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An Air Dimple System for a Hull of a Vessel

Background and Field of the Invention

This invention relates to an air dimple system for a hull of a vessel.

When a ship moves or sails through water (for example, the sea), frictional resistance occurs through the direct contact between the water and hull of the ship. This frictional resistance represents a major component of total resistance experienced by the ship during its movement, and the greater the surface area of contact between the hull and the water, the greater the frictional resistance.

It is an object of the present invention to address at least one of the disadvantages of the prior art and/or to provide the public with a useful choice.

Summary of the Invention

In a first aspect, there is provided an air dimple system for a hull of a vessel, the hull having a network of longitudinal structural members and transverse web frames, the air dimple system comprising: an array of discrete air dimples to be arranged at the hull's bottom with the discrete air dimples to be arranged between respective longitudinal structural members; and an air injection device for supplying pressurized air to the array of discrete air dimples for creating corresponding air cushions at the respective air dimples.

As it can be appreciated from the described embodiment, with the air cushions created at the respective air dimples, this reduces fictional resistance between the water (sea, ocean etc) and the hull when the vessel is sailing, and thus, improves on the power efficiency of the vessel. Further, since the air dimples are arranged between the longitudinal structural members, without structurally modifying the longitudinal structural members, the structural strength of the hull is not affected by the having the air dimple system.

At least some of the discrete air dimples may be arranged between the transverse web frames of the hull. Each air dimple may be a hemisphere.

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At least some of the discrete air dimples may be arranged to cut through the transverse web frames. In the alternative, one air dimple of the discrete air dimples may be arranged between the transverse web frames. In such cases, the air dimples may have half-cylinder shapes.

Preferably, the distance between adjacent air dimples is about 100mm. Advantageously, some of the discrete air dimples of the array are to be arranged along a longitudinal axis of the hull and some of the discrete air dimples of the array are to be arranged across the longitudinal axis and along a lateral axis of the hull.

The air dimple system may be installed during the construction of the hull or it may be retrofitted to an existing hull/vessel. Indeed, this relates to a second aspect which provides for a method of retrofitting an air dimple system as described above to a hull of a vessel. The method comprises arranging the array of air dimples at a bottom of the vessel's hull between respective longitudinal structural members, connecting air pipes to each air dimple of the array, and connecting the air injection device to the air pipes for supplying the pressurized air to the array of air dimples.

The method may further comprise creating an array of openings at the hull's bottom, each opening corresponding to respective ones of the array of air dimples.

Brief Description of the Drawings

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

Figure 1 is a perspective underside view of a hull of a vessel having an air dimple system, according to a first embodiment;

Figure 2 is an enlarged view of a portion A of Figure 1;

Figure 3 is a perspective view from the top of the hull of Figure 2 to show the air dimple system more clearly;

Figure 4 is a cross-sectional view along the length of one of the air dimples of the air dimple system of Figure 3 in the direction B-B;

Figure 5 is a cross-sectional end view of the air dimple of Figure 4 in the direction C-C;

Figure 6 is a perspective underside view of a hull of a vessel having an air dimple system, according to a second embodiment;

Figure 7 is an enlarged view of a portion D of Figure 6;

Figure 8 is a perspective view from the top of the hull of Figure 7 to show the air dimple system more clearly;

Figure 9 is a cross-sectional view along the length of one of the air dimples of the air dimple system of Figure 8 in the direction E-E;

Figure 10 is a perspective underside view of a hull of a vessel having an air dimple system, according to a third embodiment;

Figure 11 is an enlarged view of a portion F of Figure 10;

Figure 12 is a perspective view from the top of the hull of Figure 11 to show the air dimple system more clearly; and

Figure 13 is a cross-sectional view along the length of one of the air dimples of the air dimple system of Figure 12 in the direction G-G.

Detailed Description of Preferred Embodiments

Figure 1 is a perspective underside view of a vessel 100 having a hull 102 and other parts of the vessel which are not shown, according to a first embodiment. The hull 102 includes a bow 104, a stern 106, a bottom 108 and two sides 110. The bottom 108 has a substantially flat portion 108a and a curved portion 108b which joins the substantially flat portion 108a to the bow 104. The hull 102 has a longitudinal axis 112 which extends along the length of the hull 102 between the bow 104 and the stern 106. The hull 102 also has a lateral axis 114 which traverses the longitudinal axis 112 orthogonally and extends between the two sides 110 of the hull 102.

