

An Apparatus, and Method of Reducing Bow Wave Losses of Marine Vessels at any Drafts, Trims and Speeds.

Background and Field of the Invention

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The invention relates to an apparatus and method of reducing bow wave losses of marine vessel at any drafts, trims and speeds.

10 The bow 102 of many marine vessels are designed with a bulbous bow 101 as illustrated in Figure 1. Bow waves 104 are generated at the bow of marine vessels. The wave length 107 and wave height 108 of the bow waves of a particular marine vessel at particular draft and trim depend primarily on the speed 111 of the vessel. The purpose of the bulbous bow is to produce anti-bow waves 103 which are of same wave length 107 and wave height 108 as the bow waves, ahead of the bow waves 104. The
15 bulbous bow is designed so that the anti-bow waves 103 from the bulbous bow are exactly out of phase to the bow waves 104 at the designed vessel speed 111 for the particular bow at specified draft and trim. When the anti-bow waves 103 are superimposed on the bow waves 104, the anti-bow waves will cancel out the bow waves resulting in no or minimum resultant waves 105 as illustrated in Figure 1. As
20 waves generated by a marine vessel are not converted to useful propulsion energy, they are energy losses. Reducing bow waves from a marine vessel, therefore, reduces the energy losses of the vessel and improves the energy efficiency of the vessel.

25 As the wave length 107 and wave height 108 of the bow waves 104 of a marine vessel with a particular bow and at specific draft and trim depend on primarily the speed 111 of the vessel, it is obvious to those who are skilled in marine technology that the optimum bulb length 110 of the bulbous bow 101 that enables the vessel to achieve the minimum bow wave losses, depends on the speed of the vessel. Generally, the faster the vessel speed, the longer the optimum bulb length and vice versa.

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Generally, a commercial marine vessel is designed to operate at an optimum speed that will maximize the profit from the earnings of the vessel. The optimum speed depends on a number of factors such as the operating cost, fuel cost, type of cargo, freight rate, loading capacity, occupied capacity, route and so on. In times of poor
35 economic situation, the optimum speed is generally very much slower than the designed speed at the time when the vessel was constructed. In prior art, during

economic downturn, some ship owners have cut the designed bulbous bow and replaced it with bulbous bow of shorter bulb length because the optimum speed of the vessel has become much slower. It is obvious that the disadvantage of this method of maintaining the bulbous bow of the vessel at the optimum bulb length is that it requires
5 the vessel to dry dock and be re-fitted with a new bulbous bow of optimum bulb length each time the economic situation changes, whether for better or worse.

This purpose of this invention is to overcome the disadvantage of prior art whereby the vessel has to dry dock and be re-fitted with a new bulbous bow whenever the optimum
10 bulb length changed. This invention allows the marine vessel with a particular bow 102 to dynamically adjust the bulb length 110 and bulb height 106 of the bulbous bow 101 to optimize the bulb length and bulb height for any vessel's drafts, trims and speeds so to achieve minimum bow wave losses for all vessel's drafts, trims and speeds.

15 The preferred embodiment of the invention consists of a number of adjustable bulbs 201 embedded in a Dynamic Bulbous Bow (DBB) Module 205 as illustrated in Figure 2. The number of adjustable bulbs is only limited by the number of adjustable bulbs which the bulbous bow can accommodate along its total length. Two adjustable bulbs are illustrated in Figure 2. Each adjustable bulbs 201 can be moved and adjusted vertically
20 202 to adjust the bulb height 204. The DBB Module 205 forms a water tight skin which prevents the outside sea water from entering the marine vessel. Each adjustable bulbs is located at different bulb lengths 203. By activating and extending a particular bulb above the bulbous bow, the bulb length 203 and bulb height 204 can be adjusted and optimised for different desired vessel's drafts, trims and speeds as illustrated in Figure
25 2. As the activated bulb is protruding above the bulbous bow while the other bulbs are flush with the top of the bulbous bow as illustrated in Figure 2, the anti-bow waves will effectively be generated by the activated bulb at the bulb length 203 of the activated bulb. By activating the desired bulb at the desired optimum bulb length for the vessel speed and extending the activated bulb to desired optimum bulb height 204 for the
30 vessel draft and trim, the anti-bow waves of the desired wave length and wave height will be generated at the location ahead of the bow waves to effectively cancel out the bow waves.

