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VESSEL

Abstract

The present disclosure provides a vessel, thrust of which is less likely to be lost. A vessel includes a hull having a vessel bottom, and a propulsion device. The propulsion device has a propeller that can rotate about a propeller shaft penetrating a shaft hole in the vessel bottom, and generates thrust for sailing the hull by rotation of the propeller. The hull has the groove section, which is long in the front-rear direction, around the propeller in the vessel bottom. The shaft hole is arranged in the groove section.

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Background/Summary

[0001] This application claims priority under 35 U.S.C. § 119 to Japanese Patent Application No. 2024-024344, filed on Feb. 21, 2024, which is incorporated by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to a vessel that generates thrust for sailing a hull by rotation of a propeller.

BACKGROUND ART

[0003] As the related art, a vessel that includes a hull, a propeller (a propeller structure) as a propulsion device (a propulsion structure) for obtaining thrust, and the like has been known (for example, see Patent Document 1). The vessel according to the related art is a twin-screw vessel for which a twin-screw propulsion device is adopted. In the twin-screw propulsion device, two propeller shafts that extend in parallel with each other are used, and a propeller is attached to each of the propeller shafts.

[0004] In the vessel according to the related art, each of the propellers is rotatably supported by a bossing that extends rearward from a vessel bottom, and rotates in conjunction with rotation of the respective propeller shaft (a propeller shaft member). The propeller generates a propeller water flow toward the rear and thereby generates the thrust that causes the hull to move forward.

PRIOR ART DOCUMENT

Patent Document

[0005] Patent Document 1: Japanese Unexamined Patent Publication No. 2011-93503

SUMMARY OF INVENTION

Technical Problem

[0006] As in the related art, in the configuration that the propeller is arranged at the vessel bottom, turbulence of the water flow possibly occurs around the propeller shaft during a sail of the hull, and the thrust is possibly lost by the turbulence of the water flow.

[0007] An object of the present disclosure is to provide a vessel, thrust of which is less likely to be lost.

Solution to Problem

[0008] A vessel according to an aspect of the present disclosure includes a hull having a vessel bottom, and a propulsion device. The propulsion device has a propeller that can rotate about a propeller shaft penetrating a shaft hole in the vessel bottom, and generates thrust for sailing the hull by rotation of the propeller. The hull has a groove section, which is long in a front-rear direction, around the propeller in the vessel bottom. The shaft hole is arranged in the groove section.

Advantageous Effects of Invention

[0009] The present disclosure can provide the vessel in which the thrust is less likely to be lost.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0010] FIG. **1** is a schematic perspective view in which a vessel according to a first embodiment is seen from a deck side.

[0011] FIG. **2** is a schematic right view of the vessel according to the first embodiment.

[0012] FIG. **3** is a schematic perspective view in which the vessel according to the first embodiment is seen from a vessel bottom side.

[0013] FIG. **4** is a schematic bottom view of the vessel according to the first embodiment.

[0014] FIG. **5** is an enlarged view of an area Z**1** in FIG. **3** and illustrates main sections of the vessel according to the first embodiment.

[0015] FIG. **6** is an enlarged view of the area Z**1** in FIG. **4** and illustrates the main sections of the vessel according to the first embodiment.
[0016] FIG. **7** is a schematic back view of a lower portion of a hull that is seen from behind, and illustrates the main sections of the vessel according to the first embodiment.
[0017] FIG. **8** is a cross-sectional view that is taken along Y**1**-Y**1** in FIG. **6**.
[0018] FIG. **9** includes cross-sectional views that are taken along line X**1**-X**1**, line X**2**-X**2**, and line X**3**-X**3** in FIG. **6**, respectively.
[0019] FIG. **10** includes schematic perspective views illustrating the main sections of the vessel according to the first embodiment and main sections of a vessel according to a comparative example that are seen from the vessel bottom side.
[0020] FIG. **11** includes schematic bottom views illustrating the main sections of the vessel according to the first embodiment and the main sections of the vessel according to the comparative example.
[0021] FIG. **12** includes explanatory views illustrating simulation results of water flows by the vessel according to the first embodiment and the vessel according to the comparative example.
[0022] FIG. **13** includes explanatory views illustrating simulation results of water pressures on the vessel according to the first embodiment and the vessel according to the comparative example.

DESCRIPTION OF EMBODIMENTS

[0023] Hereinafter, a description will be made on an embodiment of the present disclosure with reference to the accompanying drawings. The following embodiment is an example that embodies the present disclosure and has no intention to limit the technical scope of the present disclosure.

