A fin propulsion apparatus

Field of invention

The present invention relates to a propulsion system for a maritime vessel wherein the employed means for propulsion includes flapping or oscillating foils or fins.

According to one aspect, the present invention relates to a propulsion apparatus provided within a hull of a maritime vessel.

The apparatus comprising at least one transverse translating propulsion fin being fixed to a fin axle. The means for driving the fin comprising a crankshaft, a pitching mechanism for rotating the fin around an axis of the fin axle, and a heave mechanism for translating the fin in a substantially transverse direction with respect to the axis of the fin axle and the vessel.

Background of the invention

Propulsion systems have been used for many years especially to propel maritime vessels, and the most used propulsion system today is rotating screw propeller propulsion. Even though the rotating screw propeller propulsion system provides a very reliable and simple construction it does, however, not provide a very high efficiency under normal conditions, and therefore alternative propulsion systems have been suggested in order to overcome this disadvantage.

Mechanisms of the kind mentioned in the introduction have previously been suggested as an alternative to rotating screw propeller propulsion in order to gain different advantages such as increased efficiency, and reduced noise.

US patent no. 5401196 (TRIANTAFYLLOU) especially discloses such a propulsion system, where one or more propulsion fins are arranged and being manipulated in order to provide the propulsion in a selected direction of speed. The fin is manipulated by the combined use of a heave mechanism and a pitching mechanism, and where the heave mechanism oscillates the propulsion fin in a direction substantially transverse to the selected direction, and the pitching mechanism is flapping the fin about a pivot to change its pitch angle with respect to the same direction of speed.

According to US patent no. 5401196 (TRIANTAFYLLOU); a significant increase in propulsion efficiency can be obtained by the use of this system with respect to what is provided by conventional rotating screw propeller propulsion systems. This increased efficiency is provided by optimizing the combined movement of the heave and pitching mechanism, so that the fins are manipulated to move in a pattern being very similar to the fin of a fish.

Even though fin propulsion systems like the one suggested by US patent no. 5401196 (TRIANTAFYLLOU) are suggested in order to provide a significant increase in efficiency, such systems have not, e.g. due to the complexity of the propulsion mechanisms, been widely commercially used for propulsion, and especially for propulsion of maritime vessels. Hence there is a continued need for further developing such propulsion systems.

FR 1 330 218 A (BOUIGES) teaches a water bicycle propelled by means of translating fins where the translating and/or heave mechanism incl. the pitching mechanism is mounted on a single crank. The mechanism, which operates under constrained symmetry, is exposed to the environment, and further, the mechanism is partially submerged below the waterline.

DE 2 849 027 A1 (KRAUS HELMUT) teaches a universal fin drive mechanism operating by means of a fin arranged either horizontally or vertically.

DE 10 2004 004236 A1 (KLUDSZUWEIT ALFRED) teaches a boat propulsion system comprising a frame oscillating a vane which has two parallel longitudinal members parallel to the axis of the boat. The vanes move longitudinally and out of phase and their ends are connected by swing links. The forward link has a lever which may be connected to an engine, and the aft link of the parallel longitudinal members is connected to a paddle blade by an intermediate link. The intermediate link and the paddle blade may be flexible or there may be a pivot with a spring allowing the intermediate link to move through an angle.

WO 03/026954 A1, published April 3, 2003 (Inocean) suggests a system utilizing a sinusoidal pattern of movement for propulsion or energy recovery. The system comprises a plurality of rigid hull elements arranged in a row and rotatable attached to one another for rotation about parallel axes of rotation across the longitudinal dimension of the row of hull elements. The system further comprises movement devices for rotating the hull elements relative to one another or movement devices for recovery of energy as a result of rotating the hull elements relative to one another.

WO 2006/038808 A1, published April 13, 2006 (Clavis Biopropulsion) suggests a device comprising at least one transversely translating fin. The device encompasses actuating and drive means allowing substantially free oscillating motion of the fin. The device operates by means of an impulse, established by drive means, every so many cycles and spring are used to store the pulsating energy provided by the drive means.

