

A propulsion arrangement in a ship

TECHNICAL FIELD

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The invention relates to a propulsion arrangement in a ship according to the preamble of claim 1.

10 The arrangement is intended to be used in ships provided with two propulsion units situated side by side at the stern of the ship. The propulsion units are situated on opposite sides of the center line of the hull of the ship. Such a twin propulsion unit system is used e.g. in passenger ships, passenger ferries, cargo ships, barges, oil tankers, ice breakers, off-shore ships and naval ships. Especially large ships e.g. cruisers, tankers transporting oil or liquefied natural gas, vehicle carriers, 15 container ships and ferries use a twin propulsion unit system.

BACKGROUND ART

20 WO publication 98/54052 discloses a ship with twin propellers and twin Schilling rudders i.e. a respective rudder for each propeller. Each rudder is pivotably mounted by a respective shaft, has a bulbous nose portion, a waisted mid-portion and a flared tail. The flared tail flares outwardly substantially only on the inner side of each rudder i.e. the side which faces the other rudder pair. Each rudder has an upper plate and a lower plate with the plates much more extensive on the inner 25 side than on the outer side, the plates being aligned with streamlines from the respective propeller and the lower plate having a downwardly angled portion on the inner side. The rudders seem to form some kind of a toe-out angle in relation to the centerline of the hull.

30 US patent 7,033,234 discloses a method for steering a planning V-bottomed boat with double individually steerable drive units with underwater housings, which

extend down from the bottom of the boat. When running at planning speed straight ahead, the underwater housings are set with a so called toe-in angle, i.e. inclined towards each other with opposite angles of equal magnitude relative to the boat center line. When turning the boat, the inner drive unit is set with a
5 greater steering angle than the outer drive unit.

JP patent publication 2006007937 discloses an arrangement in a ship with two pods with contra-rotating propellers situated at the stern of the ship. The first pod is in a first embodiment mounted stationary into the skeg so that the shaft line is
10 inclined upwards. The second pod is fastened by means of a horizontal axis to a steering table, which steering table rotates around a vertical axis and which steering table can be lowered and raised by means of hydraulic cylinders. The shaft line of the second pod is aligned with the shaft line of the first pod. The rear end of the first pod is in a second embodiment fastened with a horizontal axis to
15 the skeg and the front end of the first pod is fastened to a vertical cylinder. The inclination of the first pod can thus be adjusted with the cylinder. Both pods are in a third embodiment fastened to opposite ends of a common frame, which frame is supported from the middle part a horizontal axis to a steering table, which steering table rotates around a vertical axis and which steering table can be lowered and
20 raised by means of hydraulic cylinders. There is no separate rudder in this arrangement and the steering of the ship is done by rotating either only the second pod situated after the first pod in the driving direction of the ship around a vertical axis or by rotating both pods around a vertical axis.

25 SUMMARY OF THE INVENTION

The object of the invention is to improve prior art propulsion arrangements based on two side by side propulsion units in ships.

30 The propulsion arrangement according to the invention is characterized by the features in the characterizing portion of claim 1.

The propulsion arrangement comprises two propulsion units situated side by side at the stern of the ship at opposite sides of the center line of the hull of the ship. Each propulsion unit comprises a hollow support structure attached to the hull, a
5 chamber being attached to the support structure, an electric motor within the chamber, a propeller at the front end of the chamber, said propeller being connected through a shaft to the electric motor, and a pivotably supported rudder at the rear end of the chamber.

10 Each propulsion unit is according to the invention mounted in a toe-out position forming a horizontal tilt angle of 0.5 to 6 degrees in relation to the center line of the hull. The front end of the chamber is thus inclined away from the center line of the hull of the ship and the rear end of the chamber is inclined towards the center line of the hull of the ship.

15 This toe-out arrangement of the propulsion units improves the water inflow angle to the propellers, which improves the efficiency of the propeller.

The toe-out arrangement also reduces noise and vibrations, which are due to
20 cavitation as the improved inflow angle to the propellers reduces cavitation.

