Ships With Highly Efficient Propulsion System

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Ships of the 21 st century will be equipped with the new, high-efficient propulsion system comprising two coaxial (equiaxed) screw propellers. The main characteristic of such propulsion system is the fact that the energy consumption for imparting a rotational motion to the water flow is eliminated.

The other important features of this propulsion system have not been sufficiently investigated till the present day. Moreover, it was not clear how to build up the construction of the mechanical drive of the screw propellers and how the appearance of the constructional design of the ship equipped with the new propulsion system will be.

In order to solve these objectives, a longtime and complex development was undertaken whose results are set out in this article.

For carrying out the development, a mathematical propulsion model for two screws rotating in opposite directions was created which allows to analyze the effectiveness of the performance as a function of the main dimensions and other parameters. The particularity of the developed program was that it established a connection between the energy loss due to the induced circumferential speed and the axial speed of the water flow through the propulsion system.

On the basis of the carried-out analysis, it has been shown how the energy loss depends on the axial speed induced by the rotational frequency of the propulsion system. These results are shown in Fig. 1 in summarized form, comparing the efficiency of the propulsion system comprising two screw propellers (graph 1) with the efficiency of a conventional propulsion system having one screw propeller (graph 2) as a function of rotational frequency. The variation of the diameter of the screw propellers which is required for maintaining the performance on each propeller and amounts to the half of the nominal power is illustrated with graph 3, and the variation of the diameter size of the single screw propeller is shown with graph 4.

The performed analysis allowed formulating a method providing the possibility to develop a ship propulsion system of new quality and with increased efficiency factor.

As can be taken from Fig. 1, the propulsion system comprising two propulsion screws—at a constant rotational frequency (point 1 on graph 1)—has an efficiency of 0.8 instead of 0.7 as is the case with the traditional single screw propeller (point 2 on graph 2). This is due to the induced circumferential speed of the water flow being reduced virtually to zero. A further increase in efficiency of the propulsion system can be achieved by lowering the induced axial speed of the water flow. To this end, the rotational frequency of the screw propellers has to be decreased. If the rotational frequency is reduced to the value 0.8 of the nominal frequency, the efficiency of the propulsion system will have a value of 0.88 (point 3 on graph 1). Here, the diameter of the screw propellers is unchanged; in order to maintain the ship's speed, the pitch of the propeller has to be correspondingly increased by a factor of 1.25. It was also found that the optimum rotational frequency of the propulsion system is at a value of 65% of the nominal value of the rotational frequency of the single screw propeller (point 5 on graph 1). Here, the efficiency of the propulsion system reaches a maximum value of 0.9.

Accordingly, reducing the rotational frequency additionally results in increasing the efficiency of the propulsion system by 10 to 12%.

Thus, the installation of the new propulsion system in ships will result in cutting down the fuel consumption by 25 %.

The results of our developments were confirmed in practice through the tests by the company “Volvo Penta”, which has developed a mechanical drive with flange-mounted motors for the propulsion system with two coaxial, counter-rotat- ing propellers and installed it in fishing cutters and motor boats.

Obviously, the time for installing the new, effective propulsion system in heavy load vessels of deep-sea and inland water fleets has come. In order to solve this problem, we have developed a sufficiently simple concept of the mechanical drive in 2004, which can be realized in installations of heavyload vessels of any classification and is illustrated in Fig. 2. The ship's engine, which can be a diesel or turbo engine 20, is connected with the propulsion system by means of a gearbox unit 12. The gearbox unit 12 has two chambers divided by the partition 13. The front chamber houses the gearwheel 8 which rotates the rear screw propeller 19 by the outer output shaft 4. Arranged in the other chamber is the gearwheel 7 rotating the inner output shaft 3 with the front screw propeller 18 attached thereto. The reverse relative rotation between the gearwheels 7 and 8 is ensured by means of an intermediate gearwheel 25. The axial forces of the screw propellers are absorbed by means of thrust and support bearings. The proposed mechanical drive is sufficiently reliable as all its components are known in the ship building industry by tradition.