Summary of the invention

The purpose of the present invention is to provide a propulsion system that is reliable and simple in its construction while at the same time, provides the option of optimizing the system to higher efficiencies than what is possible by conventional rotating screw propellers.

According to the present invention a propulsion apparatus is suggested for providing propulsion in a fluid, and especially for propulsion of a maritime vessel. The propulsion system comprises at least one propulsion fin and means for driving the propulsion fin.

The means for driving the propulsion fin comprises a crankshaft, a pitching mechanism for rotating the propulsion fin around the axis of the fin axle, and a heave mechanism for translating the propulsion fin in a direction being substantially transverse to a longitudinal axis of the vessel, and in a substantially transverse direction with respect to the axis of the fin axle, and where the crankshaft is both driving the pitching mechanism and the heave mechanism.

The heave mechanism and the pitch mechanism are both articulated by means of a crankshaft being connected to the heave and the pitch mechanism by a single crank on the crankshaft, or by separate cranks having substantially the same radius and angular position with respect to the axis of rotation of the crankshaft.

Thereby, as the heave and the pitching mechanism are both connected to the same or to a substantially identical crank on the crankshaft, the present invention provides a very simple construction for the combined heave and pitching mechanism, and provides on one hand the option of having a construction of relatively few separate components, and on the other hand the option of optimizing the propulsion system to operate with higher

efficiencies than what is provided by a conventional propeller propulsion system, due to its relatively symmetrical pattern of movement.

In a preferred embodiment the propulsion fin is mounted to a chariot by means of the fin axle allowing the fin axle and the fin to rotate around its axis with respect to the chariot. The chariot is slid ably mounted with respect to the crankshaft so that it can oscillate in a direction to and from the crankshaft.

The heave mechanism connects the chariot to a crank on the crankshaft, and the pitching mechanism connects the fin axle to a crank on the crankshaft.

The invention is especially advantageous if both the heave mechanism and the pitching mechanism are provided by means of a common push/pull rod being connected at one end to the crank of the drive shaft, and at the other end being rigidly attached and extending substantially transverse to a fin pitching axle being rotatable connected to the chariot, so that the push/pull rod, when the crankshaft rotates, drives the chariot to oscillate to and from the crankshaft, and at the same time drives the fin pitching axle to rotate. Hereby the number of separate components are reduced to only very few.

In an alternative preferred embodiment the heave mechanism comprises a slot in the chariot, and a crank on the crankshaft being slid able arranged in the slot, and the pitching mechanism comprises a pitcher rod being connected at one end to the fin axle in a direction substantially transversal to the axis of the fin axle, and being attached at its other end to a crank on the crankshaft, and where the pitcher rod is telescopic or being connected to either the fin pitching axle or the crank via a slide bushing, so that the pitcher rod compensates for varying distances between the fin axle and the crank, and so that, when the crankshaft rotates, the heave mechanism drives the chariot to oscillate to and from the crankshaft, and at the same time the pitching mechanism drives the fin pitching axle to rotate in an oscillatory

manner. Hereby the heave forces transferred to the fins are primarily transferred by the heave mechanism and the pitching forces are transferred by the pitching mechanism. When the pitching forces are very small in relation to the heave forces, this provides the possibility of a lighter construction of the pitching mechanism.

In a further embodiment the fin pitching axle and the fin axle is the same, providing a very simple construction comprising relatively few separate components.

In a preferred and alternative embodiment the pitching mechanism comprises a synchronizing link connecting the fin pitching axle to the fin axle, said synchronising link being arranged for synchronizing the rotation of the fin axle with the rotation of the fin pitching axle. By this it is possible to connect more fins to the same fin pitching axle and pitching mechanism, and it also provides more freedom to adapt the position of the fins to specific needs e.g. adapting the design to be placed in a limited space in the hull of a maritime vessel.

The push/pull rod or the pitcher rod mentioned above may be rigidly connected to the fin pitching axle, but in an advantageous embodiment the connection between the push/pull rod or the pitcher rod and the fin pitching axle comprises means for adjusting the angle between the fin pitching axle and the push/pull rod or the pitcher rod. Hereby is provided a simple way of adjusting the fin angle to specific needs, such as a changed needed direction of thrust in case of steering.