First Embodiment

[1] Overall Configuration

[0024] First, a description will be made on an overall configuration of a vessel **10** according to the present embodiment with reference to FIGS. **1** to **4**.
[0025] The vessel **10** is a movement body that navigates (sails) on water such as the sea, a lake, a river, or the like. As an example in the present embodiment, the vessel **10** is a “pleasure boat” that is a small-sized vessel used for sports, recreation, or the like mainly in the sea. In addition, in the present embodiment, the vessel **10** is configured to be operated according to manipulation (including remote manipulation) by a person (a manipulator). In particular, the vessel **10** is of a manned type that can be boarded by the person as the manipulator.
[0026] The vessel **10** includes a hull **1**, a propulsion device **2** (see FIG. **2**), a rudder device (see FIG. **2**), and a wheel house **4**. The vessel **10** further includes a manipulation device that accepts the manipulation by the person (the manipulator), a display device, various sensors (including a detector), various meters, a communication device, a control device, various inboard facilities such as a lighting facility, and the like. Here, in FIGS. **1** and **2**, the wheel house **4** is schematically indicated by an imaginary line (a two-dot chain line). The wheel house **4** is not illustrated in the drawings other than FIGS. **1** and **2**.
[0027] In the present embodiment, as an example, a propulsion type of the vessel **10** is an “inboard engine” type in which a power source **21** (see FIG. **2**) of the propulsion device **2** is mounted near a center of the hull **1**. A stern type (a stern form) of the vessel **10** is a “bracket type” (an outer propeller/outer rudder type). As an example, it is assumed that the hull **1** is in a size having a total length of 5 meters or more and 20 meters or less and capacity of 5 to 15 persons. Furthermore, in the present embodiment, it is assumed that the vessel **10** is of a semi-planing type and has a speed length ratio of 2.0 or more and 5.0 or less. Thus, the vessel **10** sails in such a posture that a bow portion side of the hull **1** is lifted, although a vessel body (a hull body **11**) does not plane on a water surface.
[0028] In the present embodiment, for convenience of description, a vertical direction in a stopped state of the vessel **10** on water is defined as an up-down direction D**1**. Furthermore, a front-rear direction D**2** and a right-left direction D**3** are defined with a direction seen by the person (the

manipulator), who is seated on a manipulation seat (in the wheel house **4**) of the vessel **10**, being a reference. That is, a direction in which the hull **1** moves during forward movement of the hull **1**, that is, the bow side as seen from the center of the hull **1** is a front side in the front-rear direction D**2**. A direction in which the hull **1** moves during rearward movement of the hull **1**, that is, the stern side as seen from the center of the hull **1** is a rear side in the front-rear direction D**2**. A port side as seen from the center of the hull **1** is a left side in the right-left direction D**3**, and a starboard side as seen from the center of the hull **1** is a right side in the right-left direction D**3**. However, these directions are not intended to limit use directions (directions in use) of the vessel **10**.

[0029] In addition, the term "parallel" in the present disclosure means, in addition to a case where two straight lines on a plane never intersect each other no matter how far the straight lines extend, that is, a case where an angle between these two straight lines is strictly 0 degree (or 180 degrees), such a relationship that the angle between the two straight lines falls within an error range of about several degrees (less than 10 degrees, for example) from 0 degree. Similarly, the term "orthogonal" in the present disclosure means, in addition to a case where the angle between the two straight lines is exactly 90 degrees, such a relationship that the angle between the two straight lines falls within an error range of about several degrees (less than 10 degrees, for example) from 90 degrees.

[0030] As an example, the hull **1** and the wheel house **4** are each formed of a fiber-reinforced plastic (FRP) as a main material. Thus, each of the hull **1** and the wheel house **4** can have a high degree of freedom in the shape thereof while having high strength and light weight. As a result, it is possible to realize the hull **1** in any of various shapes. FIGS. **1** and **2** each exemplify the vessel **10** in a flying bridge specification that has a ship handling space in an upper portion of the wheel house **4**. However, it is not essential that the vessel **10** is in the flying bridge specification.

[0031] The hull **1** has the hull body **11** and a deck **12**. The hull body **11** constitutes the vessel body. The hull body **11** is set to have a greater dimension in the right-left direction D**3** than a dimension in the up-down direction D**1** (excluding the wheel house **4**) and to have a greater dimension in the front-rear direction D**2** than the dimension in the right-left direction D**3**. Thus, the hull body **11** is long in the front-rear direction D**2**. The hull body **11** is formed in a box shape with an opened upper surface, and the power source **21** of the propulsion device **2**, and the like are arranged in the hull body **11**.

[0032] The hull body **11** includes a pair of side vessel shells **111**, a rear vessel shell **112**, and a bottom vessel shell **113**. The paired side vessel shells **111** are arranged to oppose each other in the right-left direction D**3** and constitute both side surfaces (lateral sides) of the hull body **11** in the right-left direction D**3**. The rear vessel shell **112** constitutes a rear surface (a transom) of the hull body **11**. The bottom vessel shell **113** constitutes a vessel bottom **5** as a lower surface of the hull body **11**.

[0033] These paired side vessel shells **111**, rear vessel shell **112**, and bottom vessel shell **113** are formed integrally (seamlessly) to constitute an outer shell of the hull body **11**.

[0034] The deck **12** is joined to the hull body **11** in a manner to cover an opening surface (the upper surface) of the hull body **11**. In other words, the deck **12** constitutes the upper surface of the hull body **11** and is assumed to be boarded by a person. Here, the hull body **11** is divided into three portions in the front-rear direction D**2**, and the three portions are defined as the bow, a midship, and the stern in this order from the front (bow) side. In such a case, the portion of the deck **12** located in the bow (on the bow side) is a "bow deck", and a portion thereof located in the stern (on the stern side) is a "stern deck".

[0035] In a central portion (the midship) of the deck **12** in the front-rear direction D**2**, the wheel house **4** is arranged. On the deck **12**, a side passage is secured on each side of the wheel house **4** in the right-left direction D**3**, and the person can move between the bow deck and the stern deck through each of the side passages.

