

A foreship arrangement for a vessel of the displacement type

The present invention relates to a new design of the foreship of a vessel of the displacement type.

5 Ever since the start of oil activities in the North Sea, all vessels engaged in marine operations have been characterised by having their wheelhouse and superstructure with equipment located immediately behind the forecastle deck and extending right up to the collision bulkhead. A large loading deck or working deck has been located aft of the superstructure and wheelhouse. This arrangement is a legacy of the first platform
10 supply vessels which were used on the British continental shelf in the 1950s and is still the dominant solution today.

When these vessels are not in operation or are waiting on the weather (backing), they will normally have their bow turned upwind and into the waves.

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The bow design has been a raked bow or straight stem line up to the design water line and above that a raked bow, or a solution including a bulb and a raked bow where the bulb can be defined as a bulge in the hull, primarily below the water line, to improve the wave system and resistance.

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Typical negative effects of the aforementioned conventional bow forms are that they reflect incoming waves to too great a degree (wave formation gives energy loss), they are heavily subjected to the slamming of waves against the ship side, they generate a great deal of spray and they are subjected to the occurrence of green water on the deck
25 in front of the superstructure.

When this type of bow shape meets incoming waves, the submerged volume (later referred to as "facing volume") increases very quickly, buoyancy increases as quickly and the retardation force becomes very large. These effects intensify with increasing
30 wave height and increasing speed of the vessel into the wave direction.

Vessels with their superstructure and wheelhouse located on the weather deck immediately aft of the collision bulkhead and having a hull shape as described above are highly vulnerable to heavy weather damage.

The maximum speed at sea for these vessels is determined primarily by the water line length, entry angles of the foreship and the proportion of outwardly sloping frame lines in the bow, and by available thrust forces from the propeller(s). Typical maximum speed in calm water is about 13-16 knots, and they will normally have a loss of speed of about 3 to 5 knots in head sea. The speed loss in head sea is a direct result of the energy loss due to reflected waves, which results in retardation of the vessel.

Both during headway, in particular in head sea, and during backing/waiting, the crew, who have their quarters forward, will experience large accelerations and retardations. Such motions reduce the quality of their rest periods and have an adverse effect on their capacity to work. Reduced resting time and difficult working conditions increase the risk of accidents and injuries.

To reduce or eliminate the aforementioned drawbacks of the prior art, according to an aspect of the present invention, there is provided a foreship arrangement for a vessel of the displacement type, which foreship consists of the part of the ship in front of the vessel's midship mark (2) and which vessel has a transversely symmetrical hull shape about its centre line (CL) and a substantially conventional bow form below its design water line (Tdwl), wherein the stem line (1) of the vessel turns substantially backwards in relation to the ship length direction (negative x-direction) from a transition point (B) at or just above the design water line (Tdwl) and to an upper point (C) of the hull, wherein the frame lines (10, 20, 30, 40, 50) of the foreship are designed transversely symmetrical about the centre line (CL), and starting respectively from first points (D1, D2, D3, D4, D5) run almost perpendicularly from CL and increase in breadth (the y-direction) from the centre line (CL), whereafter the frame lines (10, 20, 30, 40, 50) respectively merge into the bilge (G1, G2, G3, G4, G5) at a given bilge radius, from which bilge and up to second points (E1, E2, E3, E4, E5) the frame lines (10, 20, 30, 40, 50) are outwardly sloping (in yz-direction), characterised in that at the points (E1, E2, E3, E4, E5) the outwardly sloping frame line form is terminated and then runs respectively upwards as a curved frame line form back to the centre line (CL) at third forward points (F1, F2, F3) in said length direction and continues upwards with very gentle curvature towards the centre line (CL) to third rear points (F4, F5) in said length direction separate from the center line (CL), the main form of the foreship being substantially rounded and without any knucle lines..

The design of the foreship according to embodiments of the invention is intended for displacement hulls in the speed range of up to about 24 knots and with the forward bulkhead of the superstructure preferably arranged forward of amidships. The new bow shape is primarily intended to be used in vessels that are engaged in marine operations,
5 such as construction vessels, pipelaying vessels, platform supply vessels, anchor handling vessels, diving ships, etc.

