

SUPER E-COLUMN ON SEMI-SUBMERSIBLE VESSEL

Field of the Invention

This invention relates to a semi-submersible vessel. Particularly, this invention
5 relates to a semi-submersible vessel having a particular support structure between the deck
and the pontoons of the semi-submersible vessel.

Prior Art

Figure 1 illustrates a typical semi-submersible vessel 100 comprises a deck 110 for
10 working space, which is supported by four or more columns 120 which are again supported
by two or more pontoons 130. The pontoons 130 are submerged inside the water, providing
majority of buoyance. Braces 140 are provided connecting a pair of columns 120 forming a
loop between the deck 110, columns 120 and pontoon 130.

15 According to vessel's functions and displacement size, traditional two pontoon semi
structural format as shown in figure 1 are either using many braces to form truss structure to
resist wave load on pontoons and columns, or using big column with haunch to fix with deck
box to resist wave load. While using many braces to form truss structure can achieve thin
deck box, such brace connections are heavily stressed to become critical fatigue points.
20 Further, using big column requires a big deck box and haunch to resist the wave load acting
on pontoon and column. Hence, there are limitations to such traditional two pontoon semi
structural format. Thus, those skilled in the art are striving to provide an improved structural
format of supporting the deck and to improve vessel hydrodynamic performance and
functional space.

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Summary of the Invention

The above and other problems are solved and an advance in the art is made by a
semi-submersible vessel in accordance with this invention. A first advantage of a semi-

submersible vessel in accordance with this invention is that the semi-submersible vessel includes double skin columns that improves current drag load during operation. This also improves dynamic positioning capability. A second advantage of a semi-submersible vessel in accordance with this invention is that the double skin columns require lesser materials to manufacture. This further leads to lower cost of manufacturing. Still further, weight of the columns is reduced. A third advantage of a semi-submersible vessel in accordance with this invention is that the inner space is functional and creates storage space.

In accordance with embodiments of this invention, a semi-submersible vessel is configured in the following manner. The semi-submersible vessel includes a deck, at least four columns supporting the deck, a first pontoon, a second pontoon, a first brace, and a second brace. Each column comprises an outer skin, an inner skin, and a number of reinforcing plates connecting the inner skin to the outer skin forming a double skin arrangement. The first pontoon is connectable to a first pair of columns and the second pontoon is connectable to a second pair of the columns. The first brace is connectable to the first of each of the two pairs of columns and the second brace connects the second of each of the two pairs of columns.

In accordance with embodiments of this invention, a perimeter of the outer skin at an upper part of the column is larger than a perimeter of the outer skin at a lower part of the column. Further, the perimeter of the outer skin at the lower part of the column conforms to a super ellipse function with the following expressions,

$$x = a \cos^{\frac{2}{r}} t$$

$$y = b \sin^{\frac{2}{r}} t$$

where a is not equal to b and r is equal to 4.

In accordance with an embodiment of this invention, a perimeter of the inner skin is the same throughout an upper part and a lower part of the column. Particularly, the perimeter of the inner skin is octagonal in shape.

5 In accordance with an embodiment of this invention, each of the columns further comprises a solid block at a bottom of the lower part of the column. The solid block has an indent at a top surface of the solid block for supporting respective first and second braces. Further, the indent conforms to the surface of the first and second braces.

10 In accordance with an embodiment of this invention, the reinforcing plates are evenly spaced apart from each other.

Brief Description of the Drawings

The above and other features and advantages in accordance with this invention are
15 described in the following detailed description and are shown in the following drawings:

Figure 1 illustrating a perspective view of a known semi-submersible vessel;

Figure 2 illustrating a perspective view of a semi-submersible vessel in accordance with an embodiment of this invention;

Figure 3 illustrating a side view from a column of the semi-submersible vessel in
20 accordance with an embodiment of this invention

Figure 4 illustrating a drag load analysis of the known semi-submersible vessel and the semi-submersible vessel in accordance with an embodiment of this invention;

Figure 5 illustrating another drag load analysis of the known semi-submersible vessel and the semi-submersible vessel in accordance with an embodiment of this invention;

25 Figure 6 illustrating a cross sectional view of the lower and upper parts of the column in accordance with an embodiment of this invention;

Figure 7 illustrating a perspective view of a portion of the column in accordance with an embodiment of this invention;

Figure 8 illustrating a plan view of an arrangement between the columns and the deck of the known semi-submersible vessel; and

5 Figure 9 illustrating a side view of an arrangement between the columns and the deck with haunch structures of the known semi-submersible vessel.

Detailed Description

This invention relates to a semi-submersible vessel. Particularly, this invention
10 relates to a semi-submersible vessel having a particular support structure between the deck and the pontoons of the semi-submersible vessel.

