Compact propeller design with overlapping propellers is more energy efficient at both water and air

With increases in size and speed of ships, the load on a propeller of a single screw vessel increases, and the efficiency of the propeller decreases. In order to increase the propeller efficiency and improve a propulsive performance, a technique of equipping two propellers is known. In the case of equipping two propellers, the load per propeller decreases by half, and the propeller efficiency improves. In this case, it is important to avoid an increase in resistance of a hull as much as possible and not to decrease hull efficiency. Known as conventional technologies capable of realizing these aims are contra-rotating propellers and overlapping propellers.

The overlapping propellers of that document provide a propulsion device formed so that: a pair of right and left propellers are provided such that the centers thereof are respectively located near the centers of right and left bilge vortices; the rotational direction of each propeller is set to a direction opposite the bilge vortex, that is, it is set to outward turning; positions of generator lines of the propellers in the ship length direction are set to be identical with each other or slightly shifted from each other; the propellers are provided close to each other such that rotary surfaces thereof do not overlap each other when viewed in plan view; and the propellers are formed such that rakes thereof incline so as to be away from each other.

Japanese Utility Model Application Publication No. Hei 4-12389 discloses overlapping propellers in which the rotational directions of starboard-side and port-side propellers are the same as each other, so that a rotating flow of a fore propeller is taken advantage of by an aft propeller.

However, in the case of a typical single screw vessel type ship, there exists a very slow fluid flow in the plane of the propeller and near the hull centerline, and the fluid flow increases in speed as it goes farther from the hull centerline. In the case of causing the propeller whose center is not identical with a hull center to rotate, each propeller blade passes through slow flow and fast flow alternately during one rotation. Therefore, the load on the propeller blade significantly fluctuates, and the bearing force becomes excessively large compared to the single screw vessel.

Moreover, since the propeller blade passes through the very slow flow in the vicinity of the hull centerline, cavitations is generated in a wide range on the propeller blade of ordinary design, thereby causing erosion of the surface of the propeller.

Means for Solving the Problems

Objects of the present invention are to reduce the bearing force and the generation of the cavitation of the propeller by, for example, sharpening a waterline shape of the stem in the plane of the propeller, providing a bracket fin, and providing a wake improved fin in a ship including a single screw vessel type stem equipped with overlapping propellers.

In order to solve the above problems, in a stern structure of a ship of the present invention, the ship comprises a single screw vessel type stem equipped with a propulsion device (hereinafter referred to as "overlapping propellers") formed so that: a pair of right and left propellers are disposed such that the propeller shaft centers thereof are respectively located near the centers of right and left bilge vortices; the rotational direction of at least one of the propellers is set to a direction opposite the bilge vortex, that is, it is set to outward turning; the propellers are provided close to each other such that the rotary surfaces thereof do not overlap each other when viewed in plan view; and the propellers are formed such that the rakes thereof incline so as to be away from each other, characterized in that a waterline shape of the stem in an area of at least 0.4R (R denotes a propeller radius) in a vertical direction from the propeller shaft center is sharpened such that: an inclination angle of an aft end portion of the waterline is 15 degrees or smaller with respect to the hull centerline; and a virtual width of the aft end position is 600 mm or smaller when the waterline shape is extended to the sharp end.

In accordance with the above construction, in the ship comprising a single screw vessel type stem equipped with overlapping propellers, the stem in the area of at least 0.4R (R denotes the propeller radius) in the vertical direction from the propeller shaft center can be sharpened toward a stem direction. With this, the fluid flow in the plane of the propeller is increased in speed, and the inflow speed of fluid flowing to the propeller blade during one rotation of the propeller is equalized, thus decreasing the bearing force. Furthermore, the fluid flow in the vicinity of the hull centerline increases in speed, so that the generation of cavitations on the propeller blade is suppressed.

The reason why the stem in the area of at least 0.4R (R denotes the propeller radius) in the vertical direction from the propeller shaft center is sharpened is because in this region, there exists a low flow rate region which becomes problematic when the overlapping propellers pass through the vicinity of the hull centerline. Moreover, although depending on the balance with the propulsive efficiency, it is preferable that the stem in the area of 0.6R in the vertical direction from the propeller shaft center be sharpened to reduce the cavitation and the bearing force. Moreover, the inclination angle of the aft end portion of the waterline is set to 15 degrees or smaller, because the flow behind the hull slows due to separation, etc. when the inclination angle exceeds 15 degrees.

Moreover, in a ship comprising a single screw vessel type stern equipped with overlapping propellers, a stem structure of the ship is such that a bracket fin is provided to fill in a space between the hull and each of stem tubes into which propeller shafts protruding from a starboard side and a port side of the stem portion located forward of an aft end are respectively inserted.

