

Marine Vessel

Technical field

- 5 This invention relates to a marine vessel comprising a hull with a centre-line, a propulsion system, and a keel arrangement according to the preamble of claim 1.

Background art

10

Marine vessels, in this case particularly tug boats, are provided with a keel in order to assist directional stability, steering force generation and roll-damping. Presently, so-called ASD (Azimuthing Stern Drive) and conventional tug boats are provided with a keel extending more or less over the hull length. These

15 keels have a low aspect ratio, rendering them inefficient as lifting surfaces, and as they are fixed and still have a large transverse area, they significantly reduce side-stepping capability. So-called Tractor Escort Tug Boats are provided with either a cycloidal propeller (VSP - Voith Schiffstechnik Cycloidal Propeller) or Z-drive in the bow and a large fixed fin at the stern providing the steering force.

20 Although there is some improvement in roll-damping in open seas, side-stepping is significantly reduced, considering the extreme fin position in relation to the centre of gravity and propulsive thrust.

Summary of invention

25

An object of the present invention is to avoid the above mentioned problems and to achieve a marine vessel with an improved manoeuvrability and superior sea keeping performance. This object is attained by a marine vessel according to claim 1.

30

The basic idea of the invention is maintaining the basic principle of a keel, while reducing the lateral area in side-stepping manoeuvres, and having the keel playing an active role in manoeuvring the marine vessel. This may be imple-

mented by providing the marine vessel with an omni-directional propulsion unit and with a keel arrangement having an active keel unit with a first active keel member and a second active keel member, which both are rotational keel members.

5

The keel, or active keel, is not a rudder. The rudder only affects yaw of a vessel on which it is employed. Also, a rudder only creates a turning force around the centre of gravity of a vessel.

- 10 A particular advantage in tug operation is that the keel plays an active role in applying a steering force to an attended vessel. The active keel acts in deliberate relation to the tow point of the marine vessel.

- By the definition active it is understood that the active keel unit as a whole, i.e.
15 the first and the second active keel member are not fixed, but that they can be moved, i.e. rotated around a vertical axis of rotation with respect to the centre-line, or keel line, of the marine vessel. The active keel unit is thus a rotational keel unit. The active keel unit is positioned below the generally more or less flat bottom of the marine vessel. The active keel unit affects both yaw and sway of
20 the marine vessel.

- By arranging the first active keel member and the second active keel member independently of each other, the hydrodynamic environment for the first keel member can be enhanced in order to increase manoeuvring efficiency. Adjust-
25 ing the direction, i.e. the angle of attack individually for each active keel member the optimum amount of lift can be achieved.

- In connection with a marine vessel conventionally having a long low aspect ratio keel, e.g. an ASD tug, the active keel unit advantageously includes a first active
30 keel member and a second active keel member. As the keel members are close to each other and aligned along the centre-line of the vessel, they have a hydrodynamic influence over each other. The aft active keel member will face a flow with another angle of attack than the forward active keel member as the forward active keel member can affect the flow direction. The active keel mem-

bers can thus be moved, i.e. rotated around a vertical axis of rotation with respect to the centre-line, or keel line, of the marine vessel. The active keel members are thus rotational keel members.

- 5 By rotating the active keel members, the angle of attack of the keel in relation to the water flow can be different from the angle of attack of the hull of the vessel. This will enable a tug boat to generate more side lift or breaking power with a smaller angle of attack for the tug boat itself. Consequently, this will allow the tug boat in escort mode to operate with the bow closer to the direction of head-
10 ing. The advantage will be seen in better control and stability for the tug boat in given operating situations.

- The active keel unit, comprising e.g. the first active keel member and the second active keel member, is advantageously provided with a support frame including a forward support member, a longitudinal support member and an aft
15 support member. The support frame provides a means for protection and stability in connection with docking and possible collision situations.

- By providing the first active keel member and the second active keel member with a common base plate, the hydrodynamic environment for both keel members can be enhanced in order to increase the lift force. The common base
20 plate can act as an end plate or tip wing for the keel member wing sections.

- The active keel members can be rotated to a transverse position in order to
25 minimize the side movement resistance of the tug boat to enable a better side stepping capability than could be achieved with a fixed keel provided with the same area.

