

DESCRIPTION

COMBINED PROPELLER CAP FOR REDUCING ROTATING FLOW AND HUB VORTEX AND ENHANCING PROPULSION EFFICIENCY

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Technical Field

The present invention relates to the structure of a propeller cap and, more particularly to a combined propeller cap for reducing rotational flow and hub vortex and enhancing
10 propulsive efficiency, whereby the propeller cap reduces noise and vibration in a vessel by decreasing hub vortex cavitation behind a propeller for propelling the vessel, prevents erosion and corrosion of a rudder, and enhances propulsive efficiency to save fuel.

15 Further, the present invention relates to a combined propeller cap for reducing rotational flow and hub vortex and improving propulsive efficiency, the combined propeller cap being capable of reducing hub vortex cavitation that is generated behind a propeller by using a combined propeller cap
20 structure in which a diffusion type propeller cap is coupled to the end of a contraction type propeller cap in order to solve the problem with a PBCF (Propeller Boss Cap Fin) in the related art, which is difficult to manufacture and is expensive due to precise machining for designing and manufacturing fins
25 caused by a configuration of attaching a plurality of small

fins to a propeller cap to reduce hub vortex, and being capable of being easily manufactured with a low cost in a simple structure as compared with the PBCF.

Further, the present invention relates to a combined
5 propeller cap for reducing rotational flow and hub vortex and improving propulsive efficiency, the combined propeller cap being capable of additionally reducing hub vortex cavitation by forming a combined propeller cap structure, in which a diffusion type propeller cap is coupled to the end of a
10 contraction type propeller cap, and by attaching plate-shaped guide fins at a contractive section or between an contractive section and a diffusive section of the propeller cap, whereby it can reduce rotational flow and hub vortex cavitation that are generated behind a propeller and can be easily manufactured
15 at a low cost in a simple configuration, as compared with an existing PBCF.

Background Art

In general, sea vessels are moved forward by a thruster
20 such as a propeller that generates propulsion and such a propeller type thruster is connected to a rotary shaft of an engine of a vessel and rotated by power from the engine.

In detail, a propeller type thruster is largely includes a propeller cap connected to the rotary shaft of an engine to
25 form the body of a propeller and a plurality of blades formed

around the propeller cap, and propulsion and torque is generated by the flows passing the blades, whereby a vessel is moved forward by the propulsion with the torque offset by power from the engine.

5 In general, the propellers of vessels use only 70% of the power from a main engine as propulsion for moving the vessels forward and the other power from the engine is wasted as friction, a thermal loss, a vortex behind the propeller, and a propeller hub vortex.

10 In these factors, the rotational flow and the hub vortex behind the propeller consume about 5 ~ 7% and 1 ~ 3% of the power. Further, a strong hub vortex generates hub vortex cavitation, which causes problems such as noise, vibration, erosion and corrosion of a rudder. Accordingly, various
15 devices have been developed in the related art to solve problems with restoration of wasted energy and cavitation.

For example, a "Ship propulsion device and ship with same" has been disclosed in Korean Patent Application Publication No. 10-2011-0120267 to increase propulsion and save fuel by
20 decreasing hub vortex cavitation behind a propeller.

In detail, Korean Patent Application Publication No. 10-2011-0120267 relates to a ship propulsion device that has fins formed on a propeller boss cap mounted at the rear of a propeller boss of a screw propeller and disposed behind and
25 between the blades of the propeller and that can be easily

manufactured with high efficiency and low weight by cutting straight the rear end of the propeller boss cap or, by recessing the rear end of the propeller boss cap within 20% of the entire length of the propeller boss cap from the edge, making the
5 entire length of the propeller boss cap 0.28 ~ 0.76 times the diameter of the front end of the cap, and by making the diameter of the rear end of the propeller boss cap 0.35 ~ 0.95 times the diameter of the front end of the cap, and a ship equipped with the ship propulsion device.

10 Further, a "Propeller boss cap of the ship" for improving propulsion and saving fuel by reducing hub vortex cavitation behind a propeller has been disclosed in Korean Patent Application Publication No. 10-2012-0134647.

In detail, the propeller boss cap for a ship disclosed in
15 10-2012-0134647 is designed to be mounted on the rear side of a propeller boss, which is connected to the shaft of a propeller, to prevent corrosion of a rudder by suppressing hub vortex cavitation due to a flow behind the propeller without increasing additional resistance by the boss cap, by forming a
20 boss groove deep such that the center and the edge thereof are not at the same level, on a rudder-side surface of the boss cap.

