Summary of invention

Embodiments of the present invention overcome the drawbacks of background art and to achieve a vessel with efficient ice breaking capacity in difficult, moderate and light ice conditions and also to ensure that operational efficiency in open water is not impaired.

According to a first aspect of the present invention, there is provided an icebreaking vessel for operation in a body of water with a water surface at sea level, which icebreaking vessel includes a hull with a bottom, a bow part and a stern part, which bow part includes a forward inclined upper bow portion, a bulbous lower bow portion with a bulb root section at a given position of the bulbous lower bow portion in a longitudinal direction of the vessel, and an intermediate bow portion be-tween the forward inclined upper bow portion and the bulbous lower bow portion, which icebreaking vessel is designed with a construction water line, an upper ice water line and a lower ice water line, wherein an upper surface of the bulbous lower bow portion is arranged to be at or in the vicinity of the water surface when the vessel operates at the construction water line of the vessel, a lower surface of the bulbous lower bow portion is arranged to penetrate the water surface when the vessel operates at the lower ice water line of the vessel, and the forward inclined upper bow portion is arranged to penetrate the water surface when the vessel operates at the upper ice water line of the vessel, and a cross-sectional area of the bulb root section of the bulbous lower bow portion at the given position is smaller than a cross-sectional area of the bulbous lower bow portion at a first position in the longitudinal direction of the vessel forward of the given position and larger than a cross-sectional area of the bow part under the construction water line at a second position in the longitudinal direction of the vessel aft of the given position.

According to a second aspect of the present invention, there is provided a method of operating an icebreaking vessel in a body of water with a water surface at a sea level, which icebreaking vessel includes a hull with a bottom, a bow part and a stern part, which bow part includes a forward inclined upper bow portion, a bulbous lower bow portion with a bulb root section at a given position of the bulbous bow portion in a longitudinal direction of the vessel, and an intermediate bow portion be-tween said forward inclined upper bow portion and the bulbous lower bow portion, whereby the icebreaking vessel is designed with a construction water line, an upper ice water line and a lower ice water line, wherein according to the method an upper surface of the bulbous lower bow portion is kept at or in the vicinity of the water surface when the vessel operates at the construction water line of the vessel, a lower surface of the bulbous lower bow portion penetrates the water surface when

the vessel operates at the lower ice water line of the vessel, and the forward inclined upper bow portion penetrates the water surface when the vessel operates at the upper ice water line of the vessel, and movement of ice or chunks of broken ice backwards along the hull in the longitudinal direction of the vessel is facilitated by a cross-sectional area of the bulb root section of the bulbous lower bow portion at the given position that is smaller than a cross-sectional area of the bulbous lower bow portion at a first position in the longitudinal direction of the vessel forward of the given and larger than a cross-sectional area of the bow part under the construction water line at a second position in the longitudinal direction of the vessel aft of the given position.

The basic idea of embodiments of the invention is to design a marine vessel that has an efficient performance when required for icebreaking operation in various ice conditions and that has an efficient performance when required for operation in open water. The departing point of such a design is the construction waterline. The vessel is designed so that an upper surface of the bulbous lower bow portion is at or in the vicinity of the water surface when the vessel operates at the construction water line of the vessel, that a lower surface of the bulbous lower bow portion is arranged to penetrate the water surface when the vessel operates at the lower ice water line of the vessel, and in that the forward inclined upper bow portion is arranged to penetrate the water surface when the vessel operates at the upper ice water line of the vessel.

The advantages of the present invention can be given as follows.

When the vessel operates at the construction waterline, the vessel is loaded and without trim. In this floating position of the vessel, the upper surface of the bulbous lower bow portion is designed to be at or in the vicinity of the water surface. In practice the definition “at or in the vicinity” defines that the upper surface of the bulbous lower bow portion is wholly or partly at the water surface, or slightly below or slightly above the water surface. In ice conditions, the upper surface of the bulbous lower bow portion advantageously is designed to engage with ice or ice sheets encountered in light and moderate ice conditions. In other words, in this floating position the vessel is capable and optimized to operate in light and moderate ice conditions.