- The omni-directional propulsion unit, e.g. a steerable propulsion unit, such as a
30 steerable thruster, or a cycloidal propeller, thus provides the primary steering force for the marine vessel.

The present invention is particularly advantageous in connection with tug boats, as discussed above and below.

Various advantageous embodiments of the present invention are given in claims 2-11.

5 **Brief description of drawings**

In the following the present invention will be described, by way of example only, in more detail with reference to the attached schematic drawings, in which

10

Fig. 1 illustrates a first embodiment of the present invention,

Fig. 2 illustrates the first embodiment in one operating mode,

Fig. 3 illustrates the first embodiment in another operating mode,

Fig. 4 illustrates a second embodiment of the present invention, and

15 Fig. 5 illustrates a third embodiment of the present invention.

Detailed description

In the figures reference numeral 1 generally indicates a marine vessel which
20 comprises a hull 2 with a centre-line 21, a propulsion arrangement (Fig. 6), and an active keel unit 3. Reference sign F indicates a forward end of the marine vessel, corresponding to the bow, and reference sign A indicates an aft end of the marine vessel, corresponding to the stern.

25 In these embodiments the marine vessel 1 is a tug boat which may be of any of the types discussed above, a so-called ASD tug boat, a Z tug boat, a Tractor Escort Tug Boat, as well as any other kind of tug boat. Tug boats are usually high-powered in relation to size, and they are designed to be highly manoeuvrable, whereby the active keel unit provides a large number of advantages.

30

The propulsion system mainly comprises an omni-directional propulsion unit, such as a Z propulsion unit, other steerable propulsion unit, a steerable thruster, or a cycloidal propeller VSP propulsion unit. The propulsion system could also comprise a conventional single screw or twin screw propulsion system.

In the following the general expression tug boat will be used for the marine vessel 1. However, it is clear that the present invention may be deployed with other types of marine vessels as well.

5

Figure 1 illustrates an embodiment, in which the marine vessel 1, i.e. the tug boat, is provided with an active keel unit 3 which comprises a first active keel member 31 and a second active keel member 32.

10 In this embodiment the active keel unit 3, i.e. the first active keel member 31 and the second active keel member 32 are arranged within a support frame 4, which is attached to the hull 2 of the tug boat, along the centre-line 21, or keel-line, of the marine vessel. The support frame 4 includes a substantially vertically arranged forward support member 41, a substantially horizontally arranged longitudinal support member 42, and a substantially vertically arranged aft support member 43. The forward support member 41 is arranged forward of the first active keel member 31 and the aft support member 43 is arranged aft of the second active keel member 32. The longitudinal support member 42 is aligned with the centre-line 21 of the tug boat. The support members frame and support the active keel unit 3 with regard to the hull 2 and centre-line 21 of the tug boat.

15

20

The first active keel member 31 and the second active keel member 32 are arranged to be rotated or turned around a substantially vertically axis of rotation (not shown) with respect to the centre-line 21, or keel-line, and the longitudinal support member 43 of the tug boat.

25

In this embodiment the omni-directional propulsion unit would typically be a steerable propulsion unit (not shown), either at the forward or aft end of the marine vessel. The marine vessel could even be provided with a plurality of such propulsion units, both at the forward or aft end of the marine vessel. The steerable propulsion unit, such as a steerable thruster, thus provides the primary steering force for the marine vessel.

30

The keel members can also be located side by side to each other with respect

to the centre-line 21, or keel-line, of the tug boat.

Figure 2 shows the active keel unit 3 of the first embodiment of figure 1 in a first mode, in which the first active keel member 31 and the second active keel member 32 are turned more or less at a right angle to the centre-line 21.

By turning the active keel members to align with an intended direction of tug boat travel, the tug boat can easily perform a manoeuvre, such as side-stepping, which with a normal fixed keel is extremely difficult. The active keel members can be rotated to a transverse position in order to minimize the side movement resistance of the tug boat to enable a better side stepping capability than could be achieved with a fixed keel provided with the same area.