It is an object of the invention to provide an apparatus and a method of reducing the
35 bow waves losses of a marine vessel which operates at various drafts, trims and

speeds which addresses the disadvantages of prior art and/or to provide the public with a useful choice.

Summary of the Invention

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In accordance with a first aspect of the present invention, there is provided a method of determining the desired bulb length and desired bulb height of the Dynamic Bulbous Bow for a particular marine vessel at any desired drafts, trims and speeds so as to generate the desired anti-bow waves to achieve minimum bow wave losses.

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The method comprises:

- (i) determining the desired optimum bulb length of the Dynamic Bulbous Bow of a particular marine vessel when travelling at a desired speed based on the relationship of the desired optimum bulb length to the desired ship's speed, to generate the desired anti-bow waves to achieve minimum bow wave losses;
- (ii) determining which of the bulbs of the Dynamic Bulbous Bow of the particular vessel to activate at or nearest to the desired optimum bulb length to generate the desired anti-bow waves to achieve minimum bow wave losses;
- (iii) determining the desired optimum bulb height of the Dynamic Bulbous Bow of the particular marine vessel when travelling at a desired draft and trim based on the relationship of the desired optimum bulb height to the desired ship's draft and trim, to generate the desired anti-bow waves to achieve minimum bow wave losses;
- (iv) adjusting the activated bulb to the desired optimum bulb height and locking the activated bulb of the Dynamic Bulbous Bow in position at the desired optimum bulb length and desired optimum bulb height to generate the desired anti-bow waves to achieve minimum bow wave losses.

It should be understood that the Dynamic Bulbous Module is a device for adjusting the desired optimum bulb length and desired optimum bulb height of the bulbous bow of a marine vessel so as to generate the desired anti-bow waves to cancel out the bow waves of the marine vessel to achieve minimum bow wave losses.

By using the proposed method as described in the preferred embodiment, it is possible to determine the desired optimum bulb length and desired optimum bulb height of the Dynamic Bulbous Bow of the marine vessel so that it produces the desired anti-bow

waves to cancel out the bow waves of the marine vessel to achieve minimum bow wave losses.

In accordance to the second aspect of the invention, the preferred embodiment is illustrated in Figure 2. In practice, there may be more adjustable bulbs; the number of adjustable bulbs is only limited by the number of adjustable bulbs which the bulbous bow can accommodate along its total length. Two adjustable bulbs are illustrated in Figure 2. Each adjustable bulbs 201 can be adjusted vertically 202 to adjust the bulb height 204. The DBB Module 205 forms a water tight skin which prevents the outside sea water from entering the marine vessel. Each adjustable bulbs is located at different bulb lengths 203. By activating and extending a particular bulb above the bulbous bow, the bulb length 203 and bulb height 204 can be adjusted and optimised for different vessel's drafts, trims and speeds as illustrated in Figure 2. As the activated bulb is protruding above the bulbous bow while the other bulbs are flush with the top of the bulbous bow as illustrated in Figure 2, the anti-bow waves will effectively be generated by the activated bulb at the bulb length 203 of the activated bulb. By activating the desired bulb at the desired optimum bulb length and extending the activated bulb to desired optimum bulb height 204, the anti-bow waves of the desired wave length and wave height will be generated at the location ahead of the bow waves to effectively cancel out the bow waves.

It should be appreciated that features of one aspect may also be applicable to another aspect.

Brief Description of the Drawings

An example of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 illustrates a simplified bow of a marine vessel with bulbous bow and how the anti-bow waves generated by the bulbous bow ahead of the bow, cancel out the bow waves generated by the bow.

