UDC 629.12:621.31(045)
DOI:10.18372/1990-5548.60.13815

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ELECTRIC PROPULSION SHIP'S TRAINING SIMULATOR BASED ON INTELLIGENT SYSTEM

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Abstract**—***The article is devoted to the development of a software and hardware complex for simulating the operation of ship's electric propulsion systems and for high-quality education, training and scientific research. A distinctive feature of the proposed simulator is the possibility of using data base from control and monitoring systems of real ships, followed by intelligent processing of the obtained data to simulate both nominal and emergency situations. The training complex reproduces most ship's operating situations, provides training on monitoring, control and management of low voltage and high-voltage power plants. The need to apply the training complex allows the formation of the required competence of the engine room personnel, develop methods and criteria for assessing competence, evaluate and demonstrate the practical skills obtained, and also provides an opportunity to conduct scientific research work. The proposed solutions can be used in the training complex for the high-quality training of engine department personnel in accordance with the requirements and standards of the Standards of Training, Certification and Watchkeeping Convention.*

Index Terms—Intelligent system; electric propulsion simulator; training engine department personnel; power and propulsion system; power management system; programmable logic controller; frequency converter; asynchronous motor.

I. INTRODUCTION

Recently, in the marine industry, diesel electric propulsion vessels have found wide application, this is associated with great advantages, such as high reliability, high maneuvering qualities, the power redundancy and other [1]. For such vessels the electric propulsion system is the most suitable because of the specificity of the modes of operation and destination. Working with those complex ship systems requires highly qualified and competent engine department personnel, which should not only implement routine maintenance of systems, but also immediate actions to be taken under fault conditions in emergency situations, to restore the system to working condition and minimize time for troubleshooting.

With various operating modes such as maneuvering, passing through narrows and channels, operating in difficult ice navigation conditions ship's systems must be reliable. But emergency situations occur when one or more of the ship's systems fail and the ship's personnel are primarily responsible for preventing collisions or other disasters that could lead to human sacrifices and environmental hazards.

II. REVIEW OF THE LITERATURE

Currently, International Maritime Organization (IMO) MARPOL regulations have set targets for reducing the Energy Efficiency Design Index (EEDI) for new ships and to enforce these advances the IMO MARPOL impose increasingly stringent restrictions on ship's emissions [2], [3].

Since the operational profile of ships became more diverse, and the fulfillment of numerous tasks leads to an increase in the power and propulsion plants and the complexity of performing various marine operations and this trade-off between efficiency and adaptability to diverse operating profiles has led to a growing variety of power and propulsion systems [4], [5]. Figure 1 shows the power and propulsion system, which can be classified as follows:

– mechanical propulsion, electrical propulsion or a hybrid combination of both;

– power generation with combustion engines, fuel cells, energy storage or a hybrid combination;

– alternating current (AC) or direct current (DC) electrical distribution.

Furthermore, more attention is paid to diesel electric propulsion vessels with a single or multiply main switchboards (MSB,) which provides power for electrical propulsion system and general ship's consumers and such systems require highly qualified personnel.