Figure 3 shows the active keel unit 3 of the first embodiment of figure 1 in a second mode, in which first active keel member 31 and the second active keel member 32 in a position where they are only slightly angled with regard to the centre-line 21.

Such a position is advantageous in view of increasing the indirect towing force when the tug boat operates in an escort mode. The angle of the active keel members can thus easily be coordinated to produce a maximum lift, and consequently a towline steering force, for a given tug boat heading. This also provides for safe escort at high speeds by providing corrective steering or braking forces e.g. when towing tankers at speeds of around 10 knots or more. This is a notable advantage as tugs that are normally designed for escort at such high speeds are less manoeuvrable due to their fixed keels. In the instance that the active keel takes the form of two keels replacing a single, fixed, low aspect ratio keel, the keel system according to the invention provides a notable advantage of a higher lift efficiency than that of the single fixed keel. This enables tugs that normally are designed for low speed work, i.e. inherently ASD tugs, to perform higher speed escort due to the ability to develop higher steering forces.

As the active keel members are aligned along the centre-line of the vessel, they have a hydrodynamic influence over each other. Adjusting the direction, i.e. the

angle of attack individually for each active keel member the optimum amount of lift can be achieved.

5 By rotating the active keel members, the angle of attack of the active keel unit in relation to the water flow can be different from the angle of attack of the hull of the vessel. This will enable a tug boat to generate more side lift or breaking power with a smaller angle of attack for the tug boat itself. Consequently, this will allow the tug boat in escort mode to operate with the bow closer to the direction of heading. The advantage will be seen in better control and stability for
10 the tug boat in given operating situations.

The support frame 4 also increases roll dampening due to an increased vortex generation at the leading edge (forward support member 41) and the trailing edge (aft support member 43) of the support frame 5.
15

The support frame 4 also provides a means for protection and stability for the active keel unit in connection with docking or possible collision situations.

The active keel unit 3 in this embodiment is thus a rotational keel unit, whereby
20 in a corresponding manner the first active keel member 31 constitutes a first rotational keel member and the second active keel member 32 constitutes a second rotational keel member.

Fig. 4 shows an embodiment where the active keel unit 3, i.e. the first active
25 keel member 31 and the second active keel member 32 are arranged independently of each other without any kind of support structure along the centre-line 21, or keel-line, of the marine vessel 1. Since no support structure or framework is present, the first active keel member 31 is provided with an enhanced hydrodynamic environment.

30

In this embodiment the omni-directional propulsion unit would typically be a steerable propulsion unit (not shown), either at the forward or aft end of the marine vessel. The marine vessel could even be provided with a plurality of such propulsion units, both at the forward or aft end of the marine vessel. The steer-

able propulsion unit, such as a steerable thruster, thus provides the primary steering force for the marine vessel.

5 As the keel members are aligned along the centre-line of the marine vessel, they have a hydrodynamic influence over each other. Adjusting the direction, i.e. the angle of attack individually for each active keel member the optimum amount of lift can be achieved.

10 The active keel unit 3 in this embodiment is thus a rotational keel unit, whereby in a corresponding manner the first active keel member 31 constitutes a first rotational keel member and the second active keel member 32 constitutes a second rotational keel member.

15 By rotating the active keel members, the angle of attack of the active keel unit in relation to the water flow can be different from the angle of attack of the hull of the vessel. This will enable a tug boat to generate more side lift or breaking power with a smaller angle of attack for the tug boat itself. Consequently, this will allow the tug boat in escort mode to operate with the bow closer to the direction of heading. The advantage will be seen in better control and stability for
20 the tug boat in given operating situations.

The different operating measures and advantages discussed in connection with the embodiment according to Figs. 1-3 are applicable also to this embodiment
25 as appropriate.

The keel members can also be located side by side to each other with respect to the centre-line 21, or keel-line, of the tug boat.

30 Fig. 5 shows an embodiment where the active keel unit 3, i.e. the first active keel member 31 and the second active keel member 32 are provided with a common base plate 5. The common base plate 5 provides some support to the active keel unit 3 at the same time as it enhances the hydrodynamic qualities of both the first active keel member 31 and the second active keel member 32.