In a very simple and therefore preferred embodiment the fin axle is parallel to the fin pitching axle.

Alternatively the fin axle can preferably be arranged to be substantially transverse to the fin pitching axle, so that it provides the possibility to adapt the design of the drive for specific needs e.g. adapting the design to be placed in a limited space in the hull of a maritime vessel.

In a further preferred embodiment the propulsion system comprises two or more fins connected to the same fin pitching axle via a single synchronizing link, so that the number of separate components are kept to relatively few.

According to another object of the present invention, a method of propelling a ship by means of a propulsion apparatus according to the teachings of this document is provided.

Brief description of the drawings

Figure 1: Is a diagrammatic side view of a ship comprising a fin propulsion system according to the present invention.

Figure 2: Is a diagrammatic top view of the ship shown in figure 1.

Figure 3: Is a detailed side view of a single fin of the propulsion system according to figure 1 and 2.

Figure 4 to 10: Are diagrams showing different preferred principal embodiments of mechanical drives for a propulsion system according to the present invention.

Detailed description of the invention

Figure 1 shows a diagrammatic side view of a ship 1 having fins 2 for providing propulsion. Such fins are well known to be used for a propulsion

system in a ship or any other maritime vessel, but also for other propulsion purposes a general description of a fin propulsion system is disclosed especially in the abstract according to US patent no. 5401196 (TRIANTAFYLLOU) which is hereby incorporated by reference.

Figure 2 shows a diagram of the ship according to figure 1 in a top view, and where two sets of three fins 2 are arranged for providing propulsion to the ship 1. The number of fins 2 and the number of sets of fins 2 may without departing from the present invention be suggested to be adapted to the propulsion needed for specific vessels, but as shown in these drawing it is preferable to arrange the fin in pairs operating in counter phase in order to cancel out transverse forces acting on the ships hull during propulsion.

According to the general principles of fin propulsion e.g. as disclosed in US patent no. 5401196 (TRIANTAFYLLOU), the fins 2 are arranged so as to extend from the ship and into the water, and in the embodiment shown the fins 2 are extending from the ships 1 hull below the waterline 4 through openings 7 (figure 3). In other embodiments however, not shown in these drawings, the fins 2 can alternatively extend from the ship and into the water from anywhere above the waterline 4. According to figures 2 and 3 it is shown that the fins 2 are each mounted to a chariot 5 by means of an fin axle 6 that extends from the fin 2 and through the chariot 5, so that each fin 2 is allowed to rotate in the chariot 5 around its fin axle 6. Each chariot 5 is slide ably mounted in the ship's hull 2 by means of a slide allowing the chariot to slide and reciprocate in a direction substantially transverse to the ship's centerline 8.

As shown in figure 2 each chariot may accommodate a plurality of fins 2.

By the combined movement of reciprocating the fins 2 in a direction transverse to the ship's centerline, and at the same time driving each fin 2 to

turn around its fin axle 6 a propulsion effect to the ship can be obtained, and by controlling the fin angle compared to its transverse movement with respect to the ships centerline 8 the possibility is provided for a very efficient and/or silent propulsion of the ship.

Figure 3 shows one fin 2 in detail extending from the hull of the ship 1 and into the water. As mentioned above the fin 2 is in this preferred embodiment of the invention arranged below the waterline 4, and therefore the chariot 5 comprises a sealing plate or chariot 5 that seals the opening 7 in the hull.

According to the present invention a number of different principal embodiments of drive systems for the fins 2 are disclosed throughout the figures 4 – 10.

Common for all these embodiments is that they all comprise a crankshaft 9 rotating around its longitudinal axis 13, and having a crank 10 for driving both a heave drive mechanism and a pitch drive mechanism respectively.

The crank 10 can according to the present invention comprise a single crank or two substantially identical cranks with respect to their angular position and radius with respect to the central axis 13 of the crankshaft 9.

According to the invention the different embodiments all further comprise a chariot 5 arranged slide ably in slides 12, and at least one fin 2.