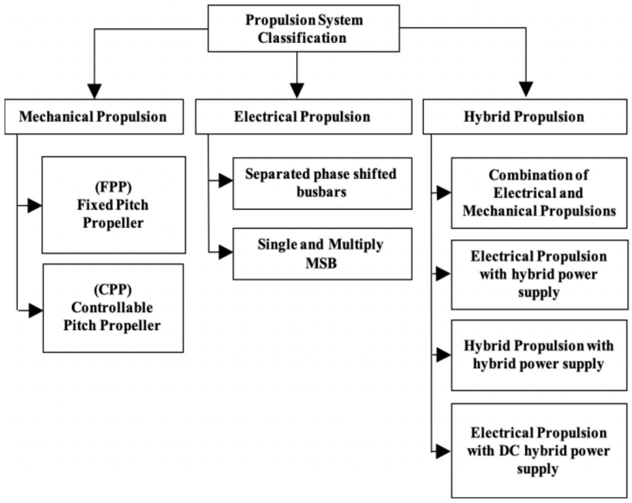

Fig. 1. Power and propulsion system classification

According to the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) including 2010 Manila Amendments in chapter III describes the standards and requirements for the competence of the engine department at the operational and management levels for the electrical propulsion of the ships [6]. Also, IMO developed a several of recommended model courses (7.02 [7], 7.04 [8], 7.08 [9], 2.07 [10]), which describes in detail the principles of training, methods of demonstration and lists of competencies, which must fully comply for the engine department officers. The tables of competences describe the minimum knowledge, understanding and professional skills with respect to ship propulsion control systems, including electric propulsion systems. In accordance with the methods for demonstrating competence and the criteria for evaluating competence is necessary comprehensive training of personnel on the simulator with the appropriate specialized laboratory equipment. In this case, the attention of delegates should be paid to the understanding of the processes in the operation of the equipment of the propulsion complex concerning the static and dynamic characteristics of power plants, the parameters of operating modes and the nature of transients.

Such training should include theoretical and practical modules that can be fully implemented using the ship's multi-functional simulator. This simulator should realize wide functional and operational capabilities to the level of physical reality, according to the tasks and scenarios modeled on the simulator, that delegates acquire the necessary knowledge and experience. At the moment, the training of engine department personnel is not good enough qualified, due to the small number of training complexes using real equipment.

The training of specialists on virtual simulators gives a good theoretical understanding of the processes taking place, but there is no state of reality and the practical impossibility of the influence of physical changes on equipment operation to create pre-emergency, emergency and rapidly changing modes of equipment state where fast, accurate and correct decision making are required.

A variety of virtual simulators are known, such as TRANSAS [11], KONGSBERG [12], and others, which are based on various types of vessels, including electric propulsion vessels. Despite the wide functionality of virtual simulators, they also have a number of disadvantages, due to software binding and the lack of equipment, which limits the training personnel from real processes at operating various ship systems.

There are also a number of publications describing the work of laboratory and training complexes, the purpose of which is the study of physical processes, scientific research, theoretical and practical exercises to improve the level of training engine department personnel according the requirements of the STCW Convention.

Training complexes are developed that take into account the above-mentioned features, which include both virtual tools and physical components. In particular in [13] a training complex is described that allows for experimental studies, as a result of which it is possible to obtain graphs of transient processes of acceleration, deceleration and reverse of a propulsion motor; voltage and current of the propulsion motor and frequency converter when running in the good and bad weather conditions, in ice navigation and in emergency conditions. On computer models, the following modes of operation of the power and propulsion systems (PPS) are implemented:

– idle operation;

– operation on the screw characteristic in the established modes (good weather, bad weather and ice navigation);

– operation on the screw characteristic in the transient conditions (acceleration, deceleration, reverse);

– operation in emergency modes (jamming of the propeller, breakdown of the propeller blade, etc.).

The simulator by changing the layout the algorithm and the laws of regulation, the load characteristics of the propeller allows to simulate the operation of the power and propulsion systems with a direct transfer of torque to the propeller.

The disadvantage of such a simulator is that a DC synchronous generator is used as a model of the electric propulsion, and an asynchronous motor is used to simulate the propeller.

Considering the fact that in modern shipbuilding on diesel electric ships use AC synchronous and asynchronous motors and electric machines of DC are practically not used in ship systems due to a number of disadvantages.

III. Problem Statement

The training of specialists on virtual simulators gives a good theoretical understanding of the processes taking place, but there is no state of reality and the ability to adapt to the operating conditions of a real ship, which significantly reduces the efficiency of personnel training.

The relevant objective is to develop a simulator complex as close as possible to the operating conditions of modern diesel electric propulsion ships. Such a simulator should allow to conduct laboratory tests with modeling of nominal and emergency modes of operation, where quick and correct decision making is required.