[0036] In addition, in the present embodiment, the deck **12** is not entirely at the same height, but is gradually increased in height from the stern side toward the bow side. Although not illustrated, the

deck **12** has a step in each of the side passages and the bow deck. Furthermore, from the bow deck, which is located in the bow portion (the bow), to the steps in the side passages on the deck **12**, a fall prevention fence (a bow rail) may be provided to surround the deck **12** along an outer peripheral edge.

[0037] The hull **1** is formed with a watertight space that is surrounded by a group of the paired side vessel shells **111**, the rear vessel shell **112**, and the bottom vessel shell **113**, which constitutes the outer shell of the hull body **11**, and the deck **12** (and the wheel house **4**). An engine room and the like are provided in a central portion of the watertight space in the front-rear direction D**2**. Furthermore, a cabin and the like are provided on a front side of the engine room in the watertight space.

[0038] As illustrated in FIG. **2**, the propulsion device **2** includes the power source **21**, a propeller shaft **22**, a propeller **23**, and a bracket **24**.

[0039] The power source **21** includes, for example, an engine (an internal combustion engine) that generates power by combustion of fuel. As an example, the engine is a diesel engine that is driven by using light oil as the fuel. In the present embodiment, as an example, the power source **21** further includes a power transmission section that transmits the power generated by the engine to the propeller shaft **22**. The power transmission section includes a clutch, a reduction gear (a marine gear), and the like, for example, and has a function to switch between a transmission state where the power is transmitted from the engine to the propeller shaft **22** and a cutoff state where the power is not transmitted.

[0040] The propeller shaft **22** transmits the power generated by the power source **21** to the propeller **23**. The propeller shaft **22** is a columnar (round rod-shaped) shaft (propeller shaft) that is long along the front-rear direction D**2**, and is arranged to penetrate a shaft hole **51** (see FIG. **3**) that is formed in the bottom vessel shell **113** (the vessel bottom **5**). A front end portion of the propeller shaft **22** is connected to the power source **21** in the hull **1** (the hull body **11**), and a rear end portion thereof is connected to the propeller **23** on the outside of the hull **1** (the hull body **11**). That is, the propeller shaft **22** mechanically connects the power source **21**, which is arranged in the watertight space inside the hull **1**, and the propeller **23**, which is arranged outside the hull **1**.

[0041] The propeller **23** is mechanically coupled to the power source **21** via the propeller shaft **22**, and is configured to be rotatable about the propeller shaft **22**. When receiving the power that is generated by the power source **21**, the propeller **23** rotates about the propeller shaft **22** and generates thrust for forward movement or rearward movement of the hull **1**.

[0042] The bracket **24** is fixed to the vessel bottom **5** in a manner to protrude downward from the vessel bottom **5**, and supports the propeller shaft **22** in a manner to allow rotation thereof. Here, the bracket **24** supports the propeller shaft **22** in such an inclined posture with respect to the vessel bottom **5** that a rear end portion of the propeller shaft **22** connected to the propeller **23** is located lower than (inclined downward to the rear from) a front end portion thereof connected to the power source **21**.

[0043] The propulsion device **2** is controlled according to the manipulation of the manipulation device. For example, there is a case where the manipulation device includes a manipulation lever that can be rotated (moved) to any of a forward movement position and a rearward movement position from a neutral position. In such a case, when the manipulation lever is at the neutral position, the propulsion device **2** does not generate the thrust, and thus the thrust of the hull **1** is zero. In this case, for the forward movement of the hull **1**, the manipulator rotates (moves) the manipulation lever from the neutral position to the forward movement position side. For the rearward movement of the hull **1**, the manipulator rotates (moves) the manipulation lever from the neutral position to the rearward movement position side. The propulsion device **2** increases a magnitude of the thrust (a rotational speed of the propeller **23**) for the forward movement of the hull **1** as a manipulation amount (a rotation angle) of the manipulation lever from the neutral position to the forward movement position side is increased.

