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TITLE OF INVENTION
HIGH-SPEED LATERAL-STABILITY HULL CONSTRUCTION

BACKGROUND OF THE INVENTION:

Field of the Invention:

The present invention relates to a high-speed lateral-stability hull construction provided with reaction flaps extending along side platings from a bow towards a stern.

Description of the Prior Art:

As a transom type high-speed ship consisting of a single hull in the prior art, a chine type high-speed ship and a round bilge type high-speed ship have been known. The former type of high-speed ship is shown in Figs. 15 to 17, and the latter type high-speed ship is shown in Figs. 18 to 19. Among these figures, Fig. 15 is a side view, Fig. 16 is a transverse cross-section view taken along line B-B in Fig. 15, Fig. 17 is another transverse cross-section view taken along line C-C in Fig. 15, Fig. 18 is a side view, Fig. 19 is a transverse cross-section view taken along line B-B in Fig. 18, and Fig. 20 is another transverse cross-section view taken along line C-C in Fig. 18.

In these respective figures, reference numeral 1 designates a still water level, numeral 2 designates a wave creeping up along a hull surface or a spray, which arises

from a bow upon navigation, numeral 3 designates a wave at a stern transom, numeral 4 designates a traveling direction of the ship, numeral 5 designates an upper deck, numeral 6 designates a bottom keel, numeral 7 designates a chine, and numeral 8 designates a round bilge.

In the heretofore known single-hull transom type high-speed ship, as a counter-measure against the wave creeping up along a hull surface or a spray 2, which arises from a bow at the time of high-speed navigation, it was a common practice to employ a chine type which forms a bilge portion in a squarish shape as shown in Figs. 15, 16 and 17, or in the case of employing a round bilge type as shown in Figs. 18, 19 and 20, to form the hull in a slender shape having a large length-to-width ratio or to add a very small-sized reaction flap, that is, a spray strip for the purpose of preventing a spray 2 from creeping up.

It has been well known that generally in the case where a ship tries to realize a high speed exceeding a certain speed, depending upon a ship type it is difficult by merely increasing power, but it is necessary to employ a ship type capable of overcoming a last hump of a wave making resistance, and in general, a ship type having a transom and taking a sliding performance in a high-speed region into consideration, is suitable.

Even in such case, in order to reduce a

resistance and to realize a higher speed, it is attempted to reduce a wave making resistance even a little by employing a slender ship type having a large length-to-width ratio. However, in this case, if a ship type having a length-to-width ratio exceeding a certain fixed value is employed and the speed becomes higher than a certain speed, then the ship loses lateral stability resulting in lateral inclination, that is, heel, moreover directional stability is also lost, and safe high-speed navigation becomes impossible.

This phenomenon implies that even if a ship has a sufficient stability at the time of a stationary state, unless it has a stability higher than a certain range, it has a tendency of increasing an instability at a high speed, and this has become clarified to a certain extent as a result of research in recent years.

In summary, in the case of the heretofore known ship type, in order to realize stable navigation at a high speed, in the event that a length-to-width ratio is smaller than a certain value and a stability at the time of a stationary state is not sufficiently large, at a speed higher than a certain value the speed cannot be increased due to occurrence of a lateral unstable phenomenon.

SUMMARY OF THE INVENTION:

It is therefore one object of the present invention to provide a high-speed lateral-stability hull construction, which is a transom type hull consisting of a single hull regardless of whether it is of chine type or of round bilge type, and which has a small wave making resistance, and moreover, is excellent in lateral stability.

Another object of the present invention is to provide a high-speed lateral-stability hull construction provided with reaction flaps formed so as to give a restoring force against large-amplitude rolling.

Still another object of the present invention is to provide a transom type hull structure provided with efficient reaction flaps having particular shape and structure at particular positions on side platings, which has a large restoring force against rolling and is excellent in high-speed lateral stability.

According to one feature of the present invention, in a transom type hull consisting of a single hull and provided with reaction flaps extending along both side platings nearly from a bow towards a stern, for the purpose of achieving the aforementioned object, as the aforementioned reaction flap, a reaction flap having the following construction is employed.

That is, the reaction flap employed in the hull according to the present invention has a length equal to at least about 10% of a ship length, is provided in the rear of a fore perpendicular of the hull, and also in front of a shoulder of the hull, extends with a rising gradient towards a bow on a side plating, and furthermore, an inner surface formed in cooperation with the side plating is curved in a parabolic shape so that water flow therein may flow smoothly, and has an upset-U-shaped cross-section having a deepest depth of 100 mm or more.

