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PROPOSALS OF UNCONVENTIONAL THRUSTERS APPLICATIONS FOR MULTI-MODE SHIP PROPULSION

ABSTRACT

Unconventional thrusters have enhanced possibilities of direction oriented thrust generating, owing to the fact they are finding application as a propulsion of chosen ships. Unconventional thrusters allow possibilities of other applications like auxiliary propulsion (or emergency), bow or aft thrusters, antiheeling equipment. It is quested possibilities for other applications. In a practice, ships equipped with this propulsion system, give a crew an enhanced comfort of work during manoeuvring and even from that reason they are pleasant seen by ship crew. Forecasted development and rise of diesel-electric propulsion systems quantity would cause increased interest of unconventional thrusters. Ultimately they may revolutionize ship propulsion systems, especially multi-mode ships.

Keywords: multi-mode ship, ships propulsion, unconventional thrusters, propulsion systems.

INITIAL REMARKS

Nowadays design possibilities and technology allows to create new constructions and built unconventional marine thrusters. Together with the fabrication offer must go hand in hand the product follow-up advertising in the aim of its sell. A chance for increasing sell gives an extension possibility of their application and reason of necessity of their use. The main thrusters advantages are: a possibility of thrust generation in optional direction independent of ship position, force compensation of two thrusters – it allows work at switching on clutches, possibility of direction and thrust stepless change – it increases ship manoeuvrability. The important disadvantages are: lower efficiency of thruster in comparison to conventional propeller at nominal work parameters, increasing investment cost (new technology, thrusters duplication, more complicated construction), necessity of hull and shafting design changes [5]. Unconventional thrusters are sufficient attractive alternative in connection with tendency to increasing ship manoeuvrability

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and its independency. They are more and more applied, especially where ship manoeuvrability is more important than fuel consumption and fuel costs.

PROPOSALS OF THRUSTER APPLICATION

To unconventional thrusters are counting: thrusters Z-type (azimuth thrusters), cycloidal thrusters (Voith-Schneider Propeller VSP), waterjets, azipods, magneto-hydrodynamic thrusters. The main application of unconventional thrusters is main ship propulsion - it concerns specialist vessels (for example: tugs), mainly multi-mode ships with dynamic positioning systems (cable ships, pipe-lay vessels, drilling platforms), superfast ships (superfast catamarans (Fig.1), trimarans), double-ended ferries (Fig.2), some big cruise liners (for example: Queen Mary II).



Fig.1. High speed craft Villum Clausen [11]



Fig.2. Double-ended ferry [9]

It was utilized in those cases: wide manoeuvre possibilities, safe and speed performance of intended manoeuvre, navigational safety (especially important at heavy traffic areas), a possibility of quick change load (often manoeuvres), quick stopping and starting of main engines. In many cases the time of power plant preparing for start is not exceeding 5 minutes. In some cases of power plants equipped with main generators, diesel-electric type or gas-electric type, it may be told that the power plant is still in work or ready for work. Every vessel needs the electricity in all exploitation conditions. The black-out is only a short time of emergency situation which wouldn't happen.

POSSIBILITIES OF THRUSTER APPLICATION

Nowadays as a main propulsion of tugs dominates propulsion solutions with unconventional thrusters: tractor-type (thrusters situated in the tug bow) or pusher-type (thrusters located in the tug stern). It is seemed to be reasonable to consider more complicated propulsion solutions, for example with two thrusters asymmetrically located on the bow and the stern of tug (Fig.3 p.4) or with three thrusters where the third one is located on the bow or the stern and may work as a part of main propulsion or as a fully functional bow or stern thruster (Fig.3 p.3) [4]. In emergency conditions two of the three thrusters give the same manoeuvre possibilities as current solutions. In the case of propulsion solution with two thrusters, in a possible situation, when it is a necessary to stop one of two thrusters (for example: when towing rope was wound to the thruster) the tug has only a half of his power and very limited manoeuvrability (is worse than in solution with one thruster because that one is located asymmetrically).

