

A HULL APPENDAGE

FIELD

The invention relates to a vessel and a hull appendage for a vessel.

BACKGROUND

When a ship moves through water, it experiences a force which opposes the movement of the ship through water. This force is called resistance. The main sources of this resistance are (i) water pressure acting perpendicular to the hull and (ii) viscosity of water causing friction which is tangential to the hull surface.

The pressure acting on the surface of the moving hull mainly depends upon the waves created by the ship, which leads to wave making resistance. For a ship, wave making resistance increases with increase in Froude Number. Rate of increase is higher at higher Froude Number.

Ships operating at relatively higher speed have higher Froude Number eg: container ships and passenger ships. A major cost component of operating a container ship is the fuel. Rising fuel price and legislated reduction of emission of carbon, SO_x and NO_x may make reduced energy consumption increasingly desirable.

With the development of advanced CFD tools, Naval Architects are able to optimize hull form for lower resistance. Bulbous bows were introduced many years back for ships with higher Froude Number. These approaches focus on the hull and appendages submerged in water.

Irrespective of optimization of hull form and use of bulbous bow, every moving ship will generate waves. Height of this wave increases significantly with increase in Froude Number. Lowering the effect of bow wave will be able to reduce the resistance and hence power consumption of the ship.

SUMMARY

In general terms the present invention proposes wing like appendages fitted on both sides of the bow of a ship. These wings are fitted above waterline. Optimum position and the angle of the wings with respect to the horizontal may depend on the hull form, draught and the Froude Number of the ship.

These appendages may reduce the height and/or profile of the bow wave and hence the overall resistance of the ship, which may lead to a reduction in fuel consumption. As the wave making

resistance is higher at higher Froude Number, there is higher fuel saving for ships operating at higher Froude Number. In particular the effect may be more pronounced in ships operating above 0.25 Froude Number, which corresponds to the speed of 19 knots for a 150 m long ship and 24,5 knots for a ship 250 m length. Depending upon the hull form and operating condition, the fuel saving may exceed 15%. The reduction may be higher for ships without a bulbous bow.

In a first specific expression of the invention there is provided a vessel according to claim 1.

In a second specific expression of the invention there is provided a hull appendage according to claim 7.

Embodiments may be implemented according to claims 2 to 6.

BRIEF DESCRIPTION OF DRAWINGS

One or more example embodiments of the invention will now be described, with reference to the following figures, in which:

Figures 1a and 1b are orthographic views of the ship and the wings for a ship without bulbous bow;

Figures 2a and 2b are orthographic views of the ship and the wings for a ship with bulbous bow;

Figure 3 is a perspective view of each wing;

Figures 4a to 4c are orthographic views of the wing showing the tilting angle; and

Figure 5 is a side view of the ship showing the reduction in bow wave.

DESCRIPTION

Figure 1 shows a vessel 100 having a hull 106, a bow 102, a design waterline 104 and a stern 108. A pair of wing like appendages 101 is fitted on both sides of the hull 106 above the waterline 104 and near the bow 102.

Figure 2 shows a vessel 200 having a bow 202, a submerged bulbous bow 203, a design waterline 204 and a stern 206. A pair of wings 201 is attached to the hull 206 above the waterline 204 and near the bow 202.

Figure 3 shows the wing 101,201 in more detail. It includes a lower surface 302, an upper surface 304 and a mounting 306. The lower surface 302 of the wing may be similar to the face of an aerofoil. The bow wave is forced up the bow hull surface as the vessel moves through the water until it encounters the lower surface 302. The lower surface 302 thereby reduces the height to which the bow wave can reach, and therefore reduces the energy required to move

the vessel through the water. In one aspect the bow wing 101 may represent a reduction in the integral of the bow wave projected over the hull surface, above the water line i.e. the bow wave profile. The mounting 306 height should be chosen so that under normal operating conditions the bow wave is guided by the lower surface 302, and that the bow wave does not flow over the upper surface 304.

The mountings 306 are to be fitted close to the bow at a location to maximise the reduction in the overall bow wave height. Typically for most vessels the bow wave occurs in the first 15% of the waterline length. The wings are fitted above design waterline. The port and starboard wings are symmetric and may be fitted at an angle perpendicular to the hull surface.

The wings are tilted at angle 400 greater than or equal to 0° (The angle is positive when the wing is turned anticlockwise when viewed from starboard) with the even keel waterline as shown in Figure 4.

Optimum size, position and the angle made with the even keel waterline may depend upon the type of ship, weather conditions, amplitude and width of the wave, operating draught, hull form of the ship and the Froude Number at which the ship operates. For example they may be determined empirically using a towing tank experiment or simulated using Computational Fluid Dynamics(CFD).

As shown in Figure 5 the wings 101 are to be fitted in such a way that the wave does not go over the wings. The shape of the wing towards the leading edge should be such that it does not cause the wave to break. The wing will be gradually lowered towards the trailing edge to maximise hydrodynamic efficiency.