It is to be noted that throughout the specification and claims of this application, the term "shoulder of a hull" means the position of a side plating where a ship width becomes maximum.

In the reaction flap employed according to the present invention, preferably an inclination angle of the inner surface at its bottom portion is chosen to be outward 45° or less so that a vector component contributing to lateral stability of the hull may be increased by these reaction flaps.

Also, in the rear of the shoulder of the hull, these reaction flaps could be formed so as to have a fixed depth along the lengthwise direction.

Still further, it is desirable that in the rear of the above-mentioned shoulder, these reaction flaps are

provided along a chine as directed downwards from the chine so that the provision of the reaction flaps may not reduce a submerged volume of the hull, nor the reaction flaps may not project laterally from the hull resulting in increase of a ship width.

In addition, a modified construction can be employed, in which the reaction flaps are provided only from the fore perpendicular of the hull over the shoulder of the hull and thereby lateral stability of the hull is effectively obtained.

Furthermore, another modified construction can be employed, in which the upset-U-shaped cross-section formed by the reaction flap and the side plating may be gradually reduced in depth, and thereby in view of a resistance performance an effective reaction flap can be obtained.

Moreover, according to the present invention, it is also effective that the reaction flaps are provided above the water line when the hull is stationary so that a propelling resistance may not be increased even at the time of low-speed navigation.

Also, according to the present invention, the length of the reaction flaps is limited to 10 - 30% of the length of the hull, and thereby a hull construction having high-speed lateral-stability which is practically effective, can be provided.

In general, as a ship navigates at a high speed, a wave would creep up along a hull surface from the portion of a bow, and sooner or later it would fall due to gravity. Such wave produced by a hull is generally called "spray" with respect to a wave forming a thin water film.

However, with the hull construction according to the present invention, owing to the fact that reaction flaps extending along side platings from a bow towards a stern and forming an upset-U-shaped cross-section between their inner surfaces and the side platings are provided, the wave or spray rising and falling along the inner surfaces of the reaction flaps would not be discharged outwards directly, but it would once collides against the recess at the top of the upset-U-shaped cross-section of the hull and then would make U-turn in the obliquely downward and outward direction, and consequently, an upward reaction force vector is produced due to a dynamic pressure caused by the collision and a spouting force directed in the downward and outward direction. Since the reaction force vector component acts as a restoring force, lateral stability at the time of high-speed navigation is improved.

More particularly, if a hull tilts laterally, then since the reaction force produced by the reaction flap provided on the ship side of the tilted side becomes larger than the reaction force produced by the other reaction

flap, a moment tending to restore the ship hull would be produced.

The above-mentioned and other objects, features and advantages of the present invention will become more apparent by reference to the following description of preferred embodiments of the invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS:

In the accompanying drawings:

Figs. 1 to 3 illustrate high-speed lateral-stability hull construction according to a first preferred embodiment of the present invention, Fig. 1 being a side view, Fig. 2 being a transverse cross-section view taken along line B-B in Fig. 1, and Fig. 3 being another transverse cross-section view taken along line C-C in Fig. 1;

Figs. 4 to 6 illustrate a high-speed lateral-stability hull construction according to a second preferred embodiment of the present invention, Fig. 4 being a side view, Fig. 5 being a transverse cross-section view taken along line B-B in Fig. 4, and Fig. 6 being another transverse cross-section view taken along line C-C in Fig. 4;

Figs. 7 to 10 illustrate test results with

respect to a hull construction according to the present invention, Fig. 7 being a side view of a test model ship, Fig. 8 being a diagram of tank test results showing a relation between a ship velocity and a heel angle, Fig. 9 being a transverse cross-section view of a right half of the model ship in Fig. 7, and Fig. 10 being an enlarged partial cross-section view of the part provided with a reaction flap in Fig. 9;

Figs. 11 and 12 illustrate a high-speed lateral-stability hull construction according to a third preferred embodiment of the present invention, Fig. 11 being a side view, and Fig. 12 being a transverse cross-section view taken along line B-B in Fig. 11;

Figs. 13 and 14 illustrate a high-speed lateral-stability hull construction according to a fourth preferred embodiment of the present invention, Fig. 13 being a side view, and Fig. 14 being enlarged partial cross-section views taken respectively along lines A-A, B-B, C-C and D-D in Fig. 13;

Figs. 15 to 17 illustrate a chine type high-speed ship in the prior art, Fig. 15 being a side view, Fig. 16 being a transverse cross-section view taken along line B-B in Fig. 15, and Fig. 17 being another transverse cross-section view taken along line C-C in Fig. 15; and

Figs. 18 to 20 illustrate a round bilge type

high-speed ship in the prior art, Fig. 18 being a side view, Fig. 19 being a transverse cross-section view taken along line B-B in Fig. 18, and Fig. 20 being another transverse cross-section view taken along line C-C in Fig. 18.