Figure 2 a pictorial illustration of the design and parts of Dynamic Bulbous Bow, illustrating how the desired bulb length and desired bulb height of a marine vessel can be adjusted to generate the desired anti-bow waves to cancel out the bow waves of a marine vessel at any drafts, trims and speeds.

Figure 6 is a flow chart illustrating steps of a method to determine the desired optimum bulb length and desired optimum bulb height of a Dynamic Bulbous Bow of a marine vessel at any drafts, trims and speeds.

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Detailed Description of Preferred Embodiment

The following definitions will be used throughout these specifications:

10 Actuator --- a device such as but not limited to pump, cylinder, motor, solenoid, gear, rack, lever, cams and roller which may be powered by but not limited to hydraulic, pneumatic and or electrical means, to move and adjust the bulbs.

15 Lock --- a device which may be powered by but not limited to hydraulic, pneumatic and or electrical means for locking the bulb in the desired position or releasing the bulb from the desired position.

Bow --- the forward part of the hull of a marine vessel

20 Bulbous bow --- the protruding bulb at the bow or front of a marine vessel, usually just below or partially below the waterline.

Bulb --- the protruding part of the bulbous bow that produces the anti-bow waves

25 Activated bulb --- the bulb at or nearest to the desired optimum bulb length that is moved and adjusted by the actuator

Bulb length --- the protruding length of the bulbous bow measured from the vertical line of the bow to the foremost point of the bulb

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Bulb height --- the height of the bulb from the bottom of the marine vessel

Bow wave --- the wave generated by and at the bow of the marine vessel

Anti-Bow wave --- the wave which is out of phase with the bow wave and when superimposed on the bow wave, will cancel out the bow wave resulting in no or minimum wave

- 5 Bow wave losses --- wave generated by the marine vessel does not contribute to the propulsion of the marine vessel. Therefore, wave generated by the marine vessel is considered as energy losses. Energy losses due to bow wave is bow wave losses.

10 Marine vessel --- any ships, boats, rigs or crafts such as but not limited to cruise ships, ferries, tankers, container ships, bulk carriers, ice breakers, oil rigs, yachts and so on, used for transportation on water

Wave length --- the distance over which the wave repeats itself and is measured by the distance between two peaks of a wave

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Wave height --- it is half the height of the wave between the elevation of the crest and the trough

Speed --- the speed of the marine vessel relative to water

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Draft --- draft is the vertical distance between the waterline of the marine vessel and the lowest part of its bottom.

25 Dynamic Bulbous Bow Module --- it is the term used to describe the module of this invention

Trim --- trim is measured as the difference between the forward and the aft draft of a marine vessel

30 Computational Fluid Dynamics --- it is a branch of fluid mechanics that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows. Computers are used to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions.

35 Towing tank --- a towing tank is a physical basin or tank used to carry out hydrodynamic tests with models of marine vessels, for the purpose of designing a

new marine vessel, or refining the design of a marine vessel to improve its performance at sea.

As explained earlier, the bulbous bow 101 of Figure 1 is configured for producing anti-bow waves 103 to cancel out the bow waves 104 for marine vessels built with a particular bow 102 and travelling at the designed draft, trim and speed 111 but it does not produce the desired anti-bow waves at other draft, trim and speed different from the designed draft, trim and speed. In other words, the configuration of the bulbous bow 102 does not produce the desired anti-bow waves to cancel out the bow waves when the marine vessel is not travelling at the designed draft, trim and speed. In this embodiment, an example will be explained to illustrate how to determine parameters such as the desired optimum bulb length 203 and the desired optimum bulb height 204 of the bulbous bow at any drafts, trims and speeds so that the desired optimum bulb length and desired optimum bulb height water may be determined and the desired bulb 201 may be activated to produce the desired anti-bow waves to cancel out the bow waves at any drafts, trims and speeds.

It would be appropriate to begin with an explanation of the methodology of how to determine the desired parameters such as the desired optimum bulb length 203 and desired optimum bulb height 204 of the described embodiment to achieve minimum bow wave losses for a marine vessel at any drafts, trims and speeds.

