УДК 621.224.34:629.54

USE HYDRO-TURBO-ELECTRIC GENERATOR FOR "GREEN" SHIPPING

K. Kyrychenko, A. Ben, S. Zinchenko, P. Mamenko, V. Mateichuk
Kherson State Maritime Academy

Abstract: *Given the trend of transition of transport to electricity, the task is to study the ways of rational transition of ships to electric propulsion. As this issue is easier to solve for small vessels, for heavy-duty vessels to ensure the minimization of the use of petroleum products and the transition to electric propulsion is an urgent scientific and technical task. Studies of hybrid types of ship engines have been considered, but the use of petroleum products remains high. The question of application is investigated in the work hydro-turbo-electric generator in ship designs, in order to use a diesel engine only to start the ship. When applying hydro-turbo-electric generator, after the start of rotation of the turbine blades, the vessel can move only on electric propulsion.*

Keywords: *electric vehicle, hybrid vehicle, shipboard power, propulsion systems, hydro-turbo-electric generator, fuel saving.*

ВИКОРИСТАННЯ ГІДРОТУРБОЕЛЕКТРОГЕНЕРАТОРА ДЛЯ «ЗЕЛЕНОГО» СУДНОПЛАВСТВА

К. В. Кириченко, А. П. Бень, С. М. Зінченко, П. П. Маменко, В. М. Матейчук
Херсонська державна морська академія

Анотація: *Враховуючи тенденцію переходу транспорту на електричну енергію, постає завдання дослідження шляхів раціонально переходу морських суден на електрорушії. Оскільки для малих суден це питання вирішується простіше, то для великовантажних суден забезпечення мінімізації використання нафтопродуктів та перехід на електрорушії є актуальним науково-технічним завданням. Розглянуті дослідження гібридних типів рушіїв судна, однак при цьому використання нафтопродуктів продовжує залишатися великим. У роботі досліджено питання застосування гідротурбоелектрогенератора в конструкціях суден, з метою використання дизельного двигуна лише для початку руху судна. При застосуванні гідротурбоелектрогенератора, після початку обертання лопатей гідротурбін, судно може рухатися виключно на електричному рушії.*

Ключові слова*: електричне судно, гібридне судно, суднова потужність, рушійні системи, гідротурбоелектрогенератор, економія палива*

The ever-increasing amount of electronics in everyday life, such as hybrid-electric and fully electric cars, and portable gadgets that are with us every day. Electrification also takes place at sea, on merchant ships, offshore platforms and other ships. The field of ship power plants has undergone significant changes and will continue to change dynamically in the coming decades [1].

Floating vehicles on electric batteries began to be built back in the 19th century, and before the era of the appearance of a compact gasoline engine, they even had certain popularity. This was common on smaller ships. It is necessary to study the rational transition of ships to electric power, since the use of diesel power on a ship

leads to harmful emissions into the atmosphere; the use of diesel power is a significant risk.

Authors of work [2] to improve the energy efficiency of a diesel-electric hybrid propulsion system, a control strategy suitable for ships with a hybrid electric propulsion system has been proposed. By controlling the number of generators in the network and the load capacity of one generator set, the fuel consumption of the hybrid electric propulsion system can be reduced and the efficiency of the diesel engine can be improved. In [3], attention is paid to environmental problems, in particular, the reduction of greenhouse gas emissions.

In the study [4], variable speed motors are considered, which are powered by a variable frequency drive that supplies power to the motors at a frequency corresponding to the desired speed. Various applications of variable speed motors on board ship are evaluated and design recommendations are presented.

The study [5] considered hybrid power systems with direct current distribution for commercial marine vessels in order to meet the new stringent environmental regulations and achieve better fuel economy. The system under study includes diesel engines, synchronous generator-rectifiers, a bidirectional bridge converter, and a lithium-ion battery bank as an energy storage device. To evaluate the potential fuel savings provided by such a system, an online fuel consumption optimization strategy was implemented. In [6–19] the issues of ship manoeuvring and safety of navigation are considered.