The common base plate 5 is arranged in a longitudinal direction and aligned with the centre-line 21, or keel-line, of the hull 2 of the tug boat.

5 In this embodiment the omni-directional propulsion unit would typically be a steerable propulsion unit (not shown), either at the forward or aft end of the marine vessel. The marine vessel could even be provided with a plurality of such propulsion units, both at the forward or aft end of the marine vessel. The steerable propulsion unit, such as a steerable thruster, thus provides the primary steering force for the marine vessel.

10

The active keel unit 3 in this embodiment is thus a rotational keel unit, whereby in a corresponding manner the first active keel member 31 constitutes a first rotational keel member and the second active keel member 32 constitutes a second rotational keel member.

15

By rotating the active keel members, the angle of attack of the active keel unit in relation to the water flow can be different from the angle of attack of the hull of the vessel. This will enable a tug boat to generate more side lift or breaking power with a smaller angle of attack for the tug boat itself. Consequently, this will allow the tug boat in escort mode to operate with the bow closer to the direction of heading. The advantage will be seen in better control and stability for the tug boat in given operating situations.

20

The different operating measures and advantages discussed in connection with the embodiment according to Figs. 1-3 are applicable also to this embodiment as appropriate.

25

The enhanced hydrodynamics with regard to the embodiments of Figs. 4 and 5 raise the efficiency of manoeuvring characteristics.

30

As the keel members are aligned along the centre-line of the marine vessel, they have a hydrodynamic influence over each other. Adjusting the direction, i.e. the angle of attack individually for each active keel member the optimum amount of lift can be achieved.

The keel members can also be located side by side to each other with respect to the centre-line 21, or keel-line, of the tug boat.

- 5 Although the discussion above mainly relates to tug boats, it is clear that an active keel unit could as well be employed for any other kind of marine vessel offering the same or similar advantages. Further, the number of active keel members is not limited to two. Depending on the application, it could as well be appropriate to provide a marine vessel with more than two active keel members,
- 10 which also can be located side by side to each other with respect to the centre-line, or keel-line, of the marine vessel. A support frame or a common base plate may be provided in connection with one or more active keel members. The design of the active keel unit takes account of the type of the propulsion system of the marine vessel.

15

The description and the thereto related drawings are only intended to clarify the basic concept of the invention. The invention may vary in detail within the scope of the ensuing claims.

Claims

1. Marine vessel comprising a hull (2) with a centre-line (21), a propulsion system, and a keel arrangement, **characterised** in that the propulsion system
5 comprises an omni-directional propulsion unit (6), that the keel arrangement comprises an active keel unit (3) with a first active keel member (31) and a second active keel member (32), and in that the first active keel member (31) is a rotational keel member and in that the second active keel member (32) is a rotational keel member.
- 10 2. Marine vessel according to claim 1, **characterised** in that the first active keel member (31) and the second active keel member (32) are arranged independently of each other.
3. Marine vessel according to claim 1, **characterised** in that direction of the first keel member (31) and the second keel member (32) is arranged to be indi-
15 vidually adjustable.
4. Marine vessel according to claim 1, **characterised** in that the first active keel member (31) and the second active keel member (32) are arranged to be rotated around a respective vertical axis of rotation with respect to the centre-line (21) of the marine vessel (1).
- 20 5. Marine vessel according to claim 1, **characterised** in that the active keel unit (3) is provided with a support frame (4).
6. Marine vessel according to claim 5, **characterised** in that the support frame (4) includes a forward support member (41), a longitudinal support member (42) and an aft support member (43).
- 25 7. Marine vessel according to claim 1, **characterised** in that the active keel unit (3) is provided with a common base plate (5).
8. Marine vessel according to claim 1, **characterised** in that the omni-directional propulsion unit (6) is a steerable propulsion unit.
9. Marine vessel according to claim 1, **characterised** in that the omni-

directional propulsion unit (6) is a cycloidal propeller propulsion unit.

10. Marine vessel according to claim 1, **characterised** in that the marine vessel is a tug boat.

11. Marine vessel according to claim 10, **characterised** in that the tug boat is
5 ASD, Z-drive, or Tractor Escort Tug Boat.