[0044] As illustrated in FIG. **3**, the rudder device **3** is attached to the stern portion of the hull **1** and adjusts an advancing direction of the hull **1**. In the present embodiment, the rudder device **3** is arranged right behind the propeller **23** of the propulsion device **2**. The rudder device **3** is controlled according to the manipulation of the manipulation device. For example, in the case where the manipulation device includes a steering wheel, the rudder device **3** is steered in a starboard or port direction when the manipulator rotates the steering wheel.
[0045] The wheel house **4** includes the manipulation seat in the upper portion thereof, for example. The manipulation device, the display device, the various meters, the communication device, and the like are arranged around the manipulation seat. The wheel house **4** is arranged above the engine room and the like. The wheel house **4** is configured to be accessible from the deck **12**. An internal space of the wheel house **4** continues to a space (a bow berth) under the deck **12**. For example, a passenger's seat, a table, a sink, a toilet, a shower room, a refrigerator, a utility box, a locker, and the like are arranged in the wheel house **4**. Furthermore, an engine room hatch for accessing the engine room, and the like are arranged in the wheel house **4**.
[0046] By the way, as illustrated in FIGS. **3** and **4**, the vessel **10** according to the present embodiment is a “two-engine, two-shaft” twin-screw vessel that includes the two propulsion devices **2**. That is, the twin-screw propulsion device **2** is adopted for the vessel **10**. In the twin-screw propulsion device **2**, the two propeller shafts **22** that extend in parallel with each other are used, and the propeller **23** is attached to each of the propeller shafts **22**. More specifically, the vessel **10** includes: the paired propeller shafts **22** that are arranged side by side in a width direction (the right-left direction D**3**) of the hull **1**; and the paired propellers **23** that are arranged side by side in the width direction of the hull **1**.
[0047] Furthermore, the vessel **10** includes a pair of the power sources **21** and a pair of the brackets **24** in a manner that each of the pairs is arranged side by side in the width direction of the hull **1**. The paired (two) propulsion devices **2**, which are arranged side by side in the width direction (the right-left direction D**3**) of the hull **1**, are basically configured in common. The paired propulsion devices **2** can be controlled separately.
[0048] For example, driving of only the right propulsion device **2**, and the like are enabled.
[0049] Similarly, the vessel **10** according to the present embodiment further includes the two rudder devices **3**. The paired (two) rudder devices **3**, which are arranged side by side in the width direction (the right-left direction D**3**) of the hull **1**, are respectively arranged right behind the paired propellers **23**.
[0050] Hereinafter, a further detailed description will be made on the configuration of the hull body **11**.
[0051] In the hull body **11**, front ends (end portions on the bow side) of the paired side vessel shells **111** are joined to each other to constitute the bow. Meanwhile, rear ends (end portions on the stern side) of the paired side vessel shells **111** are joined to each other via the rear vessel shell **112** to constitute the stern together with the rear vessel shell **112**. That is, the rear end of the side vessel shell **111** on the port side is joined to a left end of the rear vessel shell **112**, and the rear end of the side vessel shell **111** on the starboard side is joined to a right end of the rear vessel shell **112**.
[0052] Furthermore, lower ends of the paired side vessel shells **111** and a lower end of the rear vessel shell **112** are joined to the bottom vessel shell **113**. In other words, the lower end of the side vessel shell **111** on the port side is joined to a left end of the bottom vessel shell **113** in the right-left direction D**3**, and the lower end of the side vessel shell **111** on the starboard side is joined to a right end of the bottom vessel shell **113**. Then, the lower end of the rear vessel shell **112** is joined to a rear end of the bottom vessel shell **113**.
[0053] The paired side vessel shells **111** are shaped to be separated from each other in the right-left direction D**3** from the bow toward the stern. That is, the hull body **11** is shaped such that a dimension (a vessel width) thereof in the right-left direction D**3** is gradually increased from the bow toward the stern. A distance between the paired side vessel shells **111** becomes maximum in an

intermediate portion of the hull body **11** in the front-rear direction D**2**. Then, in this intermediate portion, the dimension of the hull body **11** in the right-left direction D**3** matches the vessel width. On the rear side of the portions, the distance of which becomes the maximum, the paired side vessel shells **111** are parallel to each other to the stern (the rear vessel shell **112**). Alternatively, the hull body **11** may be shaped such that, from the intermediate portion thereof in the front-rear direction D**2** to the stern, the dimension (the vessel width) of the hull body **11** in the right-left direction D**3** is gradually reduced toward the stern.

[0054] The paired side vessel shells **111** and the rear vessel shell **112** each protrude upward when compared to the deck **12**. That is, in a side view, upper end portions of the paired side vessel shells **111** and the rear vessel shell **112** protrude upward from the deck **12**, and function as bulwarks (wave protection walls), each of which prevents entry of water (a wave) into the deck **12**. Water (sea water) or the like that has entered the deck **12** is discharged to the outside of the vessel from a discharge port formed in the bulwarks. A plank-sheer as a buffer material is attached to outer peripheral surfaces of the bulwarks.

[0055] In addition, the hull body **11** has a chine **116** that is formed in a joined portion between the bottom vessel shell **113** and each of the paired side vessel shells **111**. The chine **116** extends from the bow toward the stern, and is inclined with respect to a horizontal plane such that the chine **116** is located downward to the stern. In addition, the chine **116** has a step that extends along the front-rear direction D**2**, and is configured that the higher a portion on the upper side of the step is located, the more the portion protrudes outward in the right-left direction D**3**. Thus, when seen from the same position in the front-rear direction D**2**, the distance between the paired side vessel shells **111** in the right-left direction D**3** is longer in one step than the distance between upper ends of the bottom vessel shell **113**.

[0056] The hull body **11** includes a fin-shaped skeg **117** (a fin keel) that protrudes from a central portion of the bottom vessel shell **113** in the right-left direction D**3** and extends from the bow toward the stern. The skeg **117** is provided from a front end (an end portion on the bow side) of the bottom vessel shell **113** to an intermediate portion thereof in the front-rear direction D**2**.

[0057] The hull body **11** further includes a plurality of spray strips **119**. In the present embodiment, two each (four in total) of the spray strips **119** are provided in a portion on the port side and a portion on the starboard side of the bottom vessel shell **113**. Each of the spray strips **119** extends from the bow toward the stern, and is inclined with respect to the horizontal plane in a manner to be located downward to the stern.

[0058] In the vessel **10** that is configured as described so far, a lift force is generated by a change in a pressure of a water flow under the vessel bottom during a sail. A portion on the bow side of the vessel **10** is lifted at a sailing trim angle that corresponds to the lift force. The lift force that is generated at this time becomes substantially equal to hull weight when a sailing speed exceeds a predetermined value. Accordingly, when the sailing speed becomes the predetermined sailing speed or higher, the portion on the bow side of the vessel **10** is lifted above water, and the vessel **10** sails in such a posture that the vessel bottom (the lower surface) on the stern side planes on the water surface.