The propulsion effect is according to the illustrated embodiments forcing, or propelling, the ship in a direction illustrated by the arrow or mark 17.

Figure 4 shows an especially simple and reliable construction of a propulsion system according to the present invention where both the reciprocation 14 of the chariot 5, and the pitching of the fin 2 is provided by means of a single

push/pull rod 15 being connected at one end to the crank 10 on the crankshaft 9, and at the other end being rigidly connected to the fin axle 6

When the crankshaft 9 turns as shown by the arrow 16, the push/pull rod 15 will act on the chariot 5 similar to a piston rod in a traditional combustion engine, and at the same time turn the fin 2 via its fin axle 6. Hereby the heave drive mechanism and the pitch drive mechanism are both driven by the push/pull rod.

Figure 5 shows an alternative embodiment of the present invention where a pitching rod 18 is arranged instead of the push/pull rod according to figure 4.

The pitching rod 18 is mounted to the crank 10 via a slide connection 19 allowing the pitching rod 18 to slide in the slide connection 19 when the crankshaft 9 and the crank 10 turn. In this embodiment the pitching rod 18 only drives the pitching drive mechanism and thereby the pitching of the fin 2 via its rigid connection to the fin axle 6.

The heave drive mechanism is in this embodiment provided by a slot 21 being slide ably connected to the crank 10, so that when the crankshaft 9 turns, the chariot 5 reciprocates as shown by arrow 14.

Figure 6 to 8 all shows the same principal drive mechanism as shown in figure 5, but in these alternative embodiments the position of the fin 2 and/or number of fins 2 can be altered without changing the design of the heave and pitch drive mechanisms. This is obtained by adding synchronizing links 22, 23 to the pitching drive mechanism, so that the pitching rod 18 being rigidly mounted to the pitching axle 20, forces the synchronizing link 22, 23 to turn the fin axle 6 and thereby the fin 2.

By selecting the lengths of the links 22, 23 a gearing might be obtained for specific purposes.

The principle of adding synchronizing links 22, 23 to the pitch drive mechanism can also, without departing from the present invention, be used in the embodiment shown in figure 4 and with the same result.

Figure 9 shows a further alternative embodiment of the present invention where the angular heave and pitch drives are the same as shown in figure 4, but where the angle between the fin 2 and the push/pull rod 15 can be adjusted by means of a linear motor 24 e.g. a hydraulic piston being arranged between the push/pull rod 15 and a pitching rod 25 being rigidly connected to the fin axle 6. It is obviously also possible to adapt this arrangement to the embodiments mentioned above by including a pitcher rod 25 instead of push/pull rod 15. Hereby the angle between the fin or fins 2 and the pitcher rod or push pull rod can be optimized for specific purposes, and especially so that the fin or fins 2 is positioned in parallel to the motion of the chariot 5, so that no significant propulsion effect is achieved.

It will be obvious for the skilled person that other alternatives are possible for adjusting the fins 2 angular position with respect to the angle of the push/pull rod 15 or the pitcher rod 25.

Figure 10 shows another alternative embodiment of the present invention where a gearing 26 is arranged between the fin axle 6 and the fin pitching axle 20 allowing the fin 2 to extend at an angle with respect to the fin pitching axle 20. As such a gearing can be made in various embodiments figure 10 only discloses the gearing as a closed gearbox. Figure 10 shows that the fin axle 6 is arranged transversally to the fin pitching axle 20, but it is evident that gearings can be arranged for providing other angles between the fin axle

6 and the fin pitching axle 20. In this embodiment the direction of speed 17 is different than the one shown on the figures 4 to 9.

In the above description, the present invention is described with regard to its propulsion effect. It is however evident to the skilled person that any fin propulsion system, and thereby also the fin propulsion system according to this invention, could also be used for generating power. This is because, at a given flow/ship speed, the mechanism will behave as a generator below a critical crankshaft speed, and as a propeller above that critical crankshaft speed. This provides the possibility to generate power from the system.

Furthermore the heave direction may be any direction, including horizontal (such as fish) and vertical (such as dolphins) as long as it is at a substantial angle to the main intended direction of thrust, perpendicular being slightly the best. The pitching axis should have a substantial angle with both mentioned directions, perpendicular being slightly the best.