Figure 2 shows a perspective view of a semi-submersible vessel 200. Similar to a known semi-submersible vessel 100, the semi-submersible vessel 200 also comprises a
15 deck 210, columns 220, pontoons 230 and braces 240. Water level 260 illustrates the water level in which the semi-submersible vessel 200 is in transit, i.e. moving to a new location. Water level 270 illustrates the water level in which the semi-submersible is in operation, i.e. anchored at a location. In use, the pontoons 230 are partially submerged under the water with the braces 240 above the water level 260 during transit. This ensures that the braces
20 240 are not subjected to drag forces during transit. This is also advantageous for visual inspection.

The deck 210 provides a top surface where offshore activities can be carried out. The deck 210 is supported by the columns 220. Particularly, columns 220 are connected to
25 the bottom surface of the deck 210. Although figure 2 shows deck 210 being quadrilateral, one skilled in the art will recognise that other shapes can be implemented without departing from the invention. Figure 8 illustrates a plan view of a common arrangement of the

columns and the deck where a portion of each of the columns extends outside the area of the deck 210. In such arrangement, full support of the deck 210 will not be rendered by the columns 220 since only a portion of each of the columns is supporting the deck 210. Hence, haunch structures 910 are required to adjoin the columns to the bottom surface of the deck which is shown in figure 9 being the side view of the arrangement of the columns and the deck. Differently, as shown in figure 2, the four columns 220 of the semi-submersible vessel 200 are provided within the area of the deck 210 and proximate or at corners of the deck 210. This ensures that the deck 210 is fully supported by the columns 220. Hence, additional haunch structures are not required. Although figure 2 illustrates that the columns 220 are arranged at corners of the deck 210, one skilled in the art will recognise that the columns 220 need not be exactly at the corners of the deck 210 without departing from the invention.

Although only four columns 220, with one obscured, are illustrated in the semi-submersible vessel 200 as shown in figure 2, one skilled in the art will recognize that other number of columns 220 may be provided depending on the dimension of the deck 210 and the exact number of columns 220 is left to those skilled in the art.

The pontoons 230 houses a number of ballast tanks to control the buoyancy of the pontoons 230. By controlling the ballast tank, the semi-submersible vessel 200 can be maintained at a certain level with respect to the water level. Essentially, the pontoons 230 are maintained at a certain level of buoyancy by controlling the ballast tank such that the deck 210 is above the water. Particularly, the buoyancy of the pontoons 230 are kept about the water level 270 when the semi-submersible vessel 200 is in operation and water level 260 when the semi-submersible vessel 200 is in transit. One skilled in the art will recognise that the water level 260 and water level 270 are meant for illustrative purposes. In other

words, the water level 260 and water level 270 are meant to be rough guide of the water levels when in operation and transit.

Figure 3 illustrates a side view 301 of one of the columns 220, a first cross sectional
5 view 302 between X-X of the side view 301, and a second cross sectional view 303
between Y-Y. Each of the columns 220 comprises an inner skin 320, an outer skin 310 and
a number of reinforcing plates 330 between the inner and outer skins. The columns 220
further comprise an upper part 221 and a lower part 222. The upper part 221 and lower part
222 may be integrally manufactured to obtain a better structural stability. Alternatively, the
10 upper part 221 and lower part 222 may be manufactured separately and joined together by
welding.

The reinforcing plates 330 are provided between the inner skin 320 and outer skin
310 to bind the inner skin 320 to the outer skin 310. Further, the reinforcing plates 330 are
15 arranged vertically, extending between the top and bottom of the columns 220. This double
skin arrangement of reinforcing plates 330 between the inner skin 320 and outer skin 310
creates voids within the inner skin 320 and outer skin 310 and hence reduces the amount of
materials required. Inevitably, the mass of the columns are greatly reduced and costs of
material to manufacture the columns are lowered as well. Further, the void created
20 increases the buoyancy of the semi-submersible vessel 200. Still further, the void can also
be used for storage, creating functional spaces within the inner skin. One skilled in the art
will recognise that the reinforcing plate 330 may be replaced with reinforcing bars without
departing from the invention. Further, additional reinforcing plates or reinforcing bars may
be provided to interlock the vertically arranged reinforcing plates 330 to strengthen the
25 columns 220.

The shape of the outer skin 310 is based on super ellipse function which can be described parametrically by the following expressions,

$$x = a \cos^{\frac{2}{r}} t$$

$$y = b \sin^{\frac{2}{r}} t$$

Where a is not equal to b and r is equal to 4.

