

Tugboat provided with a carrousel-type towing system**Field of the invention**

5 [0001] The present invention relates to a tugboat, comprising a single hull, a deck and a towing system having a circular or oval base connected to the deck, the base having a centre point, and a cart that is moveable over the base over 360°, wherein the cart comprises a powered winch during use provided with a tug cable for towing vessels, wherein a propulsion system is connected to the hull for providing a propulsive force in
10 a body of water. Such a towing system is also known as a carrousel-type towing system.

Background of the invention

15 [0002] Such a tugboat is known from for instance WO 2006/049483 A1 by the present applicant.

[0003] A disadvantage of the known carrousel-type tugboat is that the propulsion forces are not positioned in the most optimal way to control the tugboat's heading
20 during towing.

[0004] Another disadvantage is that a lot of engine thrust is needed to control the tugboat's heading.

25 [0005] It is therefore an object of the present invention to provide a tugboat with a carrousel-type towing system that allows the most optimal control of the tugboat and to utilize the power of the carrousel-type tugboat to its full extent.

[0006] It is a further object of the invention to provide a tugboat having a carrousel-
30 type towing construction, wherein the amount of engine thrust needed to generate the desired amount of towing force is decreased.

Summary of the invention

[0006A] According to a first aspect, there is provided a method of operating a tugboat comprising a single hull (2), a deck (3) and a towing system (4) having a circular or oval base (5) connected to the deck, the base having a centre point (CP), and a cart (6) that is moveable over the base over 360° , wherein the cart comprises a powered winch (7) during use provided with a tug cable (8) for towing vessels (9), wherein a propulsion system (10) is connected to the hull for providing a propulsive force in a body of water (11), wherein the propulsion system comprises two propulsion units (12) each capable of providing thrust over 360° in a plane perpendicular to a vertical plane of symmetry (13) extending in a longitudinal direction (X) of the tugboat, wherein the propulsion units are positioned in the vertical plane of symmetry and are aligned in the longitudinal direction, wherein one of the propulsion units is positioned in front of the centre point and the other one is positioned behind the centre point and a distance between the propulsion units is at least 10% of a length (L) of the tugboat in the longitudinal direction, wherein the tugboat is configured in such a way that during towing a vertical distance (H_{cp}) between the centre point (SP) and the waterline (14) divided by a vertical distance (H_p) between the centre of thrust of the propulsion units and the waterline is 0,3 – 1,5, wherein the method comprises the steps of: configuring the tugboat to attain such a draft during towing that the vertical (H_{cp}) distance between the centre point and the waterline (14) divided by the vertical distance (H_p) between the centre of thrust of the propulsion units and the waterline (14) is 0,3 – 1,5; connecting the tug cable to a vessel to be towed and maneuvering the tugboat in such a way that the tug cable extends at an angle of $45 - 90^\circ$ to the longitudinal direction of the vessel; operating the powered winch such that the tug cable is under tension, wherein a hydrodynamic resistance force created by the submerged hull is used to increase the tension of the tug cable; and using the propulsion units to correct the orientation of the tugboat with respect to the vessel to be towed.

[0007] Hereto, the tugboat according to an example is characterized in that the propulsion system comprises two propulsion units (12) each capable of providing thrust over 360° in a plane perpendicular to a vertical plane of symmetry (13) extending in a longitudinal direction (X) of the tugboat, wherein the propulsion units are positioned in the vertical plane of symmetry and are aligned in the longitudinal direction, wherein

one of the propulsion units is positioned in front of the centre point and the other one is positioned behind the centre point and the distance between the propulsion units is at least 10% of a length (L) of the tugboat in the longitudinal direction, wherein the tugboat is configured in such a way that during towing the vertical distance between the
 5 centre point and the waterline (H_{cp}) divided by the vertical distance between the centre of thrust of the propulsion units and the waterline (H_p) is 0,3 – 1,5. Preferably the ratio is 0,6 – 1,1.