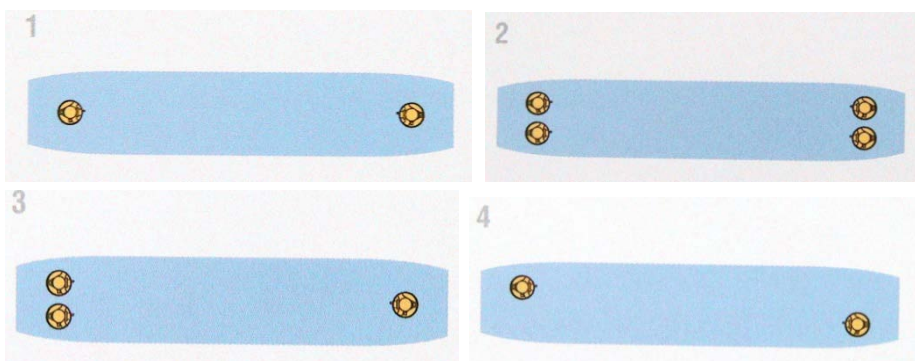


Fig.3. Possibilities of unconventional thrusters position of main propulsion [own figure]

The propulsion solutions of port-roads tugs with three thrusters should be taken into serious consideration because the investment cost of propulsion is only a little bigger but the advantages are wider manoeuvre possibilities and bigger safety of carrying out operations. The propulsion solution with four thrusters (Fig.3 p.2) is preferable for vessels with dynamic positioning system (cable ships, pipe-lay vessels etc.).

The power range of modern thrusters allows to apply them for propulsion the biggest merchant vessels, for example big passenger ships (cruise liners). The power plant of „Queen Mary II” is CODAG type (with 2 diesel engines and 2 gas turbines). The power receivers as main propulsion are 4 azipods of 21.5 MW each, two of them are located on the bow and have a possibility of a 360-degree turn, the stern two thrusters are at fixed position. Total propulsion power is 117200 kW, it means that the unconventional thrusters may be as a main propulsion any modern merchant ship.

For typical merchant ships it was a proposition of unconventional thruster application with a possibility of thruster hiding inside the hull (retractable thrusters) as a better version of bow or stern thrusters (Fig.4), especially when they may fulfill function of emergency propulsion (on condition, that the ship speed would be minimum 55% of nominal ship speed when the main propulsion is efficient). The main disadvantage of that solution is a necessity of water margin under the vessel hull because of the thruster is outside and under the hull. During operations on shallow waters that thruster may be useless.



Fig.4. Retractable thruster as an emergency propulsion and bow thruster [7]

However for thrusters ESP type (the name from Schottel or inlet thruster from VSP) (Fig.5.) [9] the essential limitation is available power of the thruster. The present propositions reach the power of about 200 kW, this is enough for small ships in river or lake navigation. The advantage is a low induced noise of that propulsion type (the thruster propulsion is a version of electric motor) This is essential importance during recreational navigation or in restricted quiet zones.

Azipods are more and more applied (Fig.6, Fig.7) as main ship propulsion and prepared to work in ice areas as well. Sometimes the propulsive systems are very complicated and developed. The ship named „Ice Maiden I” was rebuilt in 2008 [3]. There were applied 8 azipods: at stern - 2 azimuth thrusters with 3MW power each constructed by Rolls-Royce Aquamaster, at midship - 4 azimuth thrusters with 2MW power each constructed by Rolls-Royce and at bow - 2 Rolls-Royce tunnel thrusters (retractable) with 1.42MW power each [3].



Fig.5. VSP inlet thruster (Schottel ESP thruster) [9]



Fig. 6. The twin contra-rotating pod propellers installed on “Shige Maru” [6]



Fig. 7. Azipod propulsion 2*19.5 MW on mv Radiance of the Seas [1]

The unconventional thrusters are tried to apply as antiheeling devices (the function is a limitation the ship heels in bad weather conditions). This is essential significance for passenger ships (the comfort of voyage) or navy ships (ship safety, increasing the accuracy of positioning, decreasing the level of gravity loads). An example of antiheeling device is presented on Fig.8.