5 An analysis on the current drag load of a conventional semi-submersible vessel and a semi-submersible vessel 200 in accordance with this invention is shown in figures 4 and 5. Figure 4 illustrates current moving towards the front of the semi-submersible vessel. The left of figure 4 shows the current drag load of a conventional semi-submersible vessel while the right of figure 4 shows the current drag load of the semi-submersible vessel 200. Under this
10 condition, it is noted that the semi-submersible vessel 200 has a current drag load reduction of about 18% compared to the conventional semi-submersible vessel. Figure 5 illustrates current moving towards the side of the semi-submersible vessel. The left of figure 5 shows the current drag load of a conventional semi-submersible vessel while the right of figure 5 shows the current drag load of the semi-submersible vessel 200. Under this condition, it is
15 noted that the semi-submersible vessel 200 has a current drag load reduction of about 5% compared to the conventional semi-submersible vessel. This reduction in current drag load can be attributed to the shape of the outer skin 310 at the lower part 222 of the columns 220 which provide a better hydrodynamic performance than the conventional semi-submersible vessel.

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Cross sectional view 302 illustrates the cross sectional view of the lower part 222 along X-X of the column 220 while cross sectional view 303 illustrates the cross sectional view of the upper part 221 along Y-Y of the column 220. As shown, the perimeter of the inner skin 320 in the upper and lower parts of the column is the same while the perimeter of
25 the outer skin 310 at the upper part 221 of the column is larger than the perimeter of the

outer skin 310 at the lower part 222 of the column. In particular, the perimeter of the outer skin 310 at top of the upper part 221 of the column is quadrilateral with rounded vertices. A larger perimeter at the upper part 221 of the outer skin 310 allows for better connection with the deck 210. Although figure 3 shows that the shape of both inner skin 320 and outer skin 310 at the lower part 222 is in accordance with the super ellipse function mentioned above, one skilled in the art will recognise that other shapes may be implemented without departing from the invention as long as the outer skin 310 in the lower part 222 of the columns 220 conforms to the super ellipse function mentioned above. Figure 6 illustrates another configuration of the columns 220 where reference number 601 shows the cross sectional view of the lower part 222 of the column 220 and reference number 602 shows the cross sectional view of the upper part 221 of the column 220. Particularly, the cross section of the inner skin 320 is an octagon. The void within the inner skin can be used as storage space. Hence, the shape of the inner skin is a design choice left to the skilled in the art.

Figure 7 illustrates a perspective view of a portion of the column 220 with one end of the brace 240 connected to proximate bottom of the lower part of the column 220. As the double skin arrangement of the columns 220 is hollow in nature, a block structure 710 is provided at the bottom of the lower part 222 of the column 220. An indent 720 extends a length of the top of the solid block 710 and is shaped according to the surface of the braces 240 so that the brace 240 rests on the indent 720. This provides better structural support to withstand deformation induced force acting on the braces 240.

The above is a description of exemplary embodiments of a semi-submersible vessel in accordance with this invention. It is foreseeable that those skilled in the art can and will design alternative structure or assembly based on this disclosure that infringe upon this invention as set forth in the following claims.

Claims

1. A semi-submersible vessel comprising:

a deck

5 a first, second, third and fourth column supporting the deck, each of the columns comprises an outer skin, an inner skin, and a plurality of reinforcing plates connecting the inner skin to the outer skin;

a first and a second pontoon, wherein the first pontoon is connectable to the first and second columns and the second pontoon is connectable to the third and fourth columns;

10 a first brace connecting the first and third columns; and

a second brace connecting the second and fourth columns, and wherein each of the columns further comprises a block structure at a bottom of a lower part of the column, the block structure having an indent at a top surface for supporting respective first and second braces.

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2. The semi-submersible vessel according to claim 1 wherein a perimeter of the outer skin at an upper part of the column is larger than a perimeter of the outer skin at a lower part of the column.

20 3. The semi-submersible vessel according to claim 2 wherein the perimeter of the outer skin at the lower part of the column conforms to a super ellipse function with the following expressions,

$$x = a \cos^{\frac{2}{r}} t$$

$$y = b \sin^{\frac{2}{r}} t$$

where a is not equal to b and r is equal to 4.

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4. The semi-submersible vessel according to claim 1 wherein a perimeter of the inner skin is the same throughout an upper part and a lower part of the column.

5. The semi-submersible vessel according to claim 4 wherein the perimeter of the inner skin is octagonal in shape.

6. The semi-submersible vessel according to claim 1 wherein the indent conforms to the surface of the first and second braces.

10 7. The semi-submersible vessel according to claim 1 wherein the plurality of reinforcing plates are evenly spaced apart from each other.