[0008] These combined features, and in particular the described values, allow the
 10 power of the carrousel-type tug system to be fully utilized and less engine thrust is needed to generate sufficiently large towing forces. The resistance of the hull itself can be advantageously used to create a counterforce opposed to the pulling force of the tug cable and thus tension in the tug cable can be increased to huge values without needing a lot of engine thrust. This is particularly relevant when pulling in a direction
 15 perpendicular to the longitudinal direction of the tugboat. The applicant has found that the stated values for H_p provide optimal stability to the tugboat. For values larger than 1,5 applicant has found that the tugboat gets elevated too much above the waterline, causing the positive effect on stability to be almost fully negated. The vertical distance between the centre point and the waterline (H_{cp}) can for instance be 1,5 – 4,5 m. The
 20 vertical distance between the centre of thrust of the propulsion units and the waterline (H_p) can for example be 3 – 5 m.

[0009] Having one of the propulsion units positioned in front of the centre point and the other one positioned behind the centre point, wherein the distance between the
 25 propulsion units is at least 10%, preferably at least 20% or more preferably at least 30%, of a length (L) of the vessel in the longitudinal direction, allows for correction of

moments acting around a vertical axis of the vessel with only minimal amounts of engine thrust.

[0010] During tests, the applicant has achieved the following surprisingly positive results with the configuration according to the invention:

- At a speed of 10 knots, with only 2825 kW of propulsive power installed, a steering force of 161t has been achieved;
- At a speed of 10 knots, with only 2014 kW of propulsive power installed, a braking force of 144t has been achieved; and
- At a speed of 10 knots, with only 1045 kW of propulsive power installed, a braking force of 136t combined with a steering force of 75t has been achieved;

[0011] The multiplication factor of dynamic forces (at speed 10 knots; 161 t) relative to static force (static pull and function of used power; 2825 kW = 40 t static pull) is approximately 4, which is unheard of.

[0012] This means that a smaller hull can be used, but the tugboat is still able to generate the high dynamic forces that are required during escort assistance.

[0013] Another embodiment relates to an aforementioned tugboat, wherein the propulsion units comprise one or more Voith Schneider Propellers (VSP's). Such VSP's are particularly useful for generating sideways forces, especially when towing at large towing angles.

[0014] Another embodiment relates to an aforementioned tugboat, wherein the propulsion units comprise one or more azimuth thrusters. Such thrusters can also be advantageously used to generate sideways forces.

[0015] The invention also relates to a method of operating a tugboat according to any one of the preceding claims, comprising the steps of:

- configuring the tugboat to attain such a draft during towing that the vertical distance between the centre point and the waterline (H_{cp}) divided by the vertical distance between the centre of thrust of the propulsion units and the waterline (H_p) is 0,3 – 1,5.

- connecting the tug cable to a vessel to be towed and maneuvering the tugboat in such a way that the tug cable extends at an angle of 45 - 90° to the longitudinal direction of the vessel,
- operating the powered winch such that the tug cable is under tension, wherein a hydrodynamic resistance force created by the submerged hull is used to increase the tension of the tug cable,
- using the propulsion units to correct the orientation of the tugboat with respect to the vessel to be towed.

10 [0016] Such a method advantageously employs the hydrodynamic resistance force created by the submerged hull to increase the tension of the tug cable, without needing a lot of thrust from the propulsion units to achieve this.

15 [0017] Preferably, the orientation of the tugboat is corrected with the propulsion units in such a way, that the tug cable remains at an angle of 45 - 90° to the longitudinal direction of the tugboat, such that the hydrodynamic resistance of the hull (both for withstanding moments as well as withstanding movement due to the tension in the tug cable) stays relatively high.

20 [0018] More preferably, the orientation of the tugboat is corrected with the propulsion units in such a way, that the tug cable remains at an angle of about 90° to the longitudinal direction of the tugboat. In this way, the hydrodynamic resistance of the hull in sideways direction remains as high as reasonably possible.