Ecological electric shipping will become only when the energy for recharging the batteries will be supplied from environmentally friendly sources, such as wind turbines or hydro turbines.

The transition of ships to electricity can be done by installing a turbine in the on-board flow channels, closer to the middle frame, and removing the drives through an impermeable onboard partition, through a sealing seal inside the ship, where electric generators are mounted in special enclosures. For maintenance and control of the drive of a reducer of electric generators (Fig. 1) the inlets of the hydraulic channels are protected by steel bars to prevent debris in the form of logs, bars and debris in the water.

This problem is solved by the fact that when arranging in double sides of space flowing hydrokinetic channels, the shape of powerful giant ejectors increases the flow rate of flowing water jet, thereby increasing the pressure on the turbine blade, increasing torque, which will increase electricity generation. Increasing the velocity of the oncoming jet provides a vacuum produced by the ejector and brings the vacuum through the channel to the outlet of the flowing onboard hydrokinetic channels, closer to the water surface, at the waterline level of the vessel [20].

The material for the cones of the onboard ejectors is hard plastic. The Azipod rotary propulsion system is used as the ship's propulsion system. The design of the vessel's flow channels should have an angle of inclination from the waterline with an inclination in the nose of 15–25° in order to reduce keel wobble and eliminate air entrapment in the flow channels.

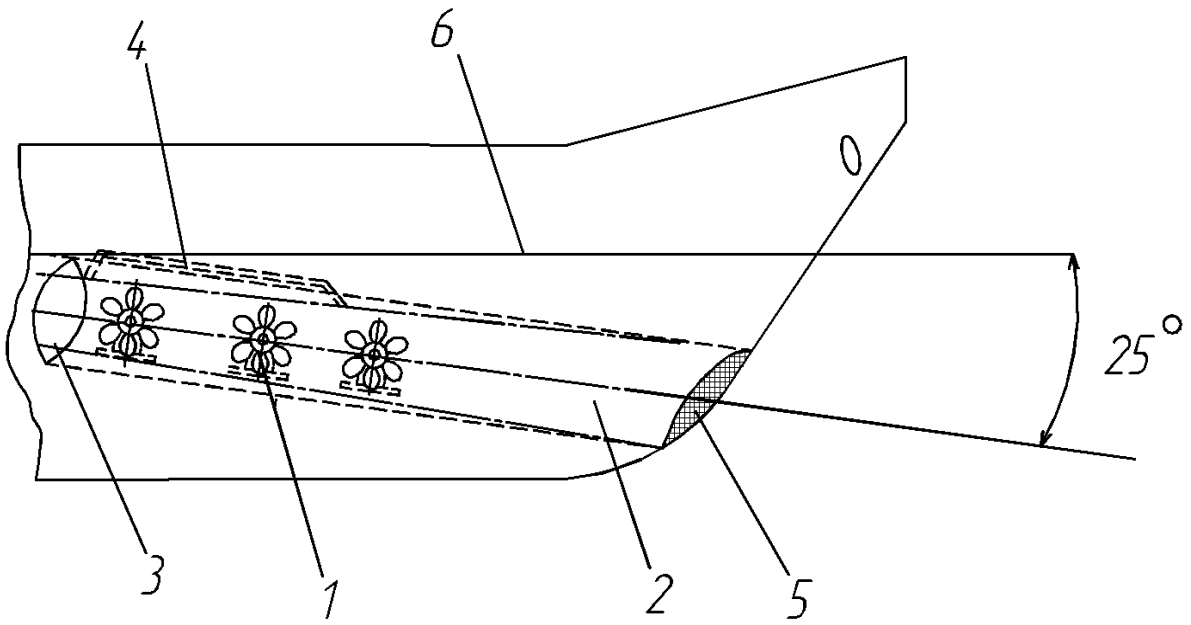

Figure 1 – View from the board on the flow channel, where 1 is a turbine, 2 – flow channels, 3 – outlet, 4 – channel, 5 – steel lattice, 6 – waterline