The hull 102 further includes an air dimple system 200 having an array of air dimples 202. Figure 2 is an enlarged view of a portion A of Figure 1 to show the underside of the hull 102 more clearly. Figure 3, on the other hand, illustrates the portion A from a top view of the hull 102. As it can be appreciated from Figures 2 and 3, to provide the necessary structural support, the hull 102 includes a network of longitudinal structural members 116 (or stiffeners) arranged along the longitudinal axis 112 of the hull 102 (i.e. the longitudinal axis of the longitudinal structural members are substantial parallel to the longitudinal axis 112 of the hull 102) and transverse web frames 118, which are substantially parallel to the lateral axis 114 of the hull 102. In other words, it may be

said that the transverse web frames 118 are also orthogonal to the longitudinal structural members. The longitudinal structural members 116 extend along almost the entire length of the hull 102. Likewise, the transverse web frames 118 extend along almost the entire width (i.e. the lateral axis 114) of the hull 102.

Using one 202a of the dimples 202 as illustration, this air dimple 202a is arranged between two longitudinal stiffeners 116 and between two (lateral) web frames 118 (although one of the web frames is not shown in Figures 2 and 3). In other words, the dimension of the air dimple 202a (and the other air dimples 202) is configured to fit between the network of longitudinal stiffeners 116 and the web frames 118 without a need to modify the network of longitudinal stiffeners 116 and the web frames 118.

In this embodiment, the array of discrete air dimples 202 has a number of columns of discrete air dimples 202 (which varies in the number of air dimples 202 as shown in Figure 1) arranged along the lateral axis 114 of the hull 102 and a number of rows of discrete air dimples 202 arranged along the longitudinal axis 112 of the hull 102. Needless to say, the number of air dimples in the array 202 may vary according to the application.

Using the example of the air dimple 202a of Figure 3, Figure 4 is an enlarged cross-sectional view along the length of the air dimple 202a in the direction B-B of Figure 3 and Figure 5 is an enlarged cross-sectional end view along the width the air dimple 202a in the direction C-C of Figure 3. It may be appreciated that in this embodiment, the air dimple 202a is a half-cylinder defined by an elongate concave portion 204 with arc-shaped end members 206 with an opening 208 of the air dimple 202 facing outwards of the hull 102. Each air dimple 202a,202b has a length of 1.8m to 2.4m (depending on the distance between the closest pair of the transverse web frames 118). The distance between the two closest longitudinal structural member may be defined by D1 ranging from 300mm to 900mm and the spacing between the air dimple 202a and the adjacent longitudinal structural members 116 is 50mm on either side (so the distance between two adjacent air dimples 202 is thus 100mm). The diameter of the opening 208 of the air dimple 202a may then be derived based on D2 = D1-50mm-50mm with the height (D3) of the air dimple 202a defined by (D2/2) which is the radius of the opening 208 of the air dimple 202a.

The air dimple system 200 includes a network of air pipes 250 having a number of primary air pipes 252 (two of which are shown in Figures 2 and 3) and a number of secondary air pipes 254 which are in fluid communication with respective primary air pipes 252. The primary air pipes 252 are supported by extended elongate structural members 116a of the hull 102 and are connected to an air injection device (not shown) such as an air compressor as an air source which generates and delivers pressurized air through each of the primary air pipes 252 and in turn, delivered to each of the secondary air pipes 254. Each secondary air pipe 252 is connected to respective air dimples 202 to fill up each air dimple 202 with pressurized air to form respective air cushions 120, as shown in Figure 4. In this embodiment, pressure inside each air dimple 202 under speed is about 300-400mm of water column. To elaborate, hydrostatic pressure in water is directly related to the depth in which the pressure is measured. Very frequently the vertical distance from the surface to the pressure point to be measured is referred to as "water column". For example, typically, 300 water Column [millimeter] = 0.426 700 300 03 pound/square inch and 400 water column [millimeter] = 0.568 933 733 37 pound/square inch.

In use, when the vessel 100 is sailing, pressurized air is injected into each air dimple 202 and the pressurized air is trapped within each air dimple 202 to form corresponding air cushions 120 at the underside of the hull 102. In this way, the air cushions 120 make contact with the water during sailing and thus, reduce direct contact between the water and the hull 102 and thereby reduce the frictional resistance between the water and the hull 102. With the frictional resistance reduced, this improves the powering of the vessel 100. It has been found that having the array of discrete air dimples 202 to form respective pressurized air pockets along the longitudinal axis 112 is preferred over a continuous air carpet along the longitudinal axis 112 because of form drag. With such an arrangement, the vessel 100 is able to travel much faster using up much less fuel in the process.