25 **Brief description of the drawings**

[0019] An embodiment of a tugboat according to the invention will by way of non-limiting example be described in detail with reference to the accompanying drawings. In the drawings:

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[0020] Figure 1 shows a side view of a tugboat according to the invention;

[0021] Figure 2 shows a front view of the tugboat according to figure 1; and

[0022] Figure 3 shows a top view of the tugboat according to figures 1 and 2.

Detailed description of the invention

5 [0023] Figures 1-3 will be discussed in conjunction. Figure 1 shows a tugboat 1, comprising a single hull 2, a deck 3 and a towing system 4 having a circular or oval base 5 connected to the deck 3. The base 5 has a centre point CP. A cart 6 is moveable over the base 5 over 360° , wherein the cart 6 comprises a powered winch 7 during use provided with a tug cable 8 for towing vessels 9. A propulsion system 10 is connected
10 to the lower side of the hull 2 for providing a propulsive force P in a body of water 11. According to the invention, the propulsion system 10 comprises two propulsion units 12 each capable of providing a thrust or propulsive force P over 360° in a plane perpendicular to a vertical plane of symmetry 13 that extends in a longitudinal direction X of the tugboat 1 (see figures 2 and 3). The maximum hull width $W_{\max}$ can for
15 instance be 8 – 14 m. The maximum hull height $H_{\max}$ can be, for instance, 2,5 – 7 m.

[0024] The propulsion units 12 are positioned in the vertical plane of symmetry 13 and are aligned in the longitudinal direction X . One of the propulsion units 12 is positioned in front of the centre point CP and the other one is positioned behind the centre point
20 CP and the distance between the propulsion units 12 is at least 10% of a length L of the tugboat 1 in the longitudinal direction X . The tugboat 1 is configured in such a way that during towing the vertical distance between the centre point and the waterline H_{cp} divided by the vertical distance between the centre of thrust of the propulsion units and the waterline H_p is 0,3 – 1,5. Preferably the ratio is 0,6 – 1,1, even more preferably
25 around 0,95. The change of hull 2 draft H_{draft} and thus of the stated distances H_{cp} and H_p may be achieved by adapting the design or weight of the tugboat 1 or by using ballast tanks or the like.

[0025] The vertical distance between the centre point CP and the waterline H_{cp} can for
30 instance be 1,5 – 4,5 m. The vertical distance between the centre of thrust of the propulsion units and the waterline H_p can for example be 3 – 5 m.

[0026] The tugboat 1 may have propulsion units 12 in the form of Voith Schneider Propellers. The tugboat 1 as shown has propulsion units 12 comprising a pair of azimuth thrusters.

- 5 [0027] Thus, the invention has been described by reference to the embodiments discussed above. It will be recognized that these embodiments are susceptible to various modifications and alternative forms well known to those of skill in the art without departing from the spirit and scope of the invention. Accordingly, although specific embodiments have been described, these are examples only and are not
- 10 limiting upon the scope of the invention.

List of reference numerals

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|----|--------------------|--|
| | 1. | Tugboat |
| | 2. | Single hull |
| 5 | 3. | Deck |
| | 4. | Towing system |
| | 5. | Base |
| | 6. | Cart |
| | 7. | Winch |
| 10 | 8. | Tug cable |
| | 9. | Vessel to be towed |
| | 10. | Propulsion system |
| | 11. | Body of water |
| | 12. | Propulsion unit |
| 15 | 13. | Vertical plane of symmetry |
| | 14. | Waterline |
| | CP | = centre point |
| 20 | X | = longitudinal direction |
| | L | = length of the vessel |
| | H _{max} | = maximum hull height |
| | H _{draft} | = hull draft |
| 25 | H _{cp} | = vertical distance between centre point and waterline |
| | H _p | = vertical distance between the centre of thrust of the propulsion units and the waterline |
| | H _{max} | = maximum hull height |
| | W _{max} | = maximum hull width |
| 30 | T | = tension exerted by tug cable on tugboat |
| | P | = propulsive force exerted by propulsion unit on tugboat |