[0059] In addition to the above-described configuration, any of various configurations can be adopted for the hull **1**. For example, an anchor storage for storing an anchor reel, an anchor storage hatch, and the like are appropriately arranged on the bow deck that corresponds to the bow portion of the deck **12**. Furthermore, a live-box, a locker, inspection openings (such as for the rudder device **3** and the propeller **23**), and the like are appropriately arranged on the stern deck that corresponds to the stern portion of the deck **12**. Moreover, the hull body **11** may appropriately have a knuckle line (a spray strip), a hull window, and the like, for example.

[2] Peripheral Structure of Propulsion Device

[0060] Next, a detailed description will be made on a peripheral structure of the propulsion device **2** for the vessel **10** according to the present embodiment with reference to FIGS. **5** to **9**. Since the

propulsion device **2** is arranged in a rear portion of the vessel bottom **5**, a description will hereinafter be made on a detailed structure of the rear portion of the vessel bottom **5**.
[0061] FIG. **5** is an enlarged view of an area Z**1** in FIG. **3**, and FIG. **6** is an enlarged view of the area Z**1** in FIG. **4**. FIG. **7** is a schematic back view of a lower portion of the hull **1** that is seen from behind. FIG. **8** is a cross-sectional view that is taken along line Y**1**-Y**1** in FIG. **6**, and FIG. **9** includes cross-sectional views that are taken along line X**1**-X**1**, line X**2**-X**2**, and line X**3**-X**3** in FIG. **6**, respectively. In FIGS. **5** to **9**, the wheel house **4** is not illustrated, either.
[0062] As described above, the vessel **10** according to the present embodiment is the twin-screw vessel including the paired propulsion devices **2** that are basically configured in common. The peripheral structures of the propulsion devices **2** in the vessel bottom **5** are configured to be (laterally) symmetrical about a centerline in the width direction (the right-left direction D**3**) of the vessel bottom **5**. Thus, the following description will be made on the left propulsion device **2** and the peripheral structure thereof unless otherwise noted, and the right propulsion device **2** and the peripheral structure thereof will not be described.
[0063] As illustrated in FIGS. **5**, **6**, and **7**, a groove section **52** is provided around the propeller **23** in the vessel bottom **5** of the hull **1**, and the groove section **52** is shaped such that a part of the vessel bottom **5** is dented upward. The groove section **52** is long in the front-rear direction D**2**. Due to provision of the groove section **52**, it is possible to avoid interference between the propeller **23** and the vessel bottom **5** while the propeller shaft **22** is arranged as high as possible.
[0064] The groove section **52** is formed from an intermediate portion of the vessel bottom **5** in the front-rear direction D**2** to the stern. That is, the groove section **52** is opened rearward. Here, as an example, the groove section **52** has a rectangular shape that is long in the front-rear direction D**2** in a bottom view (see FIG. **6**).
[0065] In the present embodiment, in the bottom view, a width dimension (a dimension in the right-left direction D**3**) of the groove section **52** is set to be greater than that of the propeller **23** such that the propeller **23** is accommodated in the groove section **52** (see FIG. **6**). In addition, in the back view, the propeller **23** is arranged at a position near the vessel bottom **5** such that at least a part (an upper portion) of the propeller **23** is accommodated in the groove section **52** (see FIG. **7**). Furthermore, the bracket **24** that supports the propeller shaft **22** is fixed into the groove section **52**.
[0066] In detail, in the back view, the groove section **52** has a substantially arcuate shape that is curved along an imaginary circle C**1** (see FIG. **7**).
[0067] The imaginary circle C**1** is drawn when a tip of a blade of the propeller **23** rotates. That is, a cross section that is orthogonal to a longitudinal direction (the front-rear direction D**2**) of a bottom surface of the groove section **52** has a shape (the substantially arcuate shape) along an arc that protrudes upward. In this way, the groove section **52** has a tunnel shape.
[0068] By the way, in the vessel **10** according to the present embodiment, as illustrated in FIGS. **5** and **6**, the shaft hole **51**, which is formed in the vessel bottom **5**, is arranged in the groove section **52**. That is, the shaft hole **51**, which is formed in the vessel bottom **5** and penetrated by the propeller shaft **22**, is located inside the groove section **52** to be accommodated in the groove section **52**.
[0069] In short, the vessel **10** according to the present embodiment includes the hull **1** having the vessel bottom **5**, and the propulsion device **2**. The propulsion device **2** has the propeller **23** that can rotate about the propeller shaft **22** penetrating the shaft hole **51** in the vessel bottom **5**. The propulsion device **2** generates the thrust for sailing the hull **1** by the rotation of the propeller **23**. The hull **1** has the groove section **52**, which is long in the front-rear direction D**2**, around the propeller **23** in the vessel bottom **5**. The shaft hole **51** is arranged in the groove section **52**.
[0070] With this configuration, since the shaft hole **51**, which is formed in the vessel bottom **5**, is arranged in the groove section **52**, which is formed to be partially dented from the vessel bottom **5**. Thus, it is possible to suppress turbulence of the water flow around the shaft hole **51** and the propeller shaft **22**, which protrudes downward from the vessel bottom **5** through the shaft hole **51**.