The foreship is designed transversely symmetrical about the centre line (CL) of the vessel. The frame lines of the hull increase in width from the base line (BL). The
10 bottom is flat or has a deadrise and merges into the bilge at a given bilge radius. From the bilge up to a given height, the frame lines are slightly outwardly sloping. At the level of the forecastle deck, the outwardly sloping line form is terminated and is run on upwards as a curved line form back towards the centre line.

15 According to embodiments of the invention, a new form of foreship has been developed which reduces or eliminates the negative effects that the commonly known bow shapes have. The foreship is designed to have slender water lines so that the submersion of the facing volume takes place over a considerable period of time, which means that the vessel cuts

into the wave and the wave laps over the bow form and out to the side. Thus, the buoyancy force is distributed over time and the retardation forces are substantially reduced. This solution reduces reflection of waves, it eliminates the slamming of waves against the vessel's sides and bottom, the speed loss in head sea is reduced by about one
 5 knot as compared with the standard bow shapes, and the stem line has a profile which is designed to prevent the waves from reaching too high up. Pitch and heave motions will be reduced due to improved distribution of internal volume and more slender entry lines of the foreship.

10 The hull in the example is run/extended up to the weather deck. At the weather deck, the stem line is advantageously bent forwards to form a barrier in the form of a spray board to prevent sea spray from reaching this deck. This means that an enclosed volume is formed that extends up to the weather deck. Waves are thus allowed to creep up to the weather deck in the case of the largest waves.

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The new design of the foreship will result in the following positive effects:

- Lower accelerations and retardations, which give higher average speed at sea, thereby reducing power requirement and consumption of fuel.
- A reduction in the amount of or the elimination of green water on deck.

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Model tests carried out by Marintek/SINTEF in February 2005 verify the positive effects of the new design of the foreship.

Apart from the advantages mentioned above, the new foreship design will result in:

- 25 • A lower probability of heavy weather damage to the foreship because the reflection of waves is reduced.
- The elimination of the possibility of heavy weather damage to the front bulkhead in the superstructure.
- Improved working environment on board with regard to
 - 30 □ accelerations and retardations, thereby improving safety during navigation and providing higher operability, especially in head sea.
 - reduction of noise and vibrations because of gentle motions and reduced slamming of the waves against the hull, thereby increasing comfort and improving safety with a view to efficient utilisation of the crew's resting and
 - 35 working time.
- Protection of mooring equipment that is usually located on the forecastle deck.

- Simpler and stronger construction of skin plates and stiffeners due to a large proportion of double-curved area.
- A reduction in loads on skin plates and stiffeners due to elimination of flare.
- Smooth foreship all the way up to the bridge deck, which results in reduced danger of icing. All deck equipment that is normally exposed to wind, weather and icing is protected.
- Smooth foreship all the way up to bridge deck, which results in simpler installation of de-icing equipment.

10 In the following, a non-limiting embodiment of the arrangement according to the invention is described in more detail with reference to the accompanying drawings, wherein:

Figure 1 is a side view of the profile of the foreship stem line.

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Figure 2 is a front view of an extract of frame lines for the foreship.

Figure 3 shows the water line for the foreship.

20 Figure 4 is a perspective view of a hull, principally from below, with the foreship designed according to the invention.

Figure 5 is another perspective view of the basic shape of the hull in Figure 4, principally from the side.

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Figure 6 is a further perspective view of the hull in Figure 4, principally from the side.

In the following description and in the claims, unless otherwise specified, all disclosures of direction are explained on the basis that the vessel is in a three-dimensional coordinate system where the vessel's length direction, breadth direction and height direction correspond respectively to the x-axis, y-axis and z-axis of the coordinate system, wherein the x-axis and the y-axis are oriented in the horizontal plane whilst the z-axis is oriented in the vertical plane. Furthermore, the forward direction of the ship corresponds to the positive x-direction.