It is obvious to those who are skilled in marine technology that for a particular marine vessel, the desired optimum bulb length 110 of the bulbous bow 101 that enables the particular vessel to achieve the minimum bow wave losses, depends on the speed of the vessel 111 at a particular draft and trim. It is well established in the science of marine technology that the relationship between the desired optimum bulb length and the speed of the vessel can be determined by computation methods such as computational fluid dynamics and or by towing tank tests using a scaled model of the marine vessel. Therefore, the desired optimum bulb length 203 of described embodiment that enables the vessel to achieve minimum bow wave losses can be determined from the speed of the vessel as illustrated by Step 301 in Figure 3 using the determined relationship between the desired optimum bulb length and the speed of the vessel.

In this embodiment as illustrated in Figure 2, there are two or more adjustable bulbs 201 embedded in a Dynamic Bulbous Bow (DBB) Module 205. The number of adjustable bulbs is only limited by the number of adjustable bulbs which the bulbous bow can accommodate along its total length. Two adjustable bulbs are illustrated in Figure 2. Each adjustable bulbs 201 can be activated and moved vertically 202 by actuators powered by hydraulic, pneumatic or electrical means, to adjust the bulb height 204. The DBB Module 205 forms a water tight skin which prevents the outside sea water from entering the marine vessel. Each adjustable bulbs is located at different bulb lengths 203.

At step 302 in Figure 3, the bulb at or nearest to the desired bulb length will be activated. As illustrated in Figure 2, for example, if the desired bulb length is or nearest to Bulb length 203, the bulb C will be activated and moved vertically upwards above the bulbous bow. All other bulbs shall remain embedded in the DBB Module and flush with the top of the bulbous bow as illustrated in Figure 2.

It is also obvious to those who are skilled in marine technology that for a particular marine vessel with a particular bow 102, the depth of a particular point, for example point B of the bulbous bow 101 below the water line 105 can be calculated from the measured draft and trim of the marine vessel. Therefore, similarly, the depth of the point C of a bulb 201 illustrated in Figure 2 can be calculated from the measured draft and trim of a particular marine vessel. For a particular marine vessel at a specific draft and trim, it is obvious that the desired depth of a bulb below the water line can be adjusted by adjusting the desired bulb height 204. It is well established in the science of marine technology that the relationship between the desired bulb depth below the water line 105 and the wave height 108 can be determined by computation methods such as computational fluid dynamics or by towing tank tests using a scaled model of the marine vessel. Therefore, the desired optimum bulb height 204 of the activated bulb of the described embodiment that enables the vessel to achieve minimum bow wave losses can be determined from the measured draft and trim of the vessel as illustrated by Step 303 in Figure 3.

In this embodiment as illustrated in Figure 2, by activating and extending a particular bulb above the bulbous bow, the desired optimum bulb length 203 and desired optimum bulb height 204 can be adjusted to the value as determined in Step 301 and 303 respectively.

At Step 304 in Figure 3, the activated bulb determined in Steps 301 & 302 is extended vertically by actuators powered by hydraulic, pneumatic or electrical means to the desired optimum bulb height and then locked into position at Step 305 by locks
5 powered by hydraulic, pneumatic or electrical means.

As the activated bulb is protruding above the bulbous bow at the desired optimum bulb length 203 and desired optimum bulb height 204 while the other bulbs are flush with the top of the bulbous bow as illustrated in Figure 2, the anti-bow waves will effectively
10 be generated by the activated bulb. At the desired optimum bulb length 203 for the vessel speed 111 and the desired optimum bulb height 204 for the specific vessel draft and trim, it is obvious to those who are skilled in marine technology that the anti-bow waves of the desired wave length 107 and wave height 108 will be generated by the activated bulb 201 at the location ahead of the bow waves to effectively cancel out the
15 bow waves.