DESCRIPTION OF THE PREFERRED EMBODIMENTS:

Now, the present invention will be described in greater detail in connection to the first to fourth preferred embodiments of the present invention illustrated in the accompanying drawings. Throughout the drawings, reference numeral 1 designates a water level at the time of stationary state, numeral 2 designates a wave creeping up along the hull surface or a spray, which arises from a bow at the time of navigation, numeral 3 designates a wave arising at a stern transom, numeral 4 designates a traveling direction, numeral 5 designates an upper deck, numeral 6 designates a bottom keel, and numeral 9 designates reaction flaps forming upset-U-shaped cross-sections between side platings and them.

At first, description will be made on a first preferred embodiment of the present invention illustrated in Figs. 1 to 3. In the illustrated hull construction, a maximum width portion exists in the proximity of a stern end, and reaction flaps 9 are provided in the rear of

a fore perpendicular along the both side platings of a freeboard above a draught line 1 at the time of stationary state, and extend from a bow towards a stern with a lowering gradient. The length of the reaction flaps 9 is chosen to be $1/3 - 1/2$ or more of a ship length and the depth d of the deepest portion is chosen to be 300 mm or more.

A cross-section configuration of the portions formed by the side platings and the reaction flaps 9 is a flared upset-U-shape. Also, the inside recess 10 formed by the reaction flap in cooperation with the side plating has an upset-U-shaped cross-section curved in a parabolic shape so that water flow therethrough may flow smoothly. It is to be noted that an inclination angle α of the inner surface of the lower end portion of the reaction flap 9 should be chosen to be at least outward 45 degrees or less for the purpose of increasing a downward reaction force vector component 11 contributing to lateral stability.

In this connection, while a long member extending from the proximity of the fore perpendicular up to the stern end is used as the reaction flap 9 in the above-described first preferred embodiment, in practical use, the reaction flap 9 is effective if its length is about 20% of a ship length and the depth d of the deepest portion is 100 mm or more as illustrated in the third and fourth

preferred embodiments which will be described later.

With such hull construction, since a wave creeping up along a hull surface from a bow portion at the time of high-speed navigation or spray 2 is not in itself repelled and splashed far externally of the hull, as shown in Fig. 2 there exists an advantage that a reaction force vector component 11 greatly contributing to lateral stability can be utilized as a lateral stabilizing force vector.

In this connection, although a vector 12 contributing to lateral stability as shown in Fig. 16 was generated by a rectangular chine or a spray strip for suppressing a spray even in the prior art, the magnitude was small and the effect was insufficient.

Therefore, as shown in Fig. 2, the recess 10 formed cooperatively by the reaction flap 9 and the side plating of the hull has a maximum width B of the opening at its lower end portion, and the recess 10 has a smooth inner surface whose cross-section has a parabolic shape with its width narrowed gradually towards the top. And a wave or a spray rising and falling along this inner surface is not directly discharged to the outside of the hull, but it once collides against a recess at the top of the upset-U-shaped cross-section of the hull and makes U-turn obliquely downwards and outwards, and consequently, an upward

reaction force vector 11 caused by a dynamic pressure due to the collision and a spouting force directed in the downward and outward direction, is generated. It is important that a reaction force vector 11 is utilized as a restoring force. Therefore, the reaction flaps 9 form a rigid construction.

Next, a second preferred embodiment of the present invention will be described with reference to Figs. 4 to 6. It is to be noted that the hull construction according to the first preferred embodiment is formed by adding reaction flaps 9 to a hull construction, and hence it is effective for reconstruction of an existing ship, whereas the hull construction according to the second preferred embodiment is formed by incorporating reaction flaps as a part of the hull construction from the time of initial building of the hull construction. By the way, with regard to ships of the same scale, for both the first and second preferred embodiments, a configuration and a displacement under the water level are nearly the same.

In the hull construction shown in Figs. 4 to 6, reaction flaps 9 directed downwards are provided above a draught line 1 at the time of a stationary state in the proximity of a chine as extending from the neighborhood of a maximum width portion (in a conventional ship type, positioned in front of a 50% point of a ship length).

The inventor of this invention conducted a tank test with respect to influences of the length of the reaction flaps 9 upon stability of a heel angle of a hull at the time of high-speed navigation, and the following items were clarified.