To be specific, in the stem tubes into which the propeller shafts of the overlapping propellers are respectively inserted, the propeller shafts project from the starboard side and the port side of the stern portion located forward of the aft end, and the bracket fin is provided to fill the space between the stem tube and the hull in the ship length direction, so that the bracket fin stops a separation vortex generated from the bottom of the hull to weaken the vortex. Thus, the rotational component of the inflow flowing to the propeller plane in the vicinity of the hull centerline decreases. As a result, since the inflow rate of fluid toward the propeller rotational direction decreases in the vicinity of the hull centerline where the cavitations tends to be generated, the observation of the cavitations (the beginning of the generation of the cavitation) is suppressed.

Meanwhile, the bearing force is generated due to no uniformity between comparatively high propeller hydrodynamic force (thrust) generated at the propeller blade passing through the slow flow in the vicinity of the hull centerline and comparatively low thrust generated at the propeller blade passing through the fast flow outside the hull. By providing the bracket fin, the rotational component of the inflow flowing to the propeller plane in the vicinity of the hull centerline decreases, and the thrust generated at the propeller blade passing through the vicinity of the hull centerline decreases. As a result, hydrodynamic forces of respective propeller blades applied to the propeller shaft are equalized, thereby reducing the bearing force. In addition, weakening the stem separation vortex brings an effect of reducing the viscous drag of the hull.

Moreover, in a ship comprising a single screw vessel type stern equipped with overlapping propellers, a stem structure of the ship is such that a wake improved fin for improving a wake distribution which is accelerated by a rotation of a fore propeller and flows into an aft propeller is provided at the stem portion above the propeller shaft so as to extend toward a portion where the amount of change of flow rate of the wake is large or a region where the fore propeller and the aft propeller overlap each other when they rotate.

In accordance with the above construction, the wake distribution, which is accelerated by the rotation of the fore propeller and flows into the aft propeller, can be improved by the wake improved fin provided at the stem portion located forward of the fore propeller. In other words, the wake improved fin decreases the drastic change in speed of the wake, that is, the wake improved fin can change the wake distribution into a flow field such that the degree of increase in speed of the wake is reduced, and its speed gradient is eased. As a result, the bearing force can be decreased, and the generation of the cavitation can be suppressed.

The wake distribution varies even in the case of using the same single screw vessel type. In the case of using a conventional single screw vessel type OLP, it is preferable that the wake improved fins are provided so as to extend toward a portion where the amount of change in the flow speed of the wake is large in a region where the fore propeller and the aft propeller overlap each other, along the hull, and symmetrically. Depending on the wake distribution, the starboard-side wake improved fin and the port-side wake improved fin may be provided at different levels in height, or the wake improved fin may be provided only on one side.

Further, in a ship comprising a single screw vessel type stem equipped with overlapping propellers, a stem structure of the ship is such that: a waterline shape of the stem in an area of at least 0.4R (R denotes a propeller radius) in a vertical direction from a propeller shaft center is sharpened such that: an inclination angle of an aft end portion of the waterline is 15 degrees or smaller with respect to a hull centerline; and a virtual width of an aft end tip position is 600 mm or smaller when the waterline shape is extended to the aft end; and a bracket fin is provided to fill a space between the hull and each of stem tubes into which propeller shafts projecting from the starboard side and the port side of the stern portion located forward of an aft end are respectively inserted.

In accordance with the above construction, by sharpening the waterline shape in a certain vertical area in the vicinity of the height of the propeller shaft center, the fluid flow in the plane of the propeller is increased, and the inflow speed of fluid flowing to the propeller blade during one rotation of the propeller is equalised. In addition, by providing the bracket fin, the rotational component of the flow flowing to the propeller plane in the vicinity of the hull centerline decreases, thereby reducing the thrust generated at the propeller blade passing through the vicinity of the hull centerline. The combination of these effects equalises the hydrodynamic forces of respective propeller blades which are applied to the propeller shaft, thereby being able to further reduce the bearing force.

Further, by increasing the speed of the fluid flow in the vicinity of the hull centerline, the observation of the cavitations of the propeller blade is suppressed. In addition, since the inflow speed of fluid toward the propeller rotational direction decreases in the vicinity of the hull centerline where the cavitations tends to be generated, the observation of the cavitation is further suppressed. Further, since the flow of the stem is also smoothened, an effect of reducing the viscous drag of the hull can be obtained.