We also have prepared the design drawings and the complete construction drawings of some vessel types comprising the new propulsion system. The constructional solution of a typical modern ship is illustrated in Fig. 3. Instead of the traditional construction in which the diesel engine is firmly connected to the shaft line of the single screw propeller by means of a rigid flange coupling, the drawing shows the installation of the gearwheel system 12 whose schematic diagram is illustrated in Fig. 2. The shaft line 3 consists of two coaxial shafts rotating the front vessel shaft 1 and the rear vessel shaft 2, respectively. The support bearing of the inner shaft 10 and the support bearing of the outer shaft 9 are of traditional construction. Regarding the sealing of the stem tube 6 and the support bearings 4 and 5 of the coaxial shaft line 3, a design has been developed which allows to replace the bearing shells during carrying out the maintenance works during operation of the ship.

The economical effectiveness of the ships equipped with the new propulsion system has been confirmed by multiple calculations. If, for instance, a new propulsion system was installed in the ferryboat of the line „Smyril Line“ connecting Denmark with the Faroe islands, where the ship „Norrona“ is in use at present, having the following data: measuring gross tonnage 35966 BRZ, load capacity 4300 tons, main engine 4xMAK6M43, the savings for one tour (700 miles = 135 tons of fuel) would amount to 34 tons, in other words, the fuel consumption would be reduced to 101 tons. This allows to save 5000 tons of fuel in one year, compensating for the costs for the installation of the new propulsion system within 8 to 10 months.

In order to demonstrate the project, a model of a ship comprising two coaxial and counter-rotating screw propellers has been exhibited on the Hamburger SMM 2006 on a special booth of the Munich inventor's club "Pionier" e.V. The project was honored with a gold medal on the international exhibition INNOVATIONS 2005 in Gdansk.

To the present day, all prerequisites are given in terms of successfully constructing vessels with a highly effective propulsion system which will change the situation in ship-related energetics. The only thing to overcome is the listlessness of perceiving the new which has been characteristic for shipbuilding at any times.