As described above, there have been various studies for increasing propulsion and saving fuel by decreasing rotational
25 flow and hub vortex cavitation. However, according to these

methods of the related art, propeller caps are formed in specific shapes different from those existing before or forming a plurality of fins separate from the blades of propellers, so the configuration is complicated, whereby it is difficult to
5 design and manufacture a propeller, and the manufacturing cost is also increased.

In detail, as for a device for restoring rotational energy behind a propeller, as described above, there are a CRP (Contra-Rotating Propeller), a pre-swirl stator, a postswirl stator, a
10 vane-wheel, and a rudder thrust (bulb) fin). These devices have been known to save energy by about 2 ~ 5%, but they are relatively large structures, so they are expensive to install and mount and have a structural danger.

Further, for example, there is a PBCF (Propeller Boss Cap
15 Fin) and a rudder bulb that are devices for overcoming the problem with hub vortex cavitation by a propeller. These devices have an energy saving effect of about 1 ~ 3% and have a small and simple configuration, as compared with the devices for restoring rotational energy behind a propeller, so they can
20 be easily mounted and manufactured at low cost.

The PBCF, which was been developed in the 1970s, improves propeller efficiency about 1 ~ 3% by absorbing hub vortex energy using small fins on a propeller cap on the hub at the rear portion of a propeller and, reduces noise and erosion and

corrosion of a rubber due to hub vortex cavitation by decreasing hub vortex cavitation by the propeller.

However, the fins for the PBCF have to be designed in different ways every time to have appropriate characteristics, depending on the types of vessels and the use environment, require very precise design, and should be manufactured substantially in the same way as a propeller after being designed. Accordingly, a large manufacturing cost is needed, as compared with the rudder bulb.

Therefore, in order to solve the problems with the methods of reducing hub vortex cavitation by a propeller using the PBCF that requires precise design for each vessel, which should be manufactured in the same way as propellers, and thus is not easy to manufacture and which increases the manufacturing cost, it is required to develop a new propeller structure that can be manufactured at a low cost with a simpler configuration, can reduce hub vortex cavitation generated behind the propeller, thereby being able to reduce noise and vibration in a vessel, prevent erosion and corrosion of a rudder, and save fuel by improving propulsive efficiency.

Documents of Related Art

(Patent Document 1) Korean Patent Application Publication No. 10-2011-0120267 (Nov. 03, 2011)

(Patent Document 2) Korean Patent Application Publication No. 10-2012-0134647 (Dec. 12, 2012)

Disclosure

Technical Problem

An object of the present invention is to provide a
5 combined propeller cap for reducing rotational flow and hub
vortex and improving propulsive efficiency, the combined
propeller cap being capable of reducing hub vortex cavitation
that is generated behind a propeller by using a combined
propeller cap structure in which a diffusion type propeller cap
10 is coupled to the end of a contraction type propeller cap in
order to solve the problem with a PBCF (Propeller Boss Cap Fin)
in the related art, which is difficult to manufacture and is
expensive due to precise machining for designing and
manufacturing fins caused by a configuration of attaching a
15 plurality of small fins to a propeller cap to reduce hub vortex
cavitation, and being capable of being easily manufactured with
a low cost in a simple structure as compared with the PBCF.

Another object of the present invention is to provide a
combined propeller cap for reducing rotational flow and hub
20 vortex and improving propulsive efficiency that is configured
not only to reduce hub vortex cavitation that is generated
behind a propeller through a combined propeller cap structure
in which a diffusion type propeller cap is coupled to the end
of a contraction type propeller cap, but also to additionally
25 reduce hub vortex cavitation by attaching plate-shaped guide

fins to the contractive section or between the contractive section and the diffusive section of the propeller cap, whereby it is possible to reduce rotational flow and hub vortex cavitation that are generated behind a propeller, to easily
5 manufacture the propeller cap at a low cost in a simple configuration, as compared with the existing PBCF, to reduce noise and vibration in a vessel and prevent erosion and corrosion of a rudder, and to save fuel by improving propulsive efficiency.

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Technical Solution

In order to achieve the objects of the present invention, according to an aspect of the present invention, there is provided a combined propeller cap for reducing rotational flow
15 and hub vortex and improving propulsive efficiency. The combined propeller cap has: a contractive section having a diameter that decreases as it goes away from a propeller; and a diffusive section extending from the contractive section and having a diameter that increases as it goes away from the
20 propeller, in which pressure of a flow from the propeller is recovered by the shape of the contractive section having the decreasing diameter, so propulsive efficiency is improved, and rotational flow (vortex) is weakened by the shape of the diffusive section having the increasing diameter at an end of
25 the propeller cap.