The toe-out arrangement also reduces shaft line vibrations and forces. This is due to the fact that there are less asymmetric forces acting on the propellers when the water inflow angle to the propellers is improved. Reduced loads and vibrations
25 will increase the lifetime of the bearings of the shafts as well as other components affected by these vibrations and forces.

In an advantageous embodiment of the invention the propulsion units are further tilted in the vertical plane so that the front end of the chamber is lower than the
30 rear end of the chamber in relation to the water line. The vertical tilt angle of the

propulsion units further improves the water inflow angle to the propeller of the propulsion units thereby further improving the efficiency of the propulsion units.

5 The invention can be used in large ships provided with two propulsion units situated side by side at the stern of the ship, e.g. cruisers, tankers transporting oil or liquefied natural gas, vehicle carriers, container ships and ferries. The power of each propulsion unit in such large ships is in the order of at least 1 MW.

BRIEF DESCRIPTION OF THE DRAWINGS

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Some specific embodiments of the invention are described in the following in detail with reference to the accompanying figures, in which:

Figure 1 shows a prior art propulsion arrangement.

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Figure 2 shows a propulsion arrangement according to the invention.

Figure 3 shows a side view of one embodiment of a propulsion arrangement according to the invention.

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Figure 4 shows a top view of the propulsion arrangement according to figure 3.

Figure 5 shows a side view of another embodiment of a propulsion arrangement according to the invention.

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Figure 6 shows a side view of a third embodiment of a propulsion arrangement according to the invention.

DETAILED DESCRIPTION OF SOME SPECIFIC EMBODIMENTS

Figure 1 shows a prior art propulsion arrangement. The arrangement comprises a twin propeller driving system 10a, 20a situated side by side at the stern of the ship. Each driving system comprises a propeller 15a, 25a driven by a shaft 14a, 24a and a rudder 16a, 26a situated after the propeller 15a, 25a in the driving direction S of the ship. The propellers 15a, 25a are situated on opposite sides of the centerline CL of the hull 100 of the ship. The first propeller 15a is driven by a first shaft 14a and the second propeller 25a is driven by a second shaft 24a. Each shaft 14a, 24a is driven by a main engine of its own (not shown in the figure). A first rudder 16a is positioned after the first propeller 15a and a second rudder 26a is situated after the second propeller 25a. The propeller shafts 14a, 24a are parallel in relation to each other and also parallel in relation to the center line CL of hull 100 of the ship. The figure also shows a cargo tank 200 for liquefied natural gas LNG. The figure shows that the position of the propellers 15a, 25a in relation to the stream lines F of the water flowing to the propellers 15a, 25a is not optimal.

Figure 2 shows a propulsion arrangement according to the invention. The arrangement comprises two propulsion units 10, 20 situated side by side at opposite sides of the center line CL of the hull 100 of the ship. Each propulsion unit 10, 20 comprises a chamber 12, 22 connected with a support structure to the hull 100 of the ship. A propeller 15, 25 situated at the front end of the chamber 12, 22 is driven by an electric motor 13, 23 positioned in the chamber 12, 22. A rudder 16, 26 is situated at the back end of the chamber 12, 22. The shaft lines SL of the propulsion units 10, 20 are arranged in a toe-out position in relation to the center line CL of the hull 100 of the ship. The shaft lines SL form a horizontal tilt angle β with the center line CL of the hull 100 of the ship so that the shaft lines SL will cross each other at a point on the center line CL of the hull of the ship, said crossing point being situated after the ship. The front end of the chambers 12, 22 is inclined outwards (toe-out position) in relation to the center line CL of the hull 100 of the ship and the back end of the chambers 12, 22 is inclined inwards in

relation to the center line CL of the hull 100 of the ship. The figure also shows a cargo tank 200 for liquefied natural gas LNG.

Figure 3 shows a side view and figure 4 shows a top view of one embodiment of a propulsion arrangement according to the invention. These figures show the arrangement of the starboard side propulsion unit 20 shown in figure 2. The port side propulsion unit 10 is identical to the starboard side propulsion unit except that the inclination is opposite so that the two propulsion units 10, 20 form mirror images of each other. The figures also show the driving direction S of the ship.