Moreover, in a ship comprising a single screw vessel type stern equipped with overlapping propellers, a stem structure of the ship is such that: a waterline shape of the stem in an area of at least 0.4R (R denotes a propeller radius) in a vertical direction from a propeller shaft center is sharpened such that: an inclination angle of an aft end portion of the waterline is 15 degrees or smaller with respect to the hull centerline; and a virtual width of an aft end position is 600 mm or smaller when the waterline shape is extended to the aft end; and a wake improved fin for improving a wake distribution which is accelerated by a rotation of a fore propeller and flows into an aft propeller is provided on the hull above a propeller shaft so as to extend toward a portion where the amount of change of flow rate of the wake is large.

In accordance with the above construction, since the effect obtained by sharpening the hull and the effect obtained by the wake improved fin are synergistically exerted, the effects of further reducing the bearing force and suppressing the generation of the cavitation can be obtained.

Moreover, in a ship comprising a single screw vessel type stern equipped with overlapping propellers, a stem structure of the ship is such that: a bracket fin is provided to fill in a space between the hull and each of stem tubes into which propeller shafts projecting from a starboard side and a port side of the stem portion located forward of an aft end are respectively inserted; and a wake improved fin for improving a wake distribution which is accelerated by the rotation of a fore propeller and flows into an aft propeller is provided at the stem portion above the propeller shaft so as to extend toward a portion where the amount of change of flow rate of the wake is large or a region where the fore propeller and the aft propeller overlap each other when they rotate.

In accordance with the above construction, since the effect obtained by the bracket fin and the effect obtained by the wake improved fin are synergistically exerted, the effects of further reducing the bearing force and suppressing the generation of the cavitations can be obtained.

Moreover, in a ship comprising a single screw vessel type stern equipped with overlapping propellers, a stem structure of the ship is such that: a waterline shape of the stem in an area of at least 0.4R (R denotes a propeller radius) in a vertical direction from a propeller shaft center is sharpened such that an inclination angle of an aft end portion of the waterline is 15 degrees or smaller with respect to a hull centerline, and a virtual width of an aft end position is 600 mm or smaller when the waterline shape is extended to the aft end; a bracket fin is provided in a space between the hull and each of stem tubes into which propeller shafts projecting from a starboard side and a port side of the stem portion located forward of an aft end are respectively inserted; and a wake improved fin for improving a wake distribution which is accelerated by a rotation of a fore propeller and flows into an aft propeller is provided above the propeller shaft and at the stern portion so as to extend toward a portion where the amount of change of flow rate of the wake is large or a region where the fore propeller and the aft propeller overlap each other when they rotate.

In accordance with the above construction, since three effects obtained by sharpening of the hull, the bracket fin and the wake improved fin are synergistically exerted, the effects of further reducing the bearing force and suppressing the generation of the cavitations can be obtained.

Moreover, in the above-described stem structure, when the bracket fin is provided within a range of an outer diameter of the stem tube and has a linear shape or a curved shape extending gradually upward or downward from a base end portion of the bracket fin toward a stern direction, the flow speed of the rotating flow flowing into the propeller is adjustable. To be specific, when the bracket fin is provided so as to extend upward toward the aft end, the flow speed of the rotating flow in the rotational direction decreases, so that the effects of suppressing the cavitations and reducing the bearing force are further improved. Meanwhile, when the bracket fin is provided so as to extend downward toward the aft end, the flow speed in the rotational direction increases, so that the propulsive efficiency is further improved.

Moreover, in the above-described stem structure, when the bracket fin is provided so as to extend linearly from the insert portion of the stem tube toward an aft direction, and has, in a vicinity of an aft end portion thereof and within a range of an outer diameter of the stem tube, a linear shape or a curved shape extending gradually upward or downward toward a stem direction, the same effects as above can be obtained.

Moreover, in the above-described stern structure, when the rotational direction of the fore propeller located on a fore side is set to a direction opposite the bilge vortex, that is, it is set to outward turning, and the rotational direction of the aft propeller located on a stem side is set to be identical with that of the fore propeller, that is, it is set to inward turning, the fore propeller tries to take the bilge vortex rotating flow, while the rotating flow generated by the rotation of the fore propeller is collected by the aft propeller located on the stem side.

Effects of the Invention

In accordance with the present invention, even in the case of using the overlapping propellers, the bearing force can be made equal to or smaller than that of the single screw vessel, and the generation of harmful cavitations can be suppressed effectively.

Moreover, by providing a bracket fin to fill a space between a stem tube into which a propeller shaft is inserted and a hull, the reduction in the bearing force and the suppression of the generation of the cavitation can be achieved, and a hull resistance can also be reduced by a maximum of about 2%.

Moreover, by providing a wake improved fin, the reduction in the bearing force and the suppression of the generation of the cavitations can be achieved.

Moreover, by mutually combining sharpening of the hull, the bracket fin and the wake improved fin, their respective operational effects are synergistically exerted, and the further reduction in the bearing force and the further suppression of the generation of the cavitations can be achieved.