This is untypical application but shows how unconventional thrusters may be universal. Everywhere where conventional propulsion has a limitation of applying or disadvantages, in these cases it was tried to apply unconventional propulsion, especially where it may fulfill more functions.

How specialized ships might be it was shown for example for pipe-lay vessel presented on Fig.9.



Fig.8. Voith-Schneider propellers as antiheeling device [9]

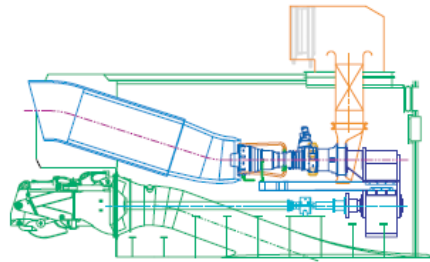
The ship function is determined about a hull shape in the aim of locating the industry part. However the exploitative considerations and moving requirements (positioning) forced an application of unconventional propulsion with the ship's dynamic positioning systems [2,4].



Fig. 9. Pipe-lay vessel „Seven Mavica” [www.subsea7.com]

On Fig.10 it was presented superfast ferry with the Rolls-Royce propulsion system with waterjets. In that case it was the necessity of applying

the waterjets. The nominal ship speed is 50 knots (about 93 km/h). At this speed it is a need of decreasing the ship's wave resistance, so the hull construction is as a catamaran or trimaran. It allows partially displacement floatation. Furthermore conventional propellers are very sensitive on cavitation phenomenon at speed over 30 knots (about 55 km/h) and significantly decreasing their efficiency, applying of water-jets is vital – there is no those problems [5,6,8].



A Rolls-Royce propulsion system with gas turbine, gearbox and waterjet.



Fig. 10. Fast ferry with a Rolls-Royce propulsion system with gas turbines and waterjets [8]

Decision of applying gas turbines arises from a need of main engine mass limitation and a long term of exploitational work during manoeuvre conditions. Gas turbines allow on a quick start of power plant and achieve nominal loads in short time. Water-jets with deflected nozzles have a worse manoeuvre possibilities in comparison to azimuth and cycloidal thrusters – but are enough for an independently navigation even at small speeds.

PROPOSALS OF THRUSTER APPLICATION IN THE FUTURE

It is quested possibilities for other applications of unconventional thrusters. By the way developing with aggressive promotion of that propulsion system advantages and presentation of theirs applications on still

increasing quantity of ships, it is created an atmosphere that it is a necessary to follow this way that no return to association – modern and safe ship is a ship equipped as a minimum with auxiliary unconventional propulsion system.

A good example of change direction is a major conversion of EDT Protea as the ship with dynamic positioning system (DP III) (Fig.11). It was made in 2006 in Naval Shipyard at Gdynia (Poland). The main propulsion consists of two Schottel Azimuth Thrusters type SRP 2020 (each 2200 kW) and as the bow thrusters two Brunvoll Tunnel FU 80 LTC-2000 (each 1100 kW) and one Brunvoll Retractable Thruster of 880 kW power. The prime mover is diesel-electric (D-E) with four 2200 kW Royce-Rolls Bergen BRG-6 engines in two separate engine rooms.



Fig. 11. EDT Protea [10]

The main area of unconventional thrusters application will be a substituting the bow and stern thrusters. The main advantage of this solution is a possibility of using thrusters not only as bow or stern thrusters but also as propulsion in emergency situations. It would be a primary cause of their application. The compound propulsive systems containing a few propulsion engines are more reliable. One element unserviceability of propulsive system deteriorates its better manoeuvring possibilities but still gives an ability for individual navigation. It is vital on big traffic areas, shallow waters, at bad weather conditions or during dangerous cargo transport. An improvement of navigation safety, extended requirements of independent navigation and manoeuvrability at still increasing amounts sea areas – all it causes that ships couldn't by-pass these areas during exploitation. An entrance there would connect with an extra expense, for example because of using tugs for

protection. It would favour spreading of unconventional propulsion to avoid many expenses.