As a result, the turbulence of the water flow (particularly around the propeller **23**) along the vessel bottom **5** is suppressed, and loss of the thrust caused by the turbulence of the water flow is less likely to occur. Therefore, it is possible to provide the vessel **10** capable of generating the thrust further efficiently.

[0071] Here, in the present embodiment, the groove section **52** is formed from the intermediate portion of the vessel bottom **5** in the front-rear direction D**2** to the stern. The shaft hole **51** is located behind a front end of the groove section **52**. That is, as described above, the groove section **52** is arranged in the rear portion of the vessel bottom **5**, and is opened rearward. Since the shaft hole **51** is arranged in such a groove section **52**, the shaft hole **51** is located behind the front end of the groove section **52** in the front-rear direction D**2**. In other words, the shaft hole **51** is arranged to be accommodated in an area between the front end and a rear end of the groove section **52**.

[0072] With this configuration, the shaft hole **51**, which is formed in the vessel bottom **5**, is located behind the front end of the groove section **52**. Accordingly, in particular, during the forward movement of the hull **1**, the turbulence of the water flow, which occurs due to an influence of the shaft hole **51**, is less likely to occur, and thus the loss of the thrust caused by the turbulence of the water flow is less likely to occur.

[0073] In addition, as illustrated in FIG. **6**, a change amount of the width dimension of the groove section **52** in the front-rear direction D**2** is 10% or less of a maximum value of the width dimension. That is, in a plan view, of an outer peripheral edge of the groove section **52**, two sides along the longitudinal direction (the front-rear direction D**2**) are parallel to each other. Thus, the dimension in the width direction (the right-left direction D**3**) of the groove section **52** is substantially constant over an entire length of the groove section **52** in the front-rear direction D**2**. Further preferably, the change amount of the width dimension of the groove section **52** in the front-rear direction D**2** is 9%, 8%, 7%, 6%, 5%, 4%, 3%, 2%, 1%, or less of the maximum value of the width dimension, and the two sides may be completely parallel to each other.

[0074] In this way, since the dimension in the width direction (the right-left direction D**3**) of the groove section **52** is substantially constant, the turbulence of the water flow through the inside of the groove section **52** along the longitudinal direction (the front-rear direction D**2**) of the groove section **52** is less likely to occur. As a result, the loss of the thrust caused by the turbulence of the water flow is less likely to occur.

[0075] Here, as described above, the vessel **10** according to the present embodiment is the twin-screw vessel that includes the paired propellers **23** arranged side by side in the width direction (the right-left direction D**3**) of the hull **1**. As illustrated in FIG. **7**, the hull **1** has the paired groove sections **52** in a manner to correspond to the paired propellers **23**, respectively. In short, the paired groove sections **52**, each of which is long in the front-rear direction D**2**, are formed in the rear portion of the vessel bottom **5** of the hull **1**. The paired groove sections **52** are symmetrical about the right-left direction D**3**. In each of the groove sections **52**, the shaft hole **51**, which is penetrated by the propeller shaft **22** of the respective propeller **23**, is arranged.

[0076] In this way, even in the twin-screw vessel, the turbulence of the water flow around the shaft hole **51** and the propeller shaft **22**, which protrudes downward from the vessel bottom **5** through the shaft hole **51**, is suppressed. As a result, the turbulence of the water flow (particularly around the propeller **23**) along the vessel bottom **5** is suppressed, and the loss of the thrust caused by the turbulence of the water flow is less likely to occur. Therefore, it is possible to provide the vessel **10** capable of generating the thrust further efficiently.

[0077] Furthermore, in the plan view, in the width direction (the right-left direction D**3**) of the hull **1**, each of the paired shaft holes **51** is located on an outer side of a center P**1** (see FIG. **6**) in the width direction (the right-left direction D**3**) of respective one of the paired groove sections **52**. In short, the shaft hole **51** (and the propeller shaft **22** that penetrates the shaft hole **51**) is not located at the center P**1** in the width direction of the respective groove section **52**, but is arranged at a position that is shifted to the outer side from the center P**1**. More specifically, in the left propulsion device **2**,

the shaft hole **51** and the propeller shaft **22** are located on a left side of the center P**1** in the width direction of the groove section **52**. In the right propulsion device **2**, the shaft hole **51** and the propeller shaft **22** are located on a right side of the center P**1** in the width direction of the groove section **52**.

[0078] In this way, the paired propeller shafts **22** and the paired propellers **23** can be arranged in a well-balanced manner in the width direction (the right-left direction D**3**) of the hull **1**. Thus, the hull **1** can sail further stably when the thrust is generated by the propulsion devices **2**.

[0079] In addition, as illustrated in FIG. **8**, in the side view, the bottom surface of the groove section **52** has a curved shape that protrudes upward. In short, a cross-sectional shape of the bottom surface of the groove section **52** along the front-rear direction D**2** is not a linear shape but the curved shape that protrudes upward. In this way, it is possible to suppress the turbulence of the water flow caused by the propeller **23** and the vessel bottom **5**.