It is necessary to provide the possibility of integrating intelligent system into the training complex which could be trained in all processes and modes of operation of the simulator in order to simulate various scenarios that are potentially and actually possible during the operation of ship's electric propulsion systems.

IV. Simulator Structure Justification

For the modeling and subsequent imitation of operating modes of ship's systems on a simulator, first of all, it is necessary to analyze information about their functioning under the operating conditions of a real ship. As an example, a seismic vessel with the following technical specification is considered:

– 3D seismic vessel with wide tow for towing streamers (maximum number 12);

– diesel electric propulsion: 2x4000 kW stern thrusters, 1x2000 kW bow thruster;

– Power Management System (PMS): Main engines / Generators 4x3355 kW, single main switchboard (MSB), separated on starboard side (STBD) and port side (PS), rated voltage 4160 V and frequency 60 Hz.

"Hoglund" IAS (Integrated Automation System) [14] is designed to meet the complete range of automation and control tasks on-board ship, which integrates the functions of control, monitoring and alarm of the following ship automation systems:

– Power Management System (PMS);
– Engine Control and Safety System (ECS);
– Ship Performance Monitor (SPM);
– Power Fault Control (PFC);
– Valve Control System (VCS);
– HVAC Control System (HCS);
– propulsion control system (in the presence of a dynamic positioning (DP) system);
– Playback and Fast Data Capture and etc.

The system structure consists of several substations connected to each other through a redundant, fast and reliable communication protocol.

Also, part of IAS, is a power management and distribution system that performs the function of monitoring and control. All signals are stored into a history file with a storage capacity for up to a year logging length, depending on disk size.

The major PMS functions are load dependent start/stop; pre-warning alarm; shut down function; load reduction; heavy consumers; blackout; switchboard configuration; active load sharing; alarm handling.

In Figure 2 shows a system for monitoring and control of a high voltage power system of a real DP seismic vessel with electric propulsion in operation during bad weather and rough sea at 6–7 points with a wave height of up to 8 meters.

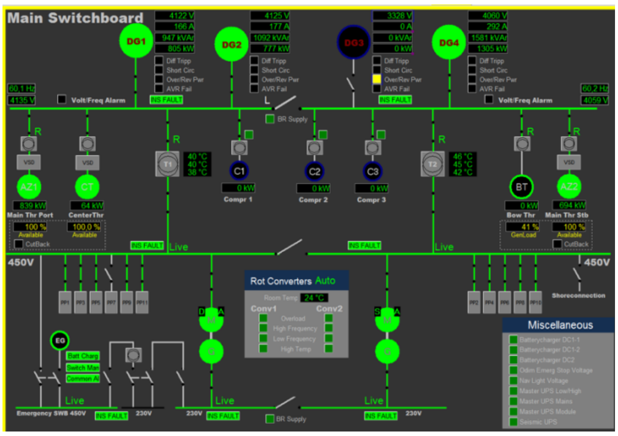

Fig. 2. High voltage diesel electric propulsion seismic vessel

When the vessel is under way at high sea excitement the propellers are periodically become bare and this results in suddenly load changes on the propulsion plants.

This mode of operation can lead to the creation of an emergency and blackout of STBD of the main switchboard and all consumers that receive power and an emergency stop of the power propulsion plant (Fig. 3). In this case marine personnel have to be fully competent to restore stopped equipment as soon as possible, to avoid any possible collision or other incidents.

To analyze occur incident and take the necessary actions the stored database allows to troubleshoot incidents with graphical presentation and carry out analysis of all the necessary parameters at the time of the occurrence of emergency or other abnormal situations.