Conclusions. A review of existing solutions to the transition of ships to electric propulsion was conducted. Currently, the number of electric ships is much less than diesel ones. However, maritime transport needs greening just as much as land transport. The design hydro-turbo-electric generator of installation of the hydroturbine in onboard flow channels, closer to a midline frame, and output of drives through an impermeable onboard partition is offered. The scheme of the flow channel with hydro turbines on board the vessel is presented. When using the proposed design, diesel fuel is used only to start the movement of the vessel.

REFERENCES

1. McCoy T. J. Electric Ships Past, Present, and Future [Technology Leaders]. IEEE Electrification Magazine, 2015, vol. 3, no. 2, pp. 4–11.

2. Zhang C. and JIA B. Research on Energy Efficiency Optimization Strategy of Electric Propulsion Ships with Energy Storage Devices, 2019 Chinese Automation Congress (CAC), 2019, pp. 4689–4694.

3. Shang C., Srinivasan D. and Reindl T. Economic and Environmental Generation and Voyage Scheduling of All-Electric Ships. IEEE Transactions on Power Systems, 2016, vol. 31, no. 5, pp. 4087–4096.

4. Gritter D., Kalsi S. S. and Henderson N. Variable speed electric drive options for electric ships. IEEE Electric Ship Technologies Symposium, 2005, pp. 347–354.

5. Zahedi B., Norum L. E., Ludvigsen K. B. Optimized efficiency of all-electric ships by dc hybrid power systems //Journal of power sources, 2014, T. 255, pp. 341–354.

6. Kyrychenko K. V., Zinchenko S. M., Nosov P. S. Minimizing damage in the event of imminent collision. Proceedings of the I International scientific-practical conference «Current transport safety issues, in energy, infrastructure (STEI-2021)», 2021, pp. 234–238.

7. Mamenko P., Zinchenko S., Nosov P., Kyrychenko K. V., Popovych I., Nahrybelnyi Ya., Kobets V. Research of divergence trajectory with a given risk of ships collisions. Modeling, control and information technologies: Materials of V international scientific and practical conference.

[Electronic edition]. – Rivne : National University of Water and Enviromental Engineering, 2021, pp. 64–67.

8. Kyrychenko K. V., Grosheva O. O., Tovstokoryi O. M., Mateichuk V. M., Moiseenko V. S., Mamenko P. P. Solving the problem of minimization damage in the event of imminent collision. Materials of the Ith international scientific and practical conference «Problems of sustainable development of the marine industry (PSDMI-2021)», 2021, pp. 112–115.

9. Nahrebelnyi Ya. A., Prokopchuk Yu. A., Mamenko P. P., Mateichuk V. M., Kyrychenko K. V. Analysis of the functional entropy influence on decision-making by a navigator in critical situation. Materials of the Ith international scientific and practical conference «Problems of sustainable development of the marine industry (PSDMI-2021)», 2021, pp. 101–103.

10. Mamenko P. P., Zinchenko S. M., Tovstokoryi O. M., Mateichuk V. M., Kyrychenko K. V. Moiseenko V. S. Solution of the problem of optimizing route with using the risk criterion. Materials of the Ith international scientific and practical conference «Problems of sustainable development of the marine industry (PSDMI-2021)», 2021, pp. 185–188.

11. Кириченко К. В., Зінченко С. М., Носов П. С., Маменко П. П. Дослідження мінімізації збитків у випадках неминучого зіткнення суден. Матеріали XII Міжнародної науково-практичної конференції «Сучасні підходи до високоефективного використання засобів транспорту». – Ізмаїл: ДІ НУ «ОМА», 2021. – С. 18–22.