CLAIMS

1. A method of reducing bow wave losses of a marine vessel fitted with a bulbous bow, wherein the bulbous bow comprises a plurality of adjustable bulbs embedded along a length of the bulbous bow at a respective bulb length, each of the plurality of adjustable bulbs being extendable vertically above a surface of the bulbous bow to an adjustable bulb height, the method comprising:

- (i) measuring a speed of the marine vessel;
 - (ii) determining an optimum bulb length based on the speed of the marine vessel;
 - (iii) activating one of the plurality of adjustable bulbs embedded in the bulbous bow and located at or close to the optimum bulb length of the marine vessel;
 - (iv) measuring a draft and trim of the marine vessel;
 - (v) determining an optimum bulb height based on the draft and trim of the marine vessel;
- and

(vi) extending the activated adjustable bulb vertically to the optimum bulb height of the marine vessel.

2. The method of claim 1, wherein the optimum bulb length is determined based on a relationship between the optimum bulb length and the speed of the marine vessel that is obtained by computational methods or by towing tank tests.

3. The method of any one of claims 1 to 2, wherein the optimum bulb height is determined based on a relationship between the optimum bulb height and the draft and trim of the marine vessel that is obtained by computational methods or by towing tank tests.

4. The method of any one of claims 1 to 3, wherein each of the plurality of adjustable bulbs is embedded in the bulbous bow, with top of each of the plurality of adjustable bulbs being flushed with the surface of the bulbous bow when not activated.

5. The method according to any one of claims 1 to 4, wherein extending the activated adjustable bulb to the optimum bulb height includes use of an actuator which may be powered by hydraulic, pneumatic, or electric means.

6. The method according any one of claims 1 to 5, further comprising locking the activated adjustable bulb at the optimum bulb height using hydraulic, pneumatic or electric means.

7. The method according to any one of claims 1 to 6, wherein the plurality of adjustable bulbs are enclosed in a module and the module is recessed into the bulbous bow to form a work tight skin to prevent external sea water from entering the marine vessel.

8. A method according to any one of claims 1 to 7, wherein the optimum bulb length and the optimum bulb height are determined so as to produce anti-bow waves of a desired height and wave length for the marine vessel at the measured speed, draft and trim, whereby the anti-bow waves reduces the bow wave losses through activating the adjustable bulb located at or nearest to the optimum bulb length and extending the activated adjustable bulb to the optimum bulb height.

9. A bulbous bow module for reducing bow wave losses in a marine vessel, the bulbous bow module comprising:

a plurality of adjustable bulbs embedded along a length of the bulbous bow module at a respective bulb length, wherein each of the plurality of adjustable bulbs is extendable vertically above a surface of the bulbous bow module to an adjustable bulb height;

wherein the bulbous bow module is configured to be recessed into bulbous bow of the marine vessel, and dependent on a speed of the marine vessel, a desired adjustable bulb of the plurality of adjustable bulbs, located at or close to an optimized bulb length of the marine vessel is to be activated; and

wherein dependent on a draft and trim of the marine vessel, the activated adjustable bulb is to be extended vertically above the surface of the bulbous bow module to an optimized bulb height of the marine vessel to reduce the bow wave losses.

10. The bulbous bow module of claim 9, wherein each of the plurality of adjustable bulbs is embedded in the bulbous bow module such that when the bulbous bow module is recessed into the bulbous bow of the marine vessel, the top of each of the plurality of adjustable bulbs is flushed with the surface of the bulbous bow of the marine vessel when not activated.

11. The bulbous bow module of claim 9 or 10, further comprising:

an actuator configured to be powered by hydraulic, pneumatic or electric means to activate and extend the plurality of adjustable bulbs.

12. The bulbous bow module of any one of claims 9 to 11, further comprising:

a lock powered by hydraulic, pneumatic or electric means to lock the plurality of adjustable bulbs into position.

13. The bulbous bow module of any one of claims 9 to 12, wherein the bulbous bow module comprises two adjustable bulbs.

14. The bulbous bow module of any one of claims 9 to 13, wherein the plurality of adjustable bulbs are embedded in the bulbous bow module and the bulbous bow module is to be recessed

into the bulbous bow of the marine vessel to form a work tight skin to prevent external sea water from entering the marine vessel.