Claims

1. A propulsion apparatus provided within a hull (1) of a maritime vessel comprising at least one transverse translating propulsion fin (2) being fixed to a fin axle (6), and means for driving said fin (2) comprising a crankshaft (9), a pitching mechanism for rotating said fin (2) around an axis of said fin axle (6), and a heave mechanism for translating said fin (2) in a substantially transverse direction with respect to said axis of said fin axle (6) and said vessel, and where said crankshaft (9) is driving said pitching mechanism and said heave mechanism **characterized in** that both said heave and said pitch mechanism are connected to a single crank (10) on said crankshaft (9), or two separate cranks having substantially the same radius and angular position with respect to the axis of rotation (13) of said crankshaft (9).

2. A propulsion apparatus according to claim 1, **characterized in** that said fin axle (6) is mounted to a chariot (5) allowing said fin axle (6) and thereby said fin (2) to rotate around its axis with respect to said chariot (5), and that said chariot (5) is slid ably mounted with respect to said crankshaft (9), and where said heave mechanism connects said chariot (5) to a crank (10) on said crankshaft (9) and said pitching mechanism connects said fin axle (6) to a crank (10) on said crankshaft (9).

3. A propulsion apparatus according to claim 2, **characterized in** that said heave mechanism and said pitching mechanism are provided by means of a common push/pull rod (15), (18) being connected at one end to said crank (10) of the drive shaft, and at the other end being attached to and extending substantially transversally from a fin pitching axle (20) being rotatable connected to said chariot (5), so that said push/pull rod (15), (18), when said crankshaft (9) rotates, drives said chariot (5) to oscillate or translate to and from said crankshaft (9), and at the same time drives said fin pitching axle (20) to rotate.

4. A propulsion apparatus according to claim 2, **characterized in** that said heave mechanism comprises a slot (21) in said chariot (5), and a crank (10) on said crankshaft (9) being slid able arranged in said slot (21), and where said pitching mechanism comprises a pitcher rod (18) being attached at one end to and extending substantially transversally from said fin pitching axle (20) and being attached at its other end to a crank (10) on said crankshaft (9), and where said pitcher rod (18) is telescopic or being connected to either said fin pitching axle (20) or said crank via a slide bushing (19), so that said pitcher rod (18) compensates for varying distances between said fin axle (6) and said crank (10), and so that, when said crankshaft (9) rotates, said heave mechanism drives said chariot (5) to oscillate or translate to and from said crankshaft (9), and at the same time said pitching mechanism drives said fin pitching axle (20) to rotate.

5. A propulsion apparatus according to claim 3 or 4, **characterized in** that said fin pitching axle (20) and the fin axle (6) are the same.

6. A propulsion apparatus according to claim 3 or 4, **characterized in** that said pitching mechanism comprises a synchronizing link or gearing (22) connecting said fin pitching axle (20) to said fin axle (6), and where said synchronizing link (22) is arranged for synchronizing the rotation of said fin axle (6) with the rotation of said fin pitching axle (20).

7. A propulsion apparatus according to claim 2 or 4, **characterized in** that said apparatus comprises means for adjusting the angle between said fin pitching axle (20) and said push/pull rod (15), (18) or said pitcher rod (15), (18).

8. A propulsion apparatus according to claim 6, **characterized in** that said fin axle (6) is parallel to said fin pitching axle (20).

9. A propulsion apparatus according to claim 6, **characterized in** that a gearing is arranged between said fin axle (6) and said fin pitching axle (20), so that said fin axle (6) is arranged at an angle apart from zero to said fin pitching axle (20).

10. A propulsion apparatus according to claim 6, **characterized in** that said apparatus comprises two or more fins (6) connected to said same fin pitching axle (20) via one or more synchronizing links (22).

11. A method of propelling a ship by means of a propulsion apparatus according to any of the preceding claims wherein said heave and said pitch mechanism are connected to a single crank (10) on said crankshaft (9), or two separate cranks having substantially the same radius and angular position with respect to the axis of rotation (13) of said crankshaft (9).