With the proposed air dimple system 200, the vessel 100 is able to achieve minimum buoyancy lost and this translates to more cargo deadweight for the vessel owner. As discussed earlier, the pressurized air within each air dimple 202 may be supplied by the air compressor which may use about one percent of the vessel's available power, but the increased engine efficiency provided by the air dimple system 200 more than makes up for the power used by the air compressor. With the air dimple system 200, besides saving fuel, CO_2 emission is also correspondingly reduced.

It should be appreciated that the air dimple system 200 is easy to manufacture or fabricate and may be constructed when building the hull 102 of the vessel 100. Since the air dimples 202 of the air dimple system 200 are arranged between the structural members 116 (and also the web frames 118), the usual technical considerations for designing and constructing the hull 102 need to be taken into account, without new or unknown considerations since the structure of the hull 102 is not affected by including the air dimple system 200. Indeed, no major construction is needed and the air dimple system 200 may be installed without modifying or affecting the longitudinal structural members 116. This is particularly useful for retrofitting the air dimple system 200 to an existing vessel/hull by connecting the network of pipes 250 to the air source and to create the necessary openings 208 at the bottom 108 and installing the air dimples 202 of the air dimple system 200 which are arranged between the longitudinal structural members 116. In other words, any modification to the hull 102 is minor and may only affect the hull's shell plating.

Figure 6 is a perspective underside view of a hull 302 of a vessel 300 having an air dimple system 400, according to a second embodiment. The hull 302 of the second embodiment is similar to the hull 102 of the first embodiment and like parts uses the same reference numerals plus 200.

The hull 302 has a bow 304, a stern 306, a bottom 308 and two sides 310. The bottom 308 has a substantially flat portion 308a and a curved portion 308b which joins the substantially flat portion 308a to the bow 304. The hull 302 has a longitudinal axis 312 which extends along the length of the hull 302 between the bow 304 and the stern 306. The hull 302 also has a lateral axis 314 which traverses the longitudinal axis 312 orthogonally and extends between the two sides 310 of the hull 302.

The hull 302 also includes an air dimple system 400 but unlike the air dimples 202 of the first embodiment, the air dimple system 400 has extended air dimples 402 which are much longer and which extend through the transverse web frames 318. Figure 7 is an enlarged view of a portion D of Figure 6 to show the underside of the hull 302 more clearly. Figure 8, on the other hand, illustrates the portion D from a top view of the hull 302. As it can be appreciated from Figures 6 and 7, to provide the necessary structural support, the hull 102 includes a network of longitudinal structural members 316 (or

stiffeners) arranged along the longitudinal axis 312 of the hull 302 and transverse web frames 318, which are substantially parallel to the lateral axis 314 of the hull 102.

Figure 9 is an enlarged cross sectional view of one of the air dimples 402a of Figure 8 in the direction E-E. It should be appreciated that the air dimple 402a has a similar cross-section to the air dimple 202 of the first embodiment, except that the air dimple 402a of the second embodiment is much longer and may extend throughout the length of the flat portion 318a. In this respect, each air dimple 402a may have two or more secondary air pipes 454 to inject sufficient pressurized air into the air dimple. Indeed, it has been found that one air pipe may be needed per 1.8-2.4m in length of the air dimple 402. Likewise, the hull 402 also has a network of air pipes 450 having a number of primary air pipes 452 and a number of the secondary air pipes 454 which are in fluid communication with the primary air pipes 452. An air injection device is also used to supply pressurized air to the air dimples 402 via the network of air pipes 450 to create an air cushion 420 in the air dimple 402a.

Again, when the vessel is sailing, water engages the air cushion 420 near the opening 408 of the air dimple 402a and this reduces the frictional resistance between the hull 402 and the water. Also, since the longitudinal structural members 316 are not modified, the presence of the extended air dimples 402 does not affect the structural strength of the hull and thus, no major modifications are needed. As explained above, the extended air dimples 402 cut though at least some of the transverse web frames 318 but the modifications are considered minor since a small hole need only be created in other for the extended air dimple 402 to run through.

Other than the length, the size/depth of the extended air dimples 402 is similar to that illustrated in Figure 5.

Figure 10 is a perspective underside view of a hull 502 of a vessel 500 having an air dimple system 600, according to a third embodiment. The hull 502 of the second embodiment is similar to the hull 102 of the first embodiment and like parts uses the same reference numerals plus 400.

The hull 502 has a bow 504, a stern 506, a bottom 508 and two sides 510. The bottom 508 has a substantially flat portion 508a and a curved portion 508b which joins the substantially flat portion 508a to the bow 504. The hull 502 has a longitudinal axis 512

which extends along the length of the hull 502 between the bow 504 and the stern 506. The hull 502 also has a lateral axis 514 which traverses the longitudinal axis 512 orthogonally and extends between the two sides 510 of the hull 502.