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The new foreship, shown from the midship mark 2 of the vessel, has a slender and distinctive bow shape. Fig. 1 shows the vessel's stem line 1, which starts at the base line

3 at point A and then rises with an increasing curvature whilst being drawn forwards in the length direction (x-direction) to a point B slightly above the design water line, Tdwl. From point B, the stem line 1 rises further, but now with a diminishing curvature and backwards (in the negative x-direction) until it reaches point C. At point C, the stem
 5 line is advantageously bent forwards and is terminated as the top of spray board 5.

The frame lines of the foreship are designed transversely symmetrical about the centre line (CL) of the vessel. Figure 2 shows the frame lines 10, 20, 30, 40, 50 of the hull which start at points D1, D2, D3, D4 and D5 and run almost perpendicularly from CL
 10 and increase in breadth (the y-direction) from CL. The frame lines 10, 20, 30, 40, 50 then respectively merge into the bilge G1, G2, G3, G4, G5 at a given bilge radius. From the bilge and up to points E1, E2, E3, E4, E5, the frame lines 10, 20, 30, 40, 50, respectively, are outwardly sloping, and in the embodiment shown in this figure at angles $a_2 = 11$ degrees, $a_3 = 19$ degrees, $a_4 = 38$ degrees and $a_5 = 30$ degrees relative to
 15 the centre line CL. At points E1, E2, E3, E4, E5, the outwardly sloping frame line form is terminated and is run on upwards as a curved frame line form, either back to the centre line CL at points F1, F2, F3 or further upwards in a very gentle curve towards the centre line CL to points F4 and F5. From the figure, it can also be seen that the bottom of the vessel is flat at zero intersection 7.

20 Figure 3 shows the water line/entry angle seen in the xy-plane (length/breadth direction), which for the embodiment illustrated in this figure is 20.3 degrees, and which advantageously is between about 16 and 25 degrees relative to the centre line CL at the design water line Tdwl for reduced or increased slenderness.

25 Figures 4, 5 and 6 show the foreship according to the illustrated embodiment of the invention in different perspectives, advantageously provided with spray board 5.

The table below shows advantageous ratios between water lines, slenderness and hull
 30 height for different ranges of water line length, where the water line Lwl is given in metres and at a given draught Tdwl, and where the hull breadth Bwl is measured at the zero intersection and at a given draught Tdwl.

Lwl	60-90	90-120	120-150	150-180	180-210	210-
Bwl/Tdwl	2	3	3.5	3.5	4	5
Lwl/Bwl	3	4.5	5	5.5	6	10
Lwl/Tdwl	5	13	17	20	22	23
Htdwl/Bwl	0.5	0.8	0.7	0.55	0.45	5
Lwl/Htdwl	2	5.5	7.5	10.5	13.5	15

The use of the above-mentioned ratios for the given water line length ranges Lwl results in more slender entry lines, increased water line length and only slightly outwardly sloping hull or frame lines (small flare).

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The abbreviations, which are used in this application, and in particular in the above table, have the following definitions:

Tdwl: Draught (at the design water line)

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Bwl: Breadth measured at a given draught Tdwl

Lwl: Water line length measured at a given draught Tdwl; in other words total length of the submerged volume.

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Htdwl: Hull height measured from Tdwl up to the top of the spray board.

For the illustrated and described exemplary embodiment, it may be specified that Tdwl = 6 metres, Lwl = 81.1 metres, Bwl = 18.5 metres and Htdwl = 14.8 metres. The spray board 5 advantageously has a vertical height of 1 metre, so that the height measured from Tdwl to the transition to the spray board is thus 13.8 metres.

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A m e n d e d c l a i m s

1.