Figure 3 also shows the flow lines F of the water flowing to the propulsion unit 20.

The propulsion unit 20 comprises a hollow support structure 21 connecting the propulsion unit 20 to the hull 100 of the ship, a chamber 22 having a front end and a rear end in relation to the driving direction S of the ship, said chamber 22 being connected to the support structure 21, an electric motor 23 within the chamber 22, a shaft 24 having a first end and a second end, said first end of the shaft 24 being connected to the rotor of the electric motor 23 and said second end of the shaft 24 protruding from the front end of the chamber 22 and being connected to a propeller 25. The electric motor 23 can be an induction motor or a synchronous motor. The propulsion unit 20 is fixed to the hull 100 of the vessel with the support structure 22. This means that the propeller 25 will remain in a fixed position in relation the hull 100 of the vessel all the time.

The shaft 14 forms a shaft line SL of the propulsion unit 20. The shaft line SL and the water line WL are parallel, which means that the vertical tilt angle α between them is 0 degrees. The angle between the axis 27 of the rudder 26 and the shaft line SL i.e. the angle γ is 90 degrees. The angle between the axis 27 of the rudder 26 and the water line WL i.e. the angle δ is also 90 degrees.

The steering of the ship is done by a separate rudder 26, which is connected to the hull 100 of the ship and the propulsion unit 20 by means of an axis 27. The rudder 26 is thus pivotably attached to the hull 100 and the propulsion unit 20. The rudder 26 is formed so that it forms a smooth continuation of the support structure 21 and the chamber 22. The lower part of the rudder 26 extends at a distance
5 below the chamber 22. A steering gear, which is not shown in the figure, rotates the axis 27 and in this way also the rudder 26 based on the commands from the navigation bridge.

10 Figure 4 shows that the shaft line SL of the propulsion unit 20 is further situated at a horizontal tilt angle β in relation to the centerline CL of the hull 100 of the ship. This means that the front side of the chamber 22 facing the propeller 25 is inclined outwardly from the center line CL of the hull 100 of the ship and the back side of the chamber 22 facing the rudder 26 is inclined inwardly towards the center line
15 CL of the hull 100 of the ship. The propulsion unit 20 is thus in a toe-out position in relation to the center line CL of the hull 100 of the ship. The port side propulsion unit 10 forms a mirror image of the starboard side propulsion unit 20. The port side propulsion unit 10 is thus also positioned in a toe-out position in relation to the center line CL of the hull 100 of the ship. The toe-out angle β is in
20 the range of 0.5 to 6 degrees.

This toe-out arrangement of the propulsion units 10, 20 will improve the water inflow angle to the propellers 15, 25. This toe-out arrangement will improve efficiency, reduce vibrations and excitation in the hull 100 of the ship.

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Figure 5 shows a side view of another embodiment of a propulsion arrangement according to the invention. The propulsion unit 20 corresponds as such to the propulsion unit shown in Fig. 3. The difference compared to the arrangement shown in Fig. 3 is that the shaft line SL of the propulsion unit 20 forms a vertical
30 tilt angle α in relation to the water line WL. This means that the front end of the chamber 22 is lower than the back end of the chamber 22 in relation to the water

line WL. The angle of the water flow F entering the propeller 25 will be improved when the propulsion unit 20 is vertically tilted. This means that the hydrodynamic efficiency of the propeller 25 will be improved. The angle between the axis 27 of the rudder 26 and the water line WL i.e. the angle δ is still 90 degrees as in figure 5 3. The angle between the axis 27 of the rudder 26 and the shaft line SL i.e. the angle γ is, however, less than 90 degrees in this embodiment due to the vertical tilting of the propulsion unit 20. The figure also shows the driving direction S of the ship.

