Table 17 by IMO model course. Parts of theory in Table 16 and 17 should be implemented lecture room in theoretical perspective and Practical parts in Table 16 and 17 should be implemented workshop, computer simulation and/or engine room in practical perspective.

As shown in Table 16, even IMO give proper learning hour to trainee and trainer through IMO Model course,

Only two institutes such as Korea maritime and ocean university(major in electric) and SUNY(major in electric), most of countries does not implement subjects amended in accordance with STCW convention. What maritime institutes is not in conformity with the convention means that trainees or students is vulnerable to advanced technology in maritime industry.

In accordance with academic regime of korea, credit is 15

hours. Hence, candidates to marine engineer are required 2547 hours (170 credits) to study all subjects by IMO as far as trainees are qualified at two level, operational and management level. subjects of electric, electronics and control in maritime institutes are almost 46 credits of total 170 credits (688 hours of total 2547 hours recommended by IMO).

What students are required to study 46 credits on such subjects is that it can be difficulties. The reason is that universities have to provide other general education curriculums to students. Considering that the current graduate credits are 150 credits in KMOU, proposed credits can not be implemented. Also, mandatory credits required to be marine engineer in domestic law of korea are just 64 credits. Under the domestic law, it is impossible to carry out 170 credits in any university in Korea.

Hence, this paper proposes 'on board training' for 3 months on subjects of electric, electronic and control in accordance with practical part recommended in Table 16 and 17. During the period of proposed 'on board training', students are provided proper contents. Proposed 3 month can be included in current "on board training". Why this paper suggests 3 month is that subjects of electric, electronics and control is 27.6 % of all subjects in Table 16. If possible, proposed on board training for such subjects is specially arranged with certain period after completion of relevant theoretical subjects.

Table 16. Proposals to learning time and related subjects for first year student and second year student(IMO, 2014a)

	Subjects	Hour
Theory	Basic electrical engineering	165
	Basic electronics	45
	Basic control engineering	70
Practice	Safety requirement for working on electrical systems	10
	Maintenance and repair : principles of maintenance, G/E, MSBD, Motors, Starters, distribution system, DC system and equipment	50
	Detection of electrical malfunction and measures to prevent damage	20
	Construction and operation electrical testing and measuring equipment	10
	Function and performance test and configuration : monitoring systems, automatic control devices, protective devices	25
	Electrical and simple electronics diagrams	5

Table 17. Proposals to learning time and related subjects for the third year student and fourth year student(IMO, 2014b)

	Subject	Hour
Theory	Marine electrotechnology	40
	Power electronics	30
	Automatic control engineering and safety devices	40
Practice	Design features and system configuration of automatic control equipment and safety devices(main engine, generator and distribution system, steam boiler)	26
	Electric machinery(generator, motor and transformer)	50
	High voltage	20
	Pneumatic and hydraulic control equipment	10
	Trouble shooting of electrical and electronic control equipment	66
	Function test of electrical, electronic control equipment and safety devices	12
	Trouble shooting of monitoring systems	12
	Software version control	20

5. Conclusion

Marine Technology is enhancing rapidly. Hence; electric, electronic and control education have to be shaped according to the expected future technology and international convention. 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 adjusted.

In this study, the condition of electric, electronics and control lectures in universities providing marine engineering education in Korea and in the world has been examined and a new model for Korean maritime universities is suggested with educational subjects and 3 month on board training. This recognised that contents and credits of electric, electronic and control lectures are found specifically insufficient all over the world.

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 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.

In closing, this paper proposes certain period on board training to study and practice subjects of electric, electro and control such as 3 months. The period should be recommendably arranged for total period, 12 months, obliged by STCW. Also, subjects of electric, electro and control should be over 25 % of total educational time for marine engineer whether the students are in major in electrical engineering or not.

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