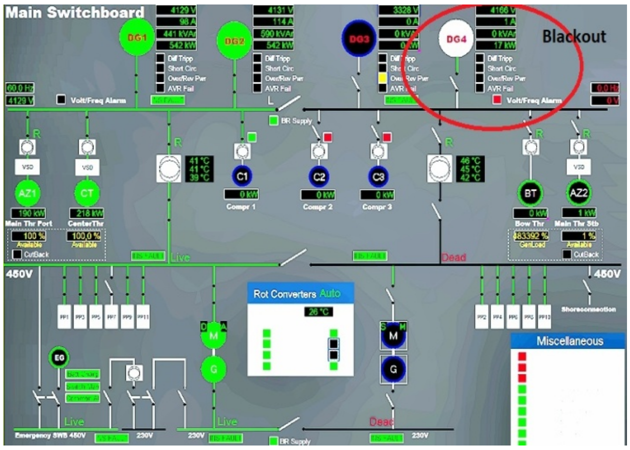

Fig. 3. Blackout of STBD of main switchboard

The results of the database on the ship's operation modes can be used later as initial information for the intelligent system, its training in the recognition of emergency and critical condition and the subsequent formation of recommendations for the crew for its prevention. On the other hand, the same intelligent system is capable of reproducing various similar situations and simulating them on a simulator.

V. EXPERIMENT

Considering the above structure of a specialized multifunctional simulator with an electric propulsion (Fig. 4) is proposed and with the possibility to conduct training of theoretical and practical parts and simulate the main modes of operation of the ship electrical equipment in accordance with operational and practical tasks to provide competence assessment according to the requirements of STCW for the engine department personnel.

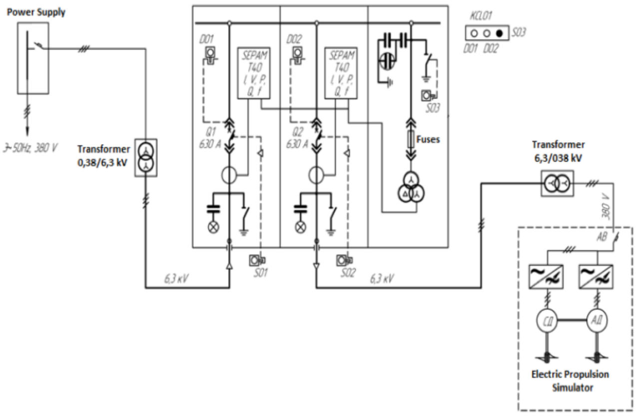

Fig. 4. General high voltage power system with electrical propulsion simulator

The simulator includes two asynchronous motors with rigid shafts connection. Each motor is operated by frequency converter with software, one of the motor using as propulsion motor and the other is a load with the ability to control the torque on the shaft (propeller). Thereby, the simulator can be used in different modes, control the rotation speed and the load on the propulsion motor.

The general overview of software and equipment communication is shown in Fig. 5.

The main operator panel gives possibility to control asynchronous motors of the electric propulsion plant using frequency converters and to simulate operating modes and loads, such as: maneuvering, operating at low and high speeds, steady mode, overload and malfunction. Through operator panel by the software various operating mode algorithms are set up with the possibility of control with auto and manual modes (Fig. 6).