[0080] Furthermore, the shaft hole **51** is arranged in a dent section **53** that is dented from a portion therearound in the bottom surface of the groove section **52**. That is, the bottom surface of the groove section **52** is formed with the dent section **53** that is partially dented, and the shaft hole **51** is arranged in the dent section **53**. More specifically, as illustrated in FIG. **8**, the shaft hole **51** is arranged in a side wall that faces rearward in an inner peripheral surface of the dent section **53**.

[0081] With this configuration, the shaft hole **51**, which is formed in the vessel bottom **5**, is located in the groove section **52**, and further in the dent section **53**. Accordingly, in particular, during the forward movement of the hull **1**, the turbulence of the water flow, which occurs due to the influence of the shaft hole **51**, is less likely to occur, and thus the loss of the thrust caused by the turbulence of the water flow is less likely to occur.

[0082] Furthermore, as illustrated in FIG. **8**, the groove section **52** has a gradual increase section **520** in at least a part of the groove section **52** in the front-rear direction D**2**. The gradual increase section **520** becomes deeper toward the stern. In the present embodiment, the gradual increase section **520** is at least provided from the front end of the groove section **52** to a fixed section of the bracket **24**. That is, at least from the front end of the groove section **52** to the fixed section of the bracket **24**, the groove section **52** is formed to gradually become deeper toward the stern.

[0083] With this configuration, at least in the gradual increase section **520**, the groove section **52** gradually becomes deeper toward the stern. Accordingly, compared to a case where the groove section **52** rapidly becomes deep, in particular, during the forward movement of the hull **1**, the turbulence of the water flow, which occurs due to the influence of the groove section **52**, is less likely to occur, and thus the loss of the thrust caused by the turbulence of the water flow is less likely to occur.

[0084] Here, a cross section that is orthogonal to the bottom surface of the groove section **52** in the front-rear direction D**2** has a shape along an arc that protrudes upward. At least in the gradual increase section **520**, a radius of curvature of the arc becomes larger toward the bow. That is, as illustrated in FIG. **9**, at least in the gradual increase section **520**, radiuses of curvature R**1**, R**2**, R**3** of the cross sections, each of which is orthogonal to the bottom surface of the groove section **52** in the front-rear direction D**2**, become larger toward the bow (R**1**<R**2**<R**3**). In other words, at least in the gradual increase section **520**, the curvatures of the cross sections, each of which is orthogonal to the bottom surface of the groove section **52** in the front-rear direction D**2**, becomes greater (steeper) toward the stern. In the present embodiment, in particular, at the front end of the groove section **52**, the radius of curvature R**3** is extremely large, and the cross section that is orthogonal to the bottom surface of the groove section **52** in the front-rear direction D**2** has a substantially linear shape. That is, in the front end portion of the groove section **52**, the inside and the outside (the front side) of the groove section **52** continue from each other seamlessly in the front-rear direction D**2**.

[0085] With this configuration, at least in the gradual increase section **520**, it is possible to lessen generation of a negative pressure, which is caused by a sudden change in a flow rate within the groove section **52**. Thus, the loss of the thrust caused by the turbulence of the water flow is further

less likely to occur.

[3] Comparison with Comparative Example

[0086] Next, a description will be made on operational effects, which are exerted when the peripheral structure of the propulsion device **2** for the vessel **10** according to the present embodiment is compared to that in a comparative example, with reference to FIGS. **10** to **13**.

[0087] As illustrated in FIGS. **10** and **11**, a vessel **10**A according to the comparative example differs from the vessel **10** according to the present embodiment (described as the "example") in that the shaft hole **51** is arranged outside the groove section **52**. In the vessel **10**A according to the comparative example, the total length (the dimension in the front-rear direction D**2**) of the groove section **52** is shorter than that in the vessel **10** according to the present embodiment, and the shaft hole **51** is located in front of the front end of the groove section **52**.

[0088] FIG. **12** illustrates a simulation result of the water flow under the vessel bottom **5** during the forward sail for each of the vessel **10** according to the present embodiment and the vessel **10**A according to the comparative example. As it is apparent from FIG. **12**, the water flow on a fore side (in front) of the propeller **23** in the vessel **10** according to the present embodiment is a straightened flow that is close to a linear shape. Thus, compared to the vessel **10**A according to the comparative example, the loss of the thrust caused by the turbulence of the water flow is less likely to occur in the vessel **10** according to the present embodiment.

[0089] FIG. **13** illustrates a simulation result of a water pressure around the vessel bottom **5** during the forward sail for each of the vessel **10** according to the present embodiment and the vessel **10**A according to the comparative example. As it is apparent from FIG. **13**, a range where the negative pressure is generated around the propeller shaft **22** is narrow in the vessel **10** according to the present embodiment. Thus, compared to the vessel **10**A according to the comparative example, the loss of the thrust, which occurs due to an influence of the negative pressure, is less likely to occur to the vessel **10** according to the present embodiment.

[4] Modified Examples

[0090] Hereinafter, modified examples of the first embodiment will be listed. The modified examples, which will be described below, can be appropriately combined and implemented.

[0091] The vessel **10** is not limited to the pleasure boat, and may be a commercial vessel such as a cargo ship or a cargo-passenger ship, a work vessel such as a tugboat or a salvage boat, a special vessel such as a meteorological observation vessel or a training ship, a fishing boat, a naval vessel, or the like. Furthermore, the vessel **10** is not limited to the vessel of the manned type that is boarded by the manipulator, and may be a vessel that can be remotely manipulated by the person (the manipulator) or an unmanned vessel that can sail autonomously.