When the vessel operates at the lower ice waterline, the vessel, e.g., if it is a cargo carrying vessel, is without cargo and operates in a ballast condition. Alternatively, to obtain this floating position, the vessel may be intentionally trimmed by shifting ballast, consumables or possible cargo. In this floating position the vessel is able to operate in light and moderate ice conditions in a sufficiently adequate manner.

Claims

1. An icebreaking vessel for operation in a body of water with a water surface at sea level, which icebreaking vessel includes a hull with a bottom, a bow part and a stern part, which bow part includes a forward inclined upper bow portion, a bulbous lower bow portion with a bulb root section at a given position of the bulbous lower bow portion in a longitudinal direction of the vessel, and an intermediate bow portion between the forward inclined upper bow portion and the bulbous lower bow portion, which icebreaking vessel is designed with a construction water line, an upper ice water line and a lower ice water line, wherein

- an upper surface of the bulbous lower bow portion is arranged to be at or in the vicinity of the water surface when the vessel operates at the construction water line of the vessel,
- a lower surface of the bulbous lower bow portion is arranged to penetrate the water surface when the vessel operates at the lower ice water line of the vessel, and
- the forward inclined upper bow portion is arranged to penetrate the water surface when the vessel operates at the upper ice water line of the vessel, and

a cross-sectional area of the bulb root section of the bulbous lower bow portion at the given position is smaller than a cross-sectional area of the bulbous lower bow portion at a first position in the longitudinal direction of the vessel forward of the given position and larger than a cross-sectional area of the bow part under the construction water line at a second position in the longitudinal direction of the vessel aft of the given position.

2. Icebreaking vessel according to claim 1, wherein an angle between the forward inclined upper bow portion and the sea level when the vessel operates at the upper ice water line is at the most 40°.

3. Icebreaking vessel according to claim 2, wherein the angle is in a range between 10 ... 40°.

4. Icebreaking vessel according to claim 1, wherein when the vessel operates at the upper ice water line the forward inclined upper bow portion intersects with the sea level at a third position in the longitudinal direction of the vessel, and an angle between the form of the bow part and a vertical plane at a center line of the vessel at the third position in the longitudinal direction of the vessel is at least 75°.

5. Icebreaking vessel according to claim 1 and 4, wherein an angle between the form of the bow part and a vertical plane at a center line of the vessel at a position half-way between the given position and the third position in the longitudinal direction of the vessel is at the most 60°.

6. A method of operating an icebreaking vessel in a body of water with a water surface at a sea level, which icebreaking vessel includes a hull with a bottom, a bow part and a stern part, which bow part includes a forward inclined upper bow portion, a bulbous lower bow portion with a bulb root section at a given position of the bulbous bow portion in a longitudinal direction of the vessel, and an intermediate bow portion between said forward inclined upper bow portion and the bulbous lower bow portion, whereby the icebreaking vessel is designed with a construction water line, an upper ice water line and a lower ice water line, wherein according to the method

- an upper surface of the bulbous lower bow portion is kept at or in the vicinity of the water surface when the vessel operates at the construction water line of the vessel,
- a lower surface of the bulbous lower bow portion penetrates the water surface when the vessel operates at the lower ice water line of the vessel, and
- the forward inclined upper bow portion penetrates the water surface when the vessel operates at the upper ice water line of the vessel, and

movement of ice or chunks of broken ice backwards along the hull in the longitudinal direction of the vessel is facilitated by a cross-sectional area of the bulb root section of the bulbous lower bow portion at the given position that is smaller than a cross-sectional area of the bulbous lower bow portion at a first position in the longitudinal direction of the vessel forward of the given and larger than a cross-sectional area of the bow part under the construction water line at a second position in the longitudinal direction of the vessel aft of the given position.