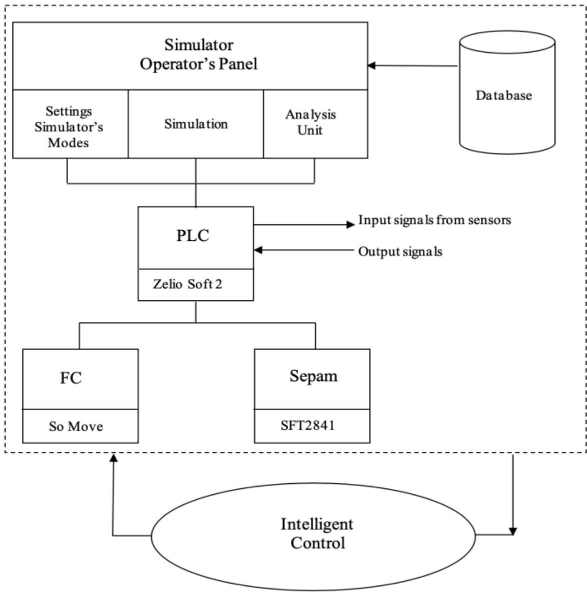

Fig. 5. General overview intelligent control of multifunction simulator

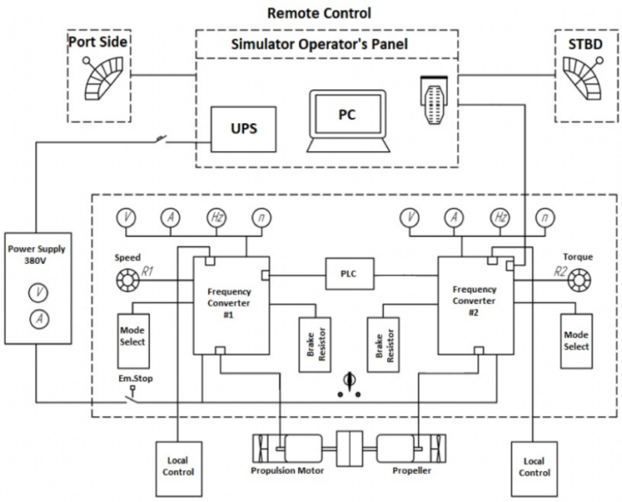

Fig. 6. Multifunction electrical propulsion simulator

In auto mode have possibility to select of ready-made options for the operating modes of the electric power plant without participation in the process of a personnel. This is achieved by creating special software algorithms in the "Zelio Soft 2" logical software and uploading it to the Programmable Logic Controller (PLC, Schneider Electric Zelio SR2B201BD) [15]. In the manual mode possible to change the settings of certain factors to adjust the operating modes of the equipment. The PLC has the ability to connect input sensors to expand the functionality of the monitoring system and use the output signals for frequency converters (to control and monitor motors) and for protective devices "Sepam" [16] (to control high voltage vacuum circuit breakers).

VI. Result and Discussion

Using the software "SFT2841" [17] for "Sepam" can perform special control and monitoring functions such as: editing logic equations for programming original functions management and control; creating personalized alarms for local operation; customization of the control matrix to match the assignment of output relays, signal lamps and signal messages.

At the time of the electric propulsion simulator in various modes of operation, there is a stream recording of all current processes and the subsequent saving of these parameters to the database.

The "analysis unit" allows analyzing the saved data for the required period of time, for example, any pre-emergency and emergency situations, or static and dynamic modes of operation of the power plant.

Frequency converters are controlled by the software "So Move" [18], where can perform the following basic operations:

– setting and editing the parameters of frequency converters;

– visual display of the status of parameters and variable drives;

– automation of experimental studies;

– oscillography of the measured coordinates;

– processing the results of experimental studies.

With the simulator various speed and load modes of operation were implemented with the possibility of observing and recording all processes as well as recording parameters and constructing graphical and screw characteristics of the electric propulsion complex.

In Figure 7 shows the variable dynamics of torque (1), voltage (2), alternating current (3) and frequency (4) during the maneuvering mode of the vessel, when the speed of propeller has been increased over a certain period of time, remained steady and decreased.