[0092] The power source **21** is not limited to the diesel engine and may include, for example, a gasoline engine and/or a motor (an electric motor). Furthermore, the vessel **10** may include the propulsion device **2** of a hybrid type that has plural types of the power sources **21** including the engine, the motor, and the like, for example. In this case, the power generated by the plural types of the power sources **21** is combined and transmitted to the propeller **23**.

[Supplementary Notes of the Invention]

[0093] Hereinafter, the overview of the invention extracted from the above-described embodiment will be supplementarily described. Configurations and processing functions described in the following supplementary notes can be appropriately selected and combined.

<Supplementary Note **1**>

[0094] A vessel includes: [0095] a hull that has a vessel bottom; and [0096] a propulsion device that has a propeller capable of rotating about a propeller shaft penetrating a shaft hole in the vessel bottom, and generates thrust for sailing the hull by rotation of the propeller, in which [0097] the hull has a groove section in a portion of the vessel bottom around the propeller, the groove section being long in a front-rear direction, and [0098] the shaft hole is arranged in the groove section.

<Supplementary Note **2**>

[0099] The vessel according to Supplementary Note **1**, in which [0100] the groove section is formed from an intermediate portion of the vessel bottom in the front-rear direction to a stern, and [0101] the shaft hole is located behind a front end of the groove section.
<Supplementary Note **3**>
[0102] The vessel according to Supplementary Note **1** or **2**, in which [0103] a change amount of a width dimension of the groove section in the front-rear direction is 10% or less of a maximum value of the width dimension.
<Supplementary Note **4**>
[0104] The vessel according to any one of Supplementary Notes **1** to **3**, in which [0105] a bottom surface of the groove section has a curved shape that protrudes upward in a side view.
<Supplementary Note **5**>
[0106] The vessel according to any one of Supplementary Notes **1** to **4**, in which [0107] the shaft hole is arranged in a dent section that is dented from a portion around the dent section in the bottom surface of the groove section.
<Supplementary Note **6**>
[0108] The vessel according to any one of Supplementary Notes **1** to **5**, in which [0109] the groove section has a gradual increase section in at least a part of the groove section in the front-rear direction, the gradual increase section becoming deeper toward the stern.
<Supplementary Note **7**>
[0110] The vessel according to Supplementary Note **6**, in which [0111] a cross section that is orthogonal to the front-rear direction of the bottom surface of the groove section has a shape along an arc that protrudes upward, and [0112] at least in the gradual increase section, a radius of curvature of the arc becomes larger toward a bow.
<Supplementary Note **8**>
[0113] The vessel according to any one of Supplementary Notes **1** to **7** further includes: [0114] a pair of the propellers arranged side by side in a width direction of the hull, in which [0115] the hull has a pair of the groove sections in a manner to correspond to the pair of the propellers, respectively.
<Supplementary Note **9**>
[0116] The vessel according to Supplementary Note **8**, in which [0117] in the width direction of the hull, each of the paired shaft holes is located on an outer side of a center in a width direction of respective one of the paired groove sections in a plan view.
REFERENCE SIGNS LIST
[0118] **1** Hull [0119] **2** Propulsion device [0120] **5** Vessel bottom [0121] **10**, **10**A Vessel [0122] **22** Propeller shaft [0123] **23** Propeller [0124] **51** Shaft hole [0125] **52** Groove section [0126] **53** Dent section [0127] **520** Gradual increase section [0128] D**2** Front-rear direction [0129] P**1** Center [0130] R**1**, R**2**, R**3** Radius of curvature

Claims

1. A vessel comprising: a hull that has a vessel bottom; and a propulsion device that has a propeller capable of rotating about a propeller shaft penetrating a shaft hole in the vessel bottom, and generates thrust for sailing the hull by rotation of the propeller, wherein the hull has a groove section in a portion of the vessel bottom around the propeller, the groove section being long in a front-rear direction, and the shaft hole is arranged in the groove section.
2. The vessel according to claim 1, wherein the groove section is formed from an intermediate portion of the vessel bottom in the front-rear direction to a stern, and the shaft hole is located behind a front end of the groove section.
3. The vessel according to claim 1, wherein a change amount of a width dimension of the groove section in the front-rear direction is 10% or less of a maximum value of the width dimension.

4. The vessel according to claim 1, wherein a bottom surface of the groove section has a curved shape that protrudes upward in a side view.
5. The vessel according to claim 1, wherein the shaft hole is arranged in a dent section that is dented from a portion around the dent section in a bottom surface of the groove section.
6. The vessel according to claim 1, wherein the groove section has a gradual increase section in at least a part of the groove section in the front-rear direction, the gradual increase section becoming deeper toward the stern.
7. The vessel according to claim 6, wherein a cross section that is orthogonal to the front-rear direction of a bottom surface of the groove section has a shape along an arc that protrudes upward, and at least in the gradual increase section, a radius of curvature of the arc becomes larger toward a bow.
8. The vessel according to claim 1, further comprising: a pair of the propellers arranged side by side in a width direction of the hull, wherein the hull has a pair of the groove sections in a manner to correspond to the pair of the propellers, respectively.
9. The vessel according to claim 8, wherein in the width direction of the hull, each of the paired shaft holes is located on an outer side of a center in a width direction of respective one of the paired groove sections in a plan view.