10 Figure 6 shows a side view of a third embodiment of a propulsion arrangement according to the invention. This arrangement corresponds as such to that of Fig. 5 i.e. the propulsion unit 20 is tilted at an angle α in relation to the water line WL. The difference is in the arrangement of the rudder 26. The angle between the axis 27 of the rudder 26 and the shaft line SL i.e. the angle γ is 90 degrees in this 15 embodiment, which corresponds to the situation in Fig. 3. This means that the axis 27 of the rudder 26 has been tilted in relation to the water line WL, i.e. the angle δ is more than 90 degrees. The arrangement where the rudder 26 axis 27 forms a right angle with the shaft line SL is advantageous in respect of the flow generated by the propeller 25. The figure also shows the driving direction S of the ship.

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At least one generator (not shown in the figures) is provided within the hull 100 of the ship providing electric power to the electric motors 13, 23 in the propulsion units 10, 20 through an electric network (not shown in the figures).

25 The horizontal tilt angle β i.e. the toe-out angle and the vertical tilt angle α have to be determined separately for each ship or series of ships. The optimization of the horizontal tilt angle β and the vertical tilt angle α is done based on model test for each ship or series of ships. The optimization is done separately for the horizontal tilt angle β and the vertical tilt angle α . The goal in the optimization is to minimize 30 the fuel consumption i.e. to increase the efficiency. The best efficiency is normally achieved when the water inflow to the propellers is straight.

The separate rudder 26 is in the figures pivotably supported at the hull 100 and at the chamber 22 of the propulsion unit 20. The rudder 26 can be pivotably supported at the hull 100 and/or at the propulsion unit 20. The rudder 26 can thus
5 be pivotably supported only at the hollow support structure 21, or at the hull 100 and the hollow support structure 21, or at the hull 100 and the chamber 22, or at the chamber 21 and the hollow support structure 21.

The examples of the embodiments of the present invention presented above are
10 not intended to limit the scope of the invention only to these embodiments. Several modifications can be made to the invention within the scope of the claims.

CLAIMS

1. A ship with a propulsion arrangement, wherein the ship comprising a hull (100) having a center line (CL), and wherein said propulsion arrangement comprising:

- a stationary first propulsion unit (10) on the port side of the center line (CL) at the stern of the hull (100),
- a stationary second propulsion unit (20) at the starboard side of the center line (CL) at the stern of the hull (100),
- said first and second propulsion units (10, 20) each comprising:
 - a hollow support structure (21) being attached to the hull (100),
 - a chamber (12, 22) having a front end and a rear end, said chamber (12, 22) being attached to the support structure (21),
 - an electric motor (13, 23) within the chamber (12, 22),
 - a shaft (24) having a first end and a second end, said first end of the shaft (24) being connected to the electric motor (13, 23) and said second end of the shaft (24) protruding from the front end of the chamber (12, 22) and being connected to a propeller (15, 25), said shaft (24) forming a shaft line (SL), and
 - a pivotably supported rudder (16, 26) at the rear end of the chamber (12, 22),

characterized in that:

- each propulsion unit (10, 20) is mounted so that the shaft line (SL) forms a horizontal tilt angle (β) in the range of 0.5 to 6 degrees with the center line (CL) of the hull (100) so that the propulsion units (10, 20) are situated in a toe-out position in relation to the center line (CL) of the hull (100) i.e. the front ends of the chambers (12, 22) are inclined away from the center line (CL) of the ship and the rear ends of the chambers (22) are inclined towards the center line (CL) of the hull (100) of the ship.

2. A propulsion arrangement according to claim 1, **characterized in that** each propulsion unit (10, 20) is mounted so that the shaft line (SL) forms a vertical tilt angle (α) in the range of 1 to 8 degrees in relation to the water line (WL) so that

the front end of the chamber (12, 22) is lower than the rear end of the chamber (12, 22) in relation to the water line (WL).

3. A propulsion arrangement according to claim 1 or 2, **characterized** in that the ship is a cruiser, a tanker transporting oil or liquefied natural gas, 5 a vehicle carrier, a container ship or a ferry.

4. A propulsion arrangement according to any of claims 1 to 3, **characterized** in that the power of each propulsion unit (10, 20) is at least 1MW.