That is, when the tests were conducted with respect to an A type ship having reaction flaps 9 additionally provided only in a bow portion extending over about $1/5$ of a ship length, and a B type ship having reaction flaps 9 extended to about $4/5$ of a ship length as shown in Fig. 7, and a ship of heretofore known type, it was proved that as shown in the diagram in Fig. 8, while a heel angle ϕ increased if the ship velocity V_s exceeded 30 kt in the case of the heretofore known type of ship (marked ○) not provided with reaction flaps 9, in the case of the B type ship (marked ●) increase of a heel angle ϕ became remarkable if the ship velocity V_s exceeded 40 kt, and in the case of the A type ship (marked ☆) gradual increase of a heel angle ϕ commenced if the ship velocity V_s exceeded about 45 kt.

It is to be noted that the reaction flaps 9 of the B type ship are submerged under a water level from the neighborhood of the maximum width portion (in a conventional ship type, positioned in front of a 50% point of a ship length) at the time of a stationary state.

Thereby it has been clarified that if the reaction flaps 9 are provided only in a bow portion above a draught line 1 at the time of a stationary state as is the case with the A type ship, and also if their length is chosen to be about 1/5 of a ship length (a length of about 10% - 30%) and their depth d is chosen to be $d \geq 100$ mm, then a further good result can be obtained. In addition, since the reaction flaps 9 are provided above the draught line at the time of a stationary state, even upon navigation, a propelling resistance would not be increased.

On the basis of these test results, it can be said to be most effective and economical that the positions of the reaction flaps are chosen in the region above a draught line 1 of a bow portion, in the rear of a fore perpendicular and in front of a shoulder, that is, a maximum ship-width position (in other words, only in the portion where a spray 2 arises largely in Fig. 15).

By the way, the above-described tests were conducted with respect to a model ship having a length of 3.8 m and a width of 0.63 m on a reduced scale of one to 12.3, the ship velocity V_s of 30 kt corresponds to 4.4 m/s (Froude number 0.7) in the test, and the ship velocity V_s of 40 kt corresponds to 5.9 m/s (Froude number 1.0). The "Froude number" is defined by $F = V/\sqrt{G \cdot L}$, where G : 9.8 m/s^2 , L : ship length (m) and V : ship velocity (m/s).

Next, description will be made on a second preferred embodiment of the present invention shown in Figs. 11 and 12 which has been proposed on the basis of the above-mentioned test results. As shown in the side view in Fig. 11 and the transverse cross-section view in Fig. 12, the reaction flaps 9 in the bow portion of the third preferred embodiment have their depths $\underline{d}$ reduced successively towards its rear end as compared to their central portion. This is because with respect to the rear portion, the effects of the reaction flaps cannot be expected so much since the height of the wave creeping up is low and if they are kept deep, they would result in increase of a resistance. In addition, a length of the reaction flaps 9 is chosen to be about 10% - 30% of a ship length, a depth at the deepest portion is chosen to be about 100 mm or more, and an inclination angle α of the inner surface of the lower end portion is selected to be outward 45 degrees or less. With such construction, since the reaction flaps 9 are positioned always above the draught line 1, a propelling resistance can be reduced.

Furthermore, description will be made on a fourth preferred embodiment of the present invention illustrated in Figs. 13 and 14. As shown in a side view in Fig. 13 and a transverse cross-section view in Fig. 14, reaction flaps 9 in the bow portion of the fourth preferred embodiment

have their depth $\underline{d}$ successively reduced towards their front end and towards their rear end as compared to their central portion.

More particularly, because of the fact that in the neighborhood of the front portion of the bow reaction flaps 9, there is no need to increase a depth of the reaction flaps because the reaction flaps are too high for a wave to creep up or because the position is too close to the fore perpendicular and hence is displaced from the point where a wave creeps up, in addition to the feature of the third preferred embodiment, with respect to the front portion also, a depth of the reaction flaps 9 is reduced. It is to be noted that like the third preferred embodiment, a length of the reaction flaps 9 is chosen to be about 10% - 30% of a ship length, a depth at the deepest portion is chosen to be about 100 mm or more, and an inclination angle α of the inner surface of their lower end portion is chosen to be outward 45 degrees or less. With such construction, a height of the bow reaction flaps 9 is determined depending upon a magnitude of a spray 2, hence a raw material cost can be minimized, and in the case where the reaction flaps are provided integrally as a part of a hull construction as is the case with the second preferred embodiment, the fourth preferred embodiment is especially effective.