Figure 11 is an enlarged view of a portion F of Figure 10 to show the underside of the hull 502 more clearly. Figure 12, on the other hand, illustrates the portion F from a top view of the hull 502. As it can be appreciated from Figures 11 and 12, to provide the necessary structural support, the hull 502 includes a network of longitudinal structural members 516,516a (or stiffeners) arranged along the longitudinal axis 512 of the hull 502 and transverse web frames 518, which are substantially parallel to the lateral axis 514 of the hull 502. The hull 502 also includes an air dimple system 600 but unlike the air dimples 202 of the first embodiment, the air dimple system 600 has hemispheric air dimples 602 and a number of these hemispheric air dimples 602 is arranged between the existing transverse web frames 518 (and between the longitudinal stiffeners 516,516a) (as compared to the first embodiment where one elongate air dimple 202 is arranged between the existing transverse web frames 518).

Figure 13 is an enlarged cross sectional view of one of the air dimples 602a of Figure 8 in the direction G-G. It should be appreciated that the air dimple 602a has a hemispheric cross-section which is unlike the air dimple 202 of the first embodiment (or the one illustrated in the second embodiment). In this respect, each air dimple 602a has one air pipe 654 connected thereto to inject sufficient pressurized air into the air dimple. Likewise, the hull 602 also has a network of air pipes 650 having a number of primary air pipes 652 and a number of the secondary air pipes 654 which are in fluid communication with the primary air pipes 652. An air injection device is also used to supply pressurized air to the air dimples 602 via the network of air pipes 650 to create an air cushion 620 in the air dimple 602a.

Again, when the vessel is sailing, water engages the air cushion 620 near the opening 608 of the air dimple 602a and this reduces the frictional resistance between the hull 602 and the water. Also, since the longitudinal structural members 516 are not modified, the presence of the extended air dimples 602 does not affect the structural strength of the hull 502 and thus, no major modifications are needed. As explained above, a number of the hemispheric air dimples 402 (in the case of Figure 12, three such air dimples 602) are arranged between the immediate pair of transverse web frames 318 (and the longitudinal structural members 516) which means that no or

minimum modifications are needed, and the hull 502 may thus retain the structural strength.

The size/depth of the hemispheric air dimples 602 is similar to that illustrated in Figure 5.

The described embodiments are not to be construed as limitative. For example, the air dimples 202, 402,602 may be arranged in other ways and take other forms. Also, different shapes and size of the air dimples may be used as part of the same air dimple system for a hull.

Having now fully described the invention, it should be apparent to one of ordinary skill in the art that many modifications can be made hereto without departing from the scope as claimed.

CLAIMS

1. An air dimple system for a hull of a vessel, the hull having a network of longitudinal structural members and transverse web frames, the air dimple system comprising:
an array of discrete air dimples to be arranged at the hull's bottom with the discrete air dimples to be arranged between respective longitudinal structural members; and
an air injection device for supplying pressurized air to the array of discrete air dimples for creating corresponding air cushions at the respective air dimples.

2. An air dimple system according to claim 1, wherein at least some of the discrete air dimples are arranged between the transverse web frames of the hull.

3. An air dimple system according to claim 1 or 2, wherein each air dimple is a hemisphere.

4. An air dimple system according to claim 1 or 2, wherein at least some of the discrete air dimples are arranged to cut through the transverse web frames.

5. An air dimple system according to claim 1, wherein one air dimple of the discrete air dimples is arranged between the transverse web frames.

6. An air dimple system according to claim 4 or 5, wherein each air dimple is a half-cylinder.

7. An air dimple system according to any preceding claim, wherein distance between adjacent air dimples is about 100mm.

8. An air dimple system according to any preceding claim, wherein some of the discrete air dimples of the array are to be arranged along a longitudinal axis of the hull and some of the discrete air dimples of the array are to be arranged across the longitudinal axis and along a lateral axis of the hull.

9. A hull comprising the air dimple system of any preceding claim.

10. A vessel comprising the hull of claim 9.

11. A method of retrofitting an air dimple system of any preceding claim to hull of a vessel, the method comprising arranging the array of air dimples at a bottom of the vessel's hull between respective longitudinal structural members, connecting air pipes to each air dimple of the array, and connecting the air injection device to the air pipes for supplying the pressurized air to the array of air dimples.

12. A method according to claim 11, further comprising creating an array of openings at the hull's bottom, each opening corresponding to respective ones of the array of air dimples.