12. Nosov, P., Zinchenko, S., Ben, A., Prokopchuk, Yu., Mamenko, P., Popovych, I., Moiseienko, V. & Kruglyj, D. Navigation safety control system development through navigator action prediction by data mining means. Eastern-European Journal of Enterprise Technologies. Information and controlling system, 2021, Vol. 2, No. 9 (110), pp. 55–68.

13. Nosov, P., Zinchenko, S., Popovych, I., Safonov, M., Palamarchuk, I. & Blakh, V. Decision support during the vessel control at the time of negative manifestation of human factor. CEUR Workshop Proceedings, 2020, Vol. 2608, pp. 12–26.

14. Маменко П. П., Зінченко С. М., Носов П. С., Кириченко К. В. Методи підвищення безпеки судноводіння. Матеріали XII Міжнародної науково-практичної конференції «Сучасні підходи до високоефективного використання засобів транспорту». – Ізмаїл: ДІ НУ «ОМА», 2021. – С. 18–22.

15. Nosov, P., Ben, A., Zinchenko, S., Popovych, I., Mateichuk, V., & Nosova, H. Formal approaches to identify cadet fatigue factors by means of marine navigation simulators. CEUR Workshop Proceedings, 2020, Vol. 2732, pp. 823–838.

16. Nosov, P. S., Cherniavskyi, V. V., Zinchenko, S. M., Popovych, I. S., Nahrybelnyi, Ya. A. & Nosova, H. V. Identification of marine emergency response of electronic navigation operator. Radio Electronics, Computer Science, Control, 2021, №1, pp. 208–223.

17. Nosov, P. S., Popovych, I. S., Cherniavskyi, V. V., Zinchenko, S. M., Prokopchuk, Yu. A., Makarchuk, D. V. Automated identification of an operator anticipation on marine transport. Radio Electronics, Computer Science, Control, 2020, № 3, pp. 158–172.

18. Zinchenko, S., Ben, A., Nosov, P., Popovich, I., Mamenko, P. & Mateychuk, V. Improving the Accuracy and Reliability of Automatic Vessel Motion Control Systems. Radio Electronics, Computer Science, Control, 2020, № 2, pp. 183–195.

19. Zinchenko, S., Mateichuk, V., Nosov, P., Popovych, I., Solovey, O., Mamenko, P. & Grosheva, O. Use of Simulator Equipment for the Development and Testing of Vessel Control Systems. Electrical, Control and Communication Engineering, 2020, Vol. 16 (2), pp. 58–64.

20. Пат. 135591 Україна, МПК МПК (2019.01) F01D 15/10 (2006.01) B63B 9/00 B63B 1/40 (2006.01) B63B 39/00. Судновий гідротурбоелектрогенератор / Г. І. Ревунов, К. С. Стасюк, О. В. Щедролосєв, М. О. Щедролосєв, К. В. Кириченко. − № u2019 00613 ; заявл. 21.01.2019 ; опубл. 10.07.2019, Бюл. № 13. – 4 с.

Кириченко Костянтин Володимирович *к.т.н., старший викладач кафедри «Управління судном» Херсонської державної морської академії. ORCID: https://orcid.org/0000-0002-0974-6904; kvklecturer@gmail.com*

Бень Андрій Павлович *к.т.н., професор, проректор з науково-педагогічної роботи Херсонської державної морської академії: ORCID: https://orcid.org/0000-0002-9029-3489; a_ben@i.ua*

Зінченко Сергій Миколайович *д.т.н., доцент, доцент кафедри «Управління судном» Херсонської державної морської академії. ORCID: http://orcid.org/0000-0001-5012-5029; srz56@ukr.net.*

Маменко Павло Петрович *к.д.п., старший викладач кафедри «Управління судном» Херсонської державної морської академії. ORCID: http://orcid.org/0000-0001-7358-9299; pavlo.mamenko@gmail.com.*

Матейчук Вадим Миколайович *старший викладач кафедри «Управління судном» Херсонської державної морської академії. ORCID: https://orcid.org/0000-0001-9328-0651; mateichykv@gmail.com.*