If the high-speed lateral-stability hull constructions according to the above-described respective preferred embodiments are employed, there is an advantage that a high speed can be realized up to the speed region where problems occurred in lateral stability in the case of a heretofore known ship type, or even in the case of the same speed region, a length-to-width ratio can be chosen so as to be more slender, and hence it is possible to reduce a resistance. Furthermore, even in the case of the same speed region and the same length-to-width ratio, it becomes possible to realize an arrangement in which a lateral restoring performance is reduced, that is, a center of gravity is raised.

In addition, in the hull construction according to the above-described respective preferred embodiments, only the advantage of improving lateral stability in a high-speed region is aimed at, as the ship type used for a base (the portion lower than the draught line 1) a heretofore known type can be employed, and so, increase of a resistance in the medium and low speed regions caused by addition of the reaction flaps 9 would not occur.

Furthermore, even with respect to a ship type for which lateral instability occurred if the ship speed exceeds a certain speed region in the prior art, and even with respect to a ship type for which it was impossible to

raise a center of gravity in the arrangement because of the fact even if the ship has a sufficient stability at the time of a stationary state, it would become unstable at the time of high-speed navigation, the performance can be improved by additionally providing reaction flaps 9.

Also, in the high-speed lateral-stability hull constructions disclosed in the first and second preferred embodiments, since the hull constructions have transverse cross-section configurations shown in Figs. 2, 3, 5 and 6, in the event that rolling has occurred, a great restoring force against rolling can be expected by making use of the fact that the reaction flaps 9 are submerged in the water and serve to produce a rolling resistance.

While the first and second preferred embodiments were disclosed for the case where the scope of application of the hanging of the recessed portion of reaction flaps 9 was chosen to be a long region extending from a position near to a bow up to a stern end, in practice, even if it is applied only to the bow portion, provided that its length is about $1/5$ times a ship length (a length of about 10% - 30%) similarly to the third and fourth preferred embodiments, a practical advantage is large.

If the last-mentioned construction is employed, in addition to the fact that substantially similar effects and advantages to the first and second preferred

embodiments can be achieved, since protruded portions such as bilge keels, spray strips and fin stabilizers are not present on the ship side portions, inconveniences would not occur in the case of approaching to a shore or approaching to a broadside.

As described in detail above, according to the present invention, there is provided a high-speed lateral-stability hull construction which is a transom type hull consisting of a single body regardless of whether it is of chine type or of round bilge type, has a small wave making resistance and yet is excellent in lateral stability, and especially which is excellent in lateral stability even in the case of a Froude number of 0.7 or less, and therefore, the present invention is industrially extremely useful.

While the present invention has been described in detail above in connection to the illustrated embodiments, it is a matter of course that the present invention should not be limited only to these embodiments but many changes and modification could be made to a configuration and a construction thereof without departing from the scope of the invention as defined in the appended claims.



WHAT IS CLAIMED IS:

1. A high-speed lateral-stability hull of single-body transom type provided with reaction flaps extending along both side platings nearly from a bow towards a stern; characterized in that said reaction flaps (9) have a length equal to at least about 10% of a ship length and are provided in the rear of a fore perpendicular of the hull, and in front of a shoulder of the hull, the reaction flaps (9) extend with a rising gradient towards a bow on the side platings, and an inner surface formed by the reaction flap (9) in cooperation with the side plating curves in a parabolic shape so that a water flow therein may flow smoothly and has an upset-U-shaped cross-section whose depth (d) at the deepest portion is 100 mm or more.

2. A high-speed lateral-stability hull as claimed in Claim 1, characterized in that an inclination angle of the inner surface of the lower end portion of said reaction flap (9) is chosen to be 45° or less.

3. A high-speed lateral-stability hull as claimed in Claim 1 or 2, characterized in that said upset-U-shaped cross-section has a nearly constant depth along the lengthwise direction in the rear of said shoulder.

4. A high-speed lateral-stability hull as claimed in Claim 3, characterized in that in the rear of said shoulder, said reaction flaps (9) are provided in



the neighborhood of a chine as directed downwards.

5. A high-speed lateral-stability hull as claimed in Claim 2, characterized in that said reaction flap (9) are provided only in the region extending from a fore perpendicular of the hull to said shoulder.

6. A high-speed lateral-stability hull as claimed in Claim 5, characterized in that said upset-U-shaped cross-section has its depth gradually reduced towards the rear.

7. A high-speed lateral-stability hull as claimed in Claim 6, characterized in that said reaction flaps (9) are provided above a draught line at the time of a stationary state of a hull.

8. A high-speed lateral-stability hull as claimed in Claim 7, characterized in that a length of said reaction flaps (9) is chosen to be about 10 - 30% of a length of the hull.