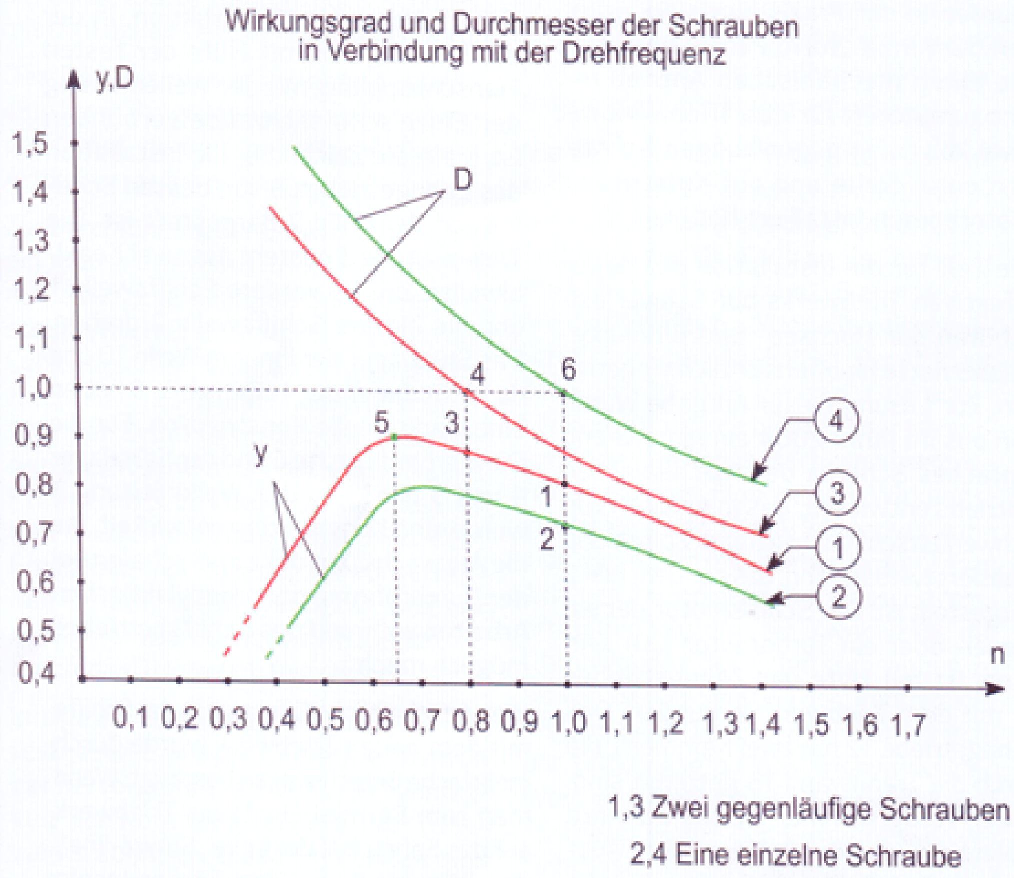

Figure 1 *Bild 1*

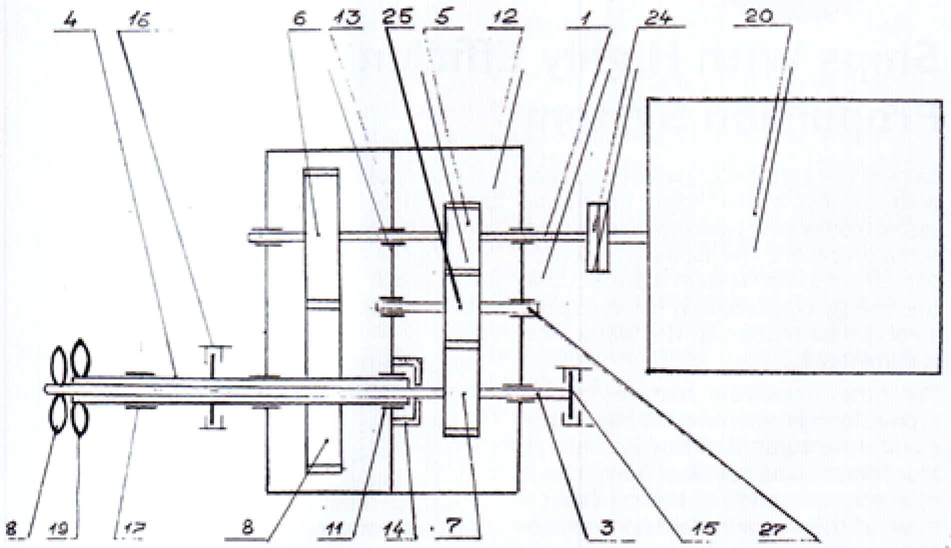

Figure 2 *Bild 2*

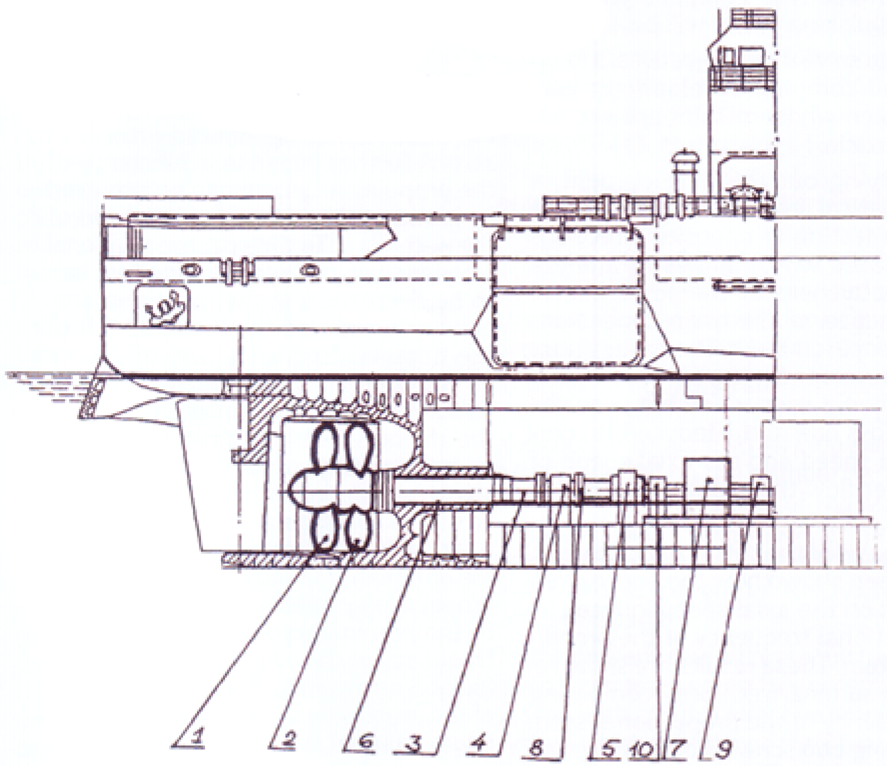

Figure 3 Bild 3

References

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