Reducing the bow wave 500 height, helps to suppress the bow wave (compared to the original 502), resulting in a reduced wave profile at the bow end of the ship. This leads to reduction in resultant force in the direction of the stern due to pressure. In addition, a hydrodynamic lift acts on the lower surface of the wings, which causes reduction in wetted surface area of the ship resulting in a further reduction in resistance. As the wings are fitted at the bow, in some cases increased trim will lead to increased length on waterline and hence reduce the effective Froude Number, which further reduces resistance. Effectively the bow wings may lead to a reduction in the bow wave profile.

The optimised location, size and other parameters of the wing, as mentioned above, may be determined empirically using a towing tank experiment. In order to do this a model must be

designed to be geometrically the same as the real ship. Then the Froude number of the real ship and the model must match i.e. this determines the water velocity in the tank.

For example

$$F_n = \frac{V}{\sqrt{Lg}} = \frac{12.51}{\sqrt{237.7 \times 9.81}} = 0.259$$

Where

F_n = Froude Number of the ship

L = Length on Water Line, m = 237.7 m

g = acceleration due to gravity = 9.81 m/s²

V_s = Speed of the ship, m/s = 12.51 m/s

Therefore V_m (speed of the model) can be calculated depending on the length on the model, for a matched F_n of 0.259.

This allows the model to be used in testing various different configurations of the wing/appendage. To determine which configuration is best, it is necessary to compare the resistance and power of each configuration. To do this the towing tank includes a load cell to monitor the total resistance on the model (R_{Tm}). This can be used for example:

C_{Tm} = Coefficient of total resistance (model) = $f(R_{Tm})$, thus is calculated from the measured R_{Tm}

$C_{Tm} = C_{Fm} + C_{Rm}$

C_{Fm} = frictional resistance coefficient (model)

C_{Rm} = residual resistance coefficient (model)

$C_{Rs} = C_{Rm}$

C_{Fs} = Frictional resistance coefficient (ship) is calculated according to the actual ship

$C_{Ts} = C_{Fs} + C_{Rm}$

C_{Ts} = Coefficient of total resistance (ship) = 2.73×10^{-3}

This allows the total resistance of the ship (R_{Ts}) to be calculated

$$R_T = \frac{1}{2} C_T \rho S V^2 = \frac{1}{2} \times 2.73 \times 10^{-3} \times 1025 \times 9943.4 \times 12.51^2 = 2177.1 \text{ kN}$$

and this in turn allows

$$P_E = R_T V = 2177.1 \times 12.51 = 27235.52 \text{ kW}$$

P_E = Effective Power of the ship, W

ρ = Density of water in which the ship is moving, kg/m³ = 1025 kg/m³

S = Wetted surface area of the ship, m² = 9943.4 m²

The power for each configuration is thus compared to determine the lowest effective power required.

The upper 304 and lower 303 surface can be roll formed from same material as the hull of the ship, for example sheet steel, into the required aerofoil profile. This can then be welded to a frame including the mounting 306. The mounting 306 can in turn be welded to the hull or fitted with a mechanism to allow its position and the angle with the waterline to be adjusted for optimum performance. The mechanism may be controlled by the main ship navigation system, or a separate controller according to an algorithm. The algorithm may adjust or retract the wing 101 for different loading conditions, wind speed, wind direction, wave height, wave direction, list and/or vessel speed. The mechanism may take the form of hydraulic or electrical actuators.

Wings can be retrofitted to ships with no modification to the shape of the hull. It may only require modification of the forward structures. Additional side stringers and vertical stiffeners can be fitted along with fore peak bulkhead, side shell, frames, side longitudinal and other structures. Alternatively the wing may take the form of an integrated appendage or wave guide during ship building.

The wings can be fitted to container ships, passenger ship, naval ships, for example.

Whilst exemplary embodiments of the invention have been described in detail, many variations are possible within the scope of the invention as claimed as will be clear to a skilled reader.

REPLACEMENT SHEETS**CLAIMS**

MCSLLP

1. A vessel comprising:
a hull having a stern, bow and design waterline,
a single hull appendage attached to each side of the hull, each hull appendage being attached above the design waterline, adjacent the bow and configured to reduce the bow wave height and/or bow wave profile;
wherein each hull appendage has a lower surface in a wing or aerofoil shape.
2. The vessel in claim 1 wherein each hull appendage is attached within, and/or extends across a substantial portion of, the first 15% the design waterline from the bow.
3. The vessel in claim 2 wherein the size of each hull appendage is determined by type of ship, operating draught, hull form of the ship and/or the Froude Number.
4. The vessel in claim 3 wherein the location of the hull appendage is fixed or controllable, and determined by type of vessel, operating draught, hull form, the Froude Number, wind direction, wave amplitude, wave width, wave direction, list and/or vessel speed.
5. The vessel in claim 4 wherein the angle of the hull appendage is determined by type of vessel, operating draught, hull form, the Froude Number, wind amplitude, wind direction, wave amplitude, wave width, wave direction, list and/or vessel speed.
6. The vessel in claim 1 wherein the hull appendage comprises a mounting fitted with a mechanism to allow its position and the angle with the design waterline to be adjusted.