A foreship arrangement for a vessel of the displacement type, which foreship consists of the part of the ship in front of the vessel's midship mark (2) and which vessel has a transversely symmetrical hull shape about its centre line (CL) and a substantially conventional bow form below its design water line (Tdwl), wherein the stem line (1) of the vessel turns substantially backwards in relation to the ship length direction (negative x-direction) from a transition point (B) at or just above the design water line (Tdwl) and to an upper point (C) of the hull, wherein the frame lines (10, 20, 30, 40, 50) of the foreship are designed transversely symmetrical about the centre line (CL), and starting respectively from first points (D1, D2, D3, D4, D5) run almost perpendicularly from CL and increase in breadth (the y-direction) from the centre line (CL), whereafter the frame lines (10, 20, 30, 40, 50) respectively merge into the bilge (G1, G2, G3, G4, G5) at a given bilge radius, from which bilge and up to second points (E1, E2, E3, E4, E5) the frame lines (10, 20, 30, 40, 50) are outwardly sloping (in yz-direction), characterised in that at the points (E1, E2, E3, E4, E5) the outwardly sloping frame line form is terminated and then runs respectively upwards as a curved frame line form back to the centre line (CL) at third forward points (F1, F2, F3) in said length direction and continues upwards with very gentle curvature towards the centre line (CL) to third rear points (F4, F5) in said length direction separate from the center line (CL), the main form of the foreship being substantially rounded and without any knuckle lines.

2.

The arrangement according to claim 1, characterised in that the stem line (1), starting from a lower point (A) at the vessel's base line (3) rises and has a substantially increasing curvature in the forward direction of the vessel to the transition point (B), and that the stem line (1) from the point (B) continues to rise, but with a substantially diminishing curvature and in the aftward direction of the vessel, optionally broken by one or more straight portions, to an upper point (C).

3.

The arrangement according to claim 2, characterised in that a spray board (5) extends out from the upper point (C), the stem line (1) being bent sharply forward at said point (C) and being terminated at the top of the spray board (5).

4.

The arrangement according to any one of the preceding claims, characterised in that the vessel's flare angles in the foreship, and above the design water line (Tdwl) are in the range of 9 – 45 degrees relative to the height direction of the vessel.

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5.

The arrangement according to any one of the preceding claims, characterised in that the vessel's stem angles between the transition point (B) and the upper point (C) increase from 0 degrees at the transition point (B) to 55 degrees at the upper point (C) relative to the height direction of the vessel.

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6.

The arrangement according to any one of the preceding claims, characterised in that the entry angle of the bow at the design water line (Tdwl), and in a plane coincident with the horizontal plane (the xy plane) is in the range of 16-25 degrees relative to the centre line (CL).

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7.

The arrangement according to any one of claims 3 to 6, characterised by the following ratios for a water line length (Lwl) in the range of 60-90 metres: $Bwl/Tdwl = 2$, $Lwl/Bwl = 3$, $Lwl/Tdwl = 5$, $Htdwl/Bwl = 0.5$ and $Lwl/Htdwl = 2$.

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8.

The arrangement according to any one of claims 3 to 6, characterised by the following ratios for a water line length (Lwl) in the range of 90-120 metres: $Bwl/Tdwl = 3$, $Lwl/Bwl = 4.5$, $Lwl/Tdwl = 13$, $Htdwl/Bwl = 0.8$ and $Lwl/Htdwl = 5.5$.

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9.

The arrangement according to any one of claims 3 to 6, characterised by the following ratios for a water line length (Lwl) in the range of 120-150 metres: $Bwl/Tdwl = 3.5$, $Lwl/Bwl = 5$, $Lwl/Tdwl = 17$, $Htdwl/Bwl = 0.7$ and $Lwl/Htdwl = 7.5$.

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10.

The arrangement according to any one of claims 3 to 6, characterised by the following ratios for a water line length (Lwl) in the range of 150-180 metres: $Bwl/Tdwl = 3.5$, $Lwl/Bwl = 5.5$, $Lwl/Tdwl = 20$, $Htdwl/Bwl = 0.55$ and $Lwl/Htdwl = 10.5$.

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11.

The arrangement according to any one of claims 3 to 6, characterised by the following ratios for a water line length (Lwl) in the range of 180-210 metres: $Bwl/Tdwl = 4$, $Lwl/Bwl = 6$, $Lwl/Tdwl = 22$, $Htdwl/Bwl = 0.45$ and $Lwl/Htdwl = 13.5$.

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12.

The arrangement according to any one of claims 3 to 6, characterised by the following ratios for a water line length (Lwl) in the range of 210 metres and above: $Bwl/Tdwl = 5$, $Lwl/Bwl = 10$, $Lwl/Tdwl = 23$, $Htdwl/Bwl = 5$ and $Lwl/Htdwl = 15$.

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