The inclination angle of the contractive section may be set to $0 \sim 40^\circ$.

A side of the contractive section may be formed straight, or the side of the contractive section may be curved to be
5 convex outwardly with a predetermined curvature, or the side of the contractive section may be curved to be convex inwardly with a predetermined curvature.

According to another aspect of the present invention, there is provide a combined propeller cap for reducing
10 rotational flow and hub vortex and improving propulsive efficiency. The combined propeller cap has: a first diffusive section having a diameter that increases from an end of a propeller as it goes toward the propeller; a straight section horizontally extending from the first diffusive section; a
15 contractive section extending from the straight section and having a diameter that decreases as it goes away from the propeller; and a second diffusive section extending from the contractive section and having a diameter that increases as it goes away from the propeller, in which the combined propeller
20 cap is convexly formed at a front portion by the first diffusive section, so pressure at a pressure side of the propeller increases and propulsive efficiency is improved, pressure of a flow passing the propeller cap from the propeller is recovered by the contractive section, so the propulsive efficiency is
25 improved, and rotational flow (vortex) of a flow from the

propeller is weakened by the second diffusive section, so hub vortex cavitation is reduced.

The inclination angles of the first diffusive section and the second diffusive section may be set to $0 \sim 40^\circ$.

5 A side of the contractive section may be formed straight, or the side of the contractive section may be curved to be convex outwardly with a predetermined curvature, or the side of the contractive section may be curved to be convex inwardly with a predetermined curvature.

10 According to another aspect of the present invention, there is provided a combined propeller cap for reducing rotational flow and hub vortex and improving propulsive efficiency. The combined propeller cap has: a contractive section having a diameter that decreases as it goes away from
15 a propeller; a diffusive section extending from the contractive section and having a diameter that increases as it goes away from the propeller; and a plurality of guide fins formed in a thin plate shape having a rectangular or curved cross-section with a predetermined uniform thickness and, disposed with
20 regular intervals between the contractive section and the diffusive section; in which pressure of a flow from the propeller is recovered by the shape of the contractive section having the decreasing diameter, so propulsive efficiency is improved, rotational flow (vortex) is weakened by the shape of
25 the diffusive section having the increasing diameter at an end

of the propeller cap, and rotational flow by rotation of the propeller is changed into a straight flow in a rotational axial direction, so the hub vortex cavitation is further reduced.

The inclination angle of the contractive section may be
5 set to $0 \sim 40^\circ$.

A side of the contractive section may be formed straight, or the side of the contractive section may be curved to be convex outwardly with a predetermined curvature, or the side of the contractive section may be curved to be convex inwardly
10 with a predetermined curvature.

The guide fins may be formed in a thin rectangular plate shape and attached between the contractive section and the diffusive section of the propeller cap by simple welding, and a size of the guide fins may be determined to correspond to
15 the diameter of the diffusive section in order to avoid an increase in resistance due to the guide fins.

The guide fins may be formed in a thin pentagonal plate shape and attached between the contractive section and the diffusive section of the propeller cap by simple welding, and
20 a length of a portion extending from an end of the diffusive section may be within two times the diameter of the diffusive section.

The guide fins may be formed in a thin trapezoidal plate shape and attached between the contractive section and the
25 diffusive section of the propeller cap by simple welding, and

a length of a shortest portion of portions extending from a side of the contractive section may be within two times the diameter of the diffusive section.

Two to eight guide fins may be disposed at the contractive
5 section or between the contractive section and the diffusive section of the propeller cap, and the guide fins may be attached with a tolerance of $+10 \sim -10$ degrees or $+20 \sim -20$ degrees with respect to 0 degree when seen from vertically above.

According to another aspect of the present invention,
10 there is provided a combined propeller cap for reducing rotational flow and hub vortex and improving propulsive efficiency. The combined propeller cap has: a first diffusive section having a diameter that increases from an end of a propeller as it goes toward the propeller; a straight section
15 horizontally extending from the first diffusive section; a contractive section extending from the straight section and having a diameter that decreases as it goes away from the propeller; a second diffusive section extending from the contractive section and having a diameter that increases as it
20 goes away from the propeller; and a plurality of guide fins formed in a thin plate shape having a rectangular or curved cross-section with a predetermined uniform thickness and, disposed with regular intervals at the contractive section or between the contractive section and the diffusive section, in
25 which the combined propeller cap is convexly formed at a front

portion by the first diffusive section, so pressure at a pressure side of the propeller increases and propulsive efficiency is improved, pressure of a flow passing the propeller cap from the propeller is recovered by the
5 contractive section, so the propulsive efficiency is improved, rotational flow (vortex) of a flow from the propeller is weakened by the second diffusive section, so hub vortex cavitation is reduced, and rotational flow by rotation of the propeller is changed into a straight flow in a rotational axial
10 direction, so the hub vortex cavitation is further reduced.