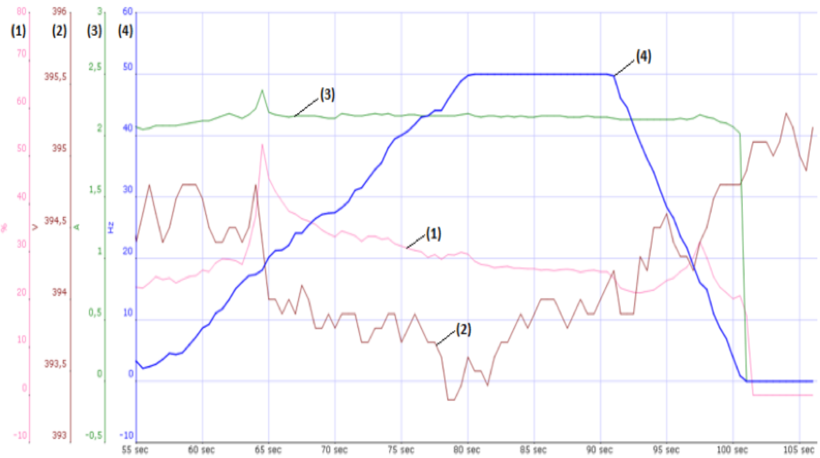

Fig. 7. Graphic visualization of parameters

At this simulator studied the steady-state modes: mechanical characteristics, curves of changes of frequency, voltage, stator current with different methods of frequency control. Dynamic modes were investigated not only at idle, but also at different values and laws of load variation.

VII. Conclusions

This simulator complex makes high-quality training of engine department personnel in accordance with the requirements and standards of an international convention (STCW) and 2010 Manila amendments. The experience and skills gained on a multifunctional simulator allows seafarers to work on various equipment of electric propulsion vessels showing a high level of knowledge and training.

A distinctive feature and the most important advantage of the proposed software and hardware complex is a rational combination of both real hardware systems for controlling ship's electric propulsion complexes, and virtual components implemented by software. The possibility of training the marine crew on real equipment allows delegates to acquire the necessary skills and competencies, while the software simulation of the operating modes provides sufficient flexibility in modeling workflows on ships of various types.

The use of an intelligent system in the structure of a software-hardware complex allows to create and analyze a date base from real ships modern monitoring systems. Later on, the simulator modeling the modes of the propulsion complex operation appropriate to various normal and emergency situations.

Prospects for using the database of other vessels allows intelligent systems to simulate various modes of operation of vessels of various types, as well as the result to be used to effectively train machine crew personnel.

REFERENCES

[1] A. F. Grigoriev, V. A. Petukhov, "Modern and Perspective Marine Shaft Generator Plants", Saint Petersburg: *Publishing House of the Admiral Makarov State Maritime Academy*, 2009. Print. (in Russian).

[2] *Marpol*, Consolidated Edition, IMO, London. 2017, 465 p.

[3] *Marpol,* AnnexVI and NTC 2008, IMO, London. 2017, 422 p.

[4] R. D. Geertsma, R. R. Negenborn, J. J. Hopman, "Design and control of hybrid power and propulsion systems for smart ships". *Elsevier. Applied Energy,* vol 194, pp 30–54, 2017.

[5] Yu. O. Lebedenko, V. V. Danyk, P. O. Krupitsa, "Adaptive Control of the Combined Propulsion System," *IEEE International Conference Actual Problems of Unmanned Aerial Vehicles Developments (APUAVD) Proceedings,* vol 4rd, 2006. Print. doi: 10.1109/MSNMC.2016.7783145

[6] *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, (STCW) Code*, IMO, London, 2017, 378 p.

[7] *IMO Model Course 7.02, Chief Engineer Officer and Second Engineer Officer*, London, 2014, 278 p.

[8] *IMO Model Course 7.04, Officer in Charge of an Engineering Watch,* London, 2014, 236 p.

[9] *IMO Model Course 7.08, Electro-Technical Officer*, London, 2014, 152 p.

[10] *IMO Model Course 2.07, Engine-Room Simulator*, London, 2017, 184 p.

[11] Transas, ERS 5000 Engine Room Simulator. [Online]. Available:https://www.transas.com/products/simulation/engine-room-and-cargo-handling-simulators/ERS5000

[12] Kongsberg, DE Dual Fuel LNG Carrier DEDF21. [Online]. Available: https://www.kongsberg.com/digital/models-and-examples/k-sim-engine-models/diesel-electric-dual-fuel-lng-carrier-dedf21

[13] A. V. Grigoryev, R. R. Zaynullin, S. M. Malyshev, "Designing of Scientific-Educational Laboratory-Training Complex of Ship Electric Propulsion Systems and Electric Propulsion Plants of new Generation," *Vestnik*, Edition 4 (38), pp 203–210, 2016. Print. doi: 10.21821/2309-5180-2016-8-4-203-210