Claims

1. Method of operating a tugboat comprising a single hull (2), a deck (3) and a towing system (4) having a circular or oval base (5) connected to the deck, the base
5 having a centre point (CP), and a cart (6) that is moveable over the base over 360°, wherein the cart comprises a powered winch (7) during use provided with a tug cable (8) for towing vessels (9), wherein a propulsion system (10) is connected to the hull for providing a propulsive force in a body of water (11), wherein the propulsion system comprises two propulsion units (12) each capable of providing thrust over 360° in a
10 plane perpendicular to a vertical plane of symmetry (13) extending in a longitudinal direction (X) of the tugboat, wherein the propulsion units are positioned in the vertical plane of symmetry and are aligned in the longitudinal direction, wherein one of the propulsion units is positioned in front of the centre point and the other one is positioned behind the centre point and a distance between the propulsion units is at least 10% of a
15 length (L) of the tugboat in the longitudinal direction, wherein the tugboat is configured in such a way that during towing a vertical distance (H_{cp}) between the centre point (SP) and the waterline (14) divided by a vertical distance (H_p) between the centre of thrust of the propulsion units and the waterline is 0,3 – 1,5,
wherein the method comprises the steps of:
 - 20 - configuring the tugboat to attain such a draft during towing that the vertical (H_{cp}) distance between the centre point and the waterline (14) divided by the vertical distance (H_p) between the centre of thrust of the propulsion units and the waterline (14) is 0,3 – 1,5;
 - connecting the tug cable to a vessel to be towed and maneuvering the tugboat in
25 such a way that the tug cable extends at an angle of 45 - 90° to the longitudinal direction of the vessel;
 - operating the powered winch such that the tug cable is under tension, wherein a hydrodynamic resistance force created by the submerged hull is used to increase the tension of the tug cable; and
 - 30 - using the propulsion units to correct the orientation of the tugboat with respect to the vessel to be towed.

2. Method according to claim 1, wherein the propulsion units comprise one or more Voith Schneider Propellers.
3. Method according to claim 1 or 2, wherein the propulsion units comprise one or more azimuth thrusters.
4. Method according to claim 1, wherein the orientation of the tugboat is corrected with the propulsion units in such a way, that the tug cable remains at an angle of 45 - 90° to the longitudinal direction of the tugboat.
5. Method according to claim 4, wherein the orientation of the tugboat is corrected with the propulsion units in such a way, that the tug cable remains at an angle of about 90° to the longitudinal direction of the tugboat.
6. Method according to claim 1, wherein the tugboat has a longitudinal direction, the single hull is an elongated hull, the towing system is a carousel-type towing system, and wherein the base is a circular base.
7. Method according to claim 6, wherein each of the two propulsion units (12) is arranged below the hull's draft and capable of providing thrust over 360° in a plane below the hull's draft and perpendicular to vertical plane of symmetry (13) of the tugboat, wherein the vertical plane of symmetry (13) extends in the longitudinal direction of the tugboat.
8. Method according to claim 6, wherein the vertical distance (Hcp) between the centre point (Cp) and the water line (14) is in the range of 1,5 – 4,5 m, and wherein the vertical distance between the centre of thrust of the propulsion units and the water line is in the range of 3 – 5 m.
9. Method according to claim 1, wherein the tugboat (1) is configured in such a way that during towing the vertical distance (Hcp) between the centre point (CP) and the waterline (14) divided by the vertical distance (Hp) between the centre of thrust of the propulsion units (12) and the waterline (14) is 0,6 – 1,1.

10. Method according to claim 1, wherein the distance between the propulsion (12) units is at least 30% of the length (L) of the vessel in the longitudinal direction.
- 5 11. Method according to claim 1, wherein one of the propulsion units is positioned in front of the centre point (CP) and the base (5) and the other one is positioned behind the centre point (CP) and the base (5) when seen along the longitudinal direction (X).