In many opinions the propulsive system of the future will be magneto-hydrodynamic propulsion. Nowadays it made attempts to use mainly for submarines, in general in the navies. Its advantage is a relative low level of noise and vibration. The necessary problem for solution is to find superconductive materials at high temperatures (over 100K) and to keep this property in long time of engine work. Thanks to the total efficiency of that propulsive system may increase and be bigger than conventional propulsion with marine propellers. It would be an impulse for common use.

The unconventional thrusters: azimuth or cycloidal (VSP) thrusters, water-jets may be to apply in those cases when the magneto-hydrodynamic propulsion would have restricted possibility of application or when the application would be impossible.

I expect that in immediate future designers of ships would suggest doing specialized ship with different types of thrusters, for example ships with dynamic positioning system with azimuth thrusters as main propulsion and cycloidal thrusters as antiheeling device and emergency or support propulsion.

It is important that an application of unconventional propulsion doesn't require using steering machine. This function may be to perform by the thrusters. It demands an application of two systems: first one – the power steering system (thruster force steering), second one – the direction steering system of thrust force. Present solutions are very intuitive in case of cycloidal thrusters (there are the speed lever and steering wheel) and very simple in understanding and learning of their utilization in case of azimuth thrusters (there are the joysticks for steering of each thruster separately). There are neutral positions of the steering devices. It allows a safe escape in situation of a danger. It gives a moment of time for calm master tense nerves, thinking, a sense of security and safe work but it doesn't absolve anybody of responsibility.

Using of manoeuvre simulators with computer programmes simulating work of unconventional thrusters allows to speed crew training process up but it must be told the process can't completely substitute all training. A work on real object gives enhanced quantity of stimuli from surroundings but also demands to carry personal responsibility for effects of somebody actions (crew health and life safety). In a process of unconventional thrusters application may appear one unfavourable phenomenon – feeling of security and wider manoeuvre possibilities of these thrusters – favours undertaking more hazardous actions and manoeuvres, abandoning from widely accepted principles, common known as „good seamanship“. „Safety first“ is not only a call but a necessity in work at sea.

FINAL REMARKS

In a practice, ships equipped with unconventional thrusters propulsion system, give a crew an enhanced comfort of work during manoeuvring and even from that reason they are pleasant seen by ship crew. It must be seen that unconventional thrusters have excellent future, especially for multi-mode ships needed dynamic positioning systems. The efficiency drop of propulsion is about 6-8% in comparison with conventional propulsion system and increasing fuel consumption, but this is the only one disadvantage. Forecasted development and rise of diesel-electric propulsion systems quantity would cause increased interest of unconventional thrusters, especially azimuths. Propulsion of marine thrusters by electric motors is more and more popular and well-founded. An improvement of propulsive efficiency with unconventional thrusters (for minimizing the efficiency drop) would take to their popularization and domination in the end. Ultimately they may revolutionize ship propulsion systems, especially multi-mode ships.

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PROPOZYCJE ZASTOSOWAŃ AKTYWNYCH PĘDNIKÓW DO NAPĘDU STATKÓW WIELOFUNKCYJNYCH

STRESZCZENIE

Pędniki aktywne posiadają zwiększone możliwości wytwarzania ukierunkowanej siły naporu, dzięki temu znajdują zastosowanie do napędu wybranych jednostek morskich. Dają one również możliwości innych zastosowań np. jako napęd awaryjny (pomocniczy), stery strumieniowe, urządzenia przeciwprzechyłowe. Poszukuje się ich możliwości dalszych zastosowań. W praktyce, jednostki wyposażone w tą formę napędu dają zwiększony komfort pracy podczas manewrowania i z tego chociażby powodu są mile widziane przez załogi statków. Przewidywany rozwój i wzrost liczebności napędów diesel-elektrycznych (z tzw. przekładnią elektryczną) spowoduje zwiększone zainteresowanie pędnikami aktywnymi. Docelowo mogą one zrewolucjonizować napędy statków, szczególnie wielofunkcyjnych.