[14] Hoglund., Integrated Automation System (IAS). [Online]. Available: https://hma.no/solutions/marine-automation/integrated-automation-system-ias

[15] Schneider Electric, Programmable Logic Controller Zelio Logic SR2/SR3. [Online]. Available: https://www.schneider-electric.com/en/product/SR2B201BD/compact-smart-relay-zelio-logic---20-i-o---24-v-dc---clock---display/

[16] Schneider Electric, Protection Relay Sepam series 40. [Online]. Available: https://www.schneider-electric.com/en/product-range/934-sepam-series-40/

[17] Schneider Electric, Software SFT2841. [Online]. Available: https://www.schneider-electric.com/en/download/document/Setup_Software_SFT2841/

[18] Schneider Electric, Software So Move. [Online]. Available: https://www.schneider-electric.com/en/product-range/2714-somove/?subNodeId=827547180en_WW

Received March 21, 2019

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А. А. Іванов, Ю. О. Лебеденко, С. О. Рожков, І. В. Колосов. Інтелектуальна система як частина симулятора пропульсивного комплексу судна з електрорушієм

Стаття присвячена розробці програмно-технічного комплексу для моделювання роботи суднових електроенергетичних систем, а також для якісного навчання, підготовки і наукових досліджень. Відмінною особливістю пропонованого тренажера є можливість використання бази даних систем управління і контролю реальних судів з подальшою інтелектуальною обробкою отриманих даних для моделювання як штатних, так і аварійних ситуацій. Навчальний комплекс відтворює більшість умов експлуатації судна, проводить тренінги з моніторингу, контролю та управління низьковольтними і високовольтними електростанціями. Необхідність застосування навчального комплексу дозволяє сформувати необхідний рівень компетентності персоналу машинного відділення, розробити методи і критерії оцінки компетентності, оцінити і продемонструвати отримані практичні навички, а також дає можливість проводити науково-дослідні роботи. Запропоновані рішення можуть бути використані в тренажерному комплексі для якісного навчання персоналу машинного відділення відповідно до вимог і стандартів Конвенції ПДНВ.
Ключові слова: інтелектуальна система; тренажер силової установки; навчання персоналу машинного відділення; силова пропульсивна установка; система управління живленням; програмований логічний контролер; перетворювач частоти; асинхронний двигун.

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Напрямок наукової діяльності: силова електроніка, енергетика, автоматизовані системи управління.
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А. А. Иванов, Ю. А. Лебеденко, С. А. Рожков, И. В. Колосов. Интеллектуальная система как часть симулятора пропульсивного комплекса судна с электродвижением

Статья посвящена разработке программно-технического комплекса для моделирования работы судовых электроэнергетических систем, а также для качественного обучения, подготовки и научных исследований. Отличительной особенностью предлагаемого тренажера является возможность использования базы данных систем управления и контроля реальных судов с последующей интеллектуальной обработкой полученных данных для моделирования как штатных, так и аварийных ситуаций. Учебный комплекс воспроизводит большинство условий эксплуатации судна, проводит тренинги по мониторингу, контролю и управлению низковольтными и высоковольтными электростанциями. Необходимость применения учебного комплекса позволяет сформировать необходимую компетентность персонала машинного отделения, разработать методы и критерии оценки компетентности, оценить и продемонстрировать полученные практические навыки, а также дает возможность проводить научно-исследовательские работы. Предлагаемые решения могут быть использованы в тренажерном комплексе для качественного обучения персонала машинного отделения в соответствии с требованиями и стандартами Конвенции ПДНВ.

Ключевые слова: интеллектуальная система; тренажер силовой установки; обучение персонала машинного отделения; силовая пропульсивная установка; система управления питанием; программируемый логический контроллер; преобразователь частоты; асинхронный двигатель.

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