The inclination angles of the first diffusive section and the contractive section may be set to $0 \sim 40^\circ$.

A side of the contractive section may be formed straight, or the side of the contractive section may be curved to be
15 convex outwardly with a predetermined curvature, or the side of the contractive section may be curved to be convex inwardly with a predetermined curvature.

The guide fins may be formed in a thin rectangular plate shape and attached between the contractive section and the
20 second diffusive section of the propeller cap by simple welding, and a size of the guide fins may be determined to correspond to the diameter of the diffusive section in order to avoid an increase in resistance due to the guide fins.

The guide fins may be formed in a thin pentagonal plate
25 shape and attached between the contractive section and the

second diffusive section of the propeller cap by simple welding, and a length of a portion extending from an end of the second diffusive section may be within two times the diameter of the second diffusive section.

5 The guide fins may be formed in a thin trapezoidal plate shape and attached between the contractive section and the diffusive section of the propeller cap by simple welding, and a length of a shortest portion of portions extending from a side of the contractive section may be within two times the
10 diameter of the second diffusive section.

Two to eight guide fins may be disposed at the contractive section or between the contractive section and the second diffusive section of the propeller cap, and the guide fins may be attached with a tolerance of $+10 \sim -10$ degrees or $+20 \sim -20$
15 degrees with respect to 0 degree when seen from vertically above.

According to another aspect of the present invention, there is provided a propeller for a vessel, which uses the combined propeller caps described above, in which as compared
20 with existing propellers, energy loss due to hub vortex cavitation and a propeller cap shape is prevented and propulsive efficiency is improved, vibration and noise are reduced, and erosion and corrosion of a rudder by the hub vortex cavitation are prevented, and in comparison to existing PBCFs,
25 manufacturing cost is reduced.

Advantageous Effects

According to the present invention, there is provided a combined propeller cap for reducing rotational flow and hub vortex and improving propulsive efficiency, the combined propeller cap being capable of reducing hub vortex cavitation that is generated behind a propeller and being capable of being easily manufactured at a low cost in a simple configuration, as compared with the existing PBCF, through a combined propeller cap structure in which a diffusion type propeller cap is coupled to the end of a contraction type propeller cap, whereby it is possible to solve the problem with a PBCF (Propeller Boss Cap Fin) in the related art, whereby manufacturing is difficult and expensive due to precise machining for designing and manufacturing fins caused by a configuration of attaching a plurality of small fins to a propeller cap to reduce hub vortex cavitation.

Further, according to the present invention, as described above, there is provided a combined propeller cap for reducing rotational flow and hub vortex and improving propulsive efficiency that is configured not only to reduce hub vortex cavitation that is generated behind a propeller through the combined propeller cap in which a diffusion type propeller cap is coupled to the end of a contraction type propeller cap, but also to additionally reduce hub vortex cavitation by attaching

plate-shaped guide fins to the contractive section or between the contractive section and the diffusive section of the propeller gap. Accordingly, it is possible to reduce rotational flow and hub vortex cavitation that are generated behind a propeller, to easily manufacture the propeller cap at a low cost in a simple configuration, as compared with the existing PBCF, to reduce noise and vibration in a vessel and prevent erosion and corrosion of a rudder, and to save fuel by improving propulsive efficiency.

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Description of Drawings

FIG. 1 is a view schematically showing the structure of a propeller cap of the related art.

FIG. 2 is a view schematically showing the entire configuration of a combined propeller cap according to a first embodiment of the present invention.

FIG. 3 is a view schematically showing the entire configuration of a combined propeller cap according to a second embodiment of the present invention.

FIG. 4 is a view comparing efficiency of a propeller equipped with a propeller cap of the related art and a propeller equipped with the combined propeller cap according to the first embodiment of the present invention shown in FIG. 2.

FIG. 5 is a view schematically showing the entire configuration of a combined propeller cap according to a third embodiment of the present invention.

FIG. 6 is a view schematically showing the entire
5 configuration of a combined propeller cap according to a fourth embodiment of the present invention.

FIG. 7 is a view comparing efficiency of a propeller equipped with a propeller cap of the related art and a propeller equipped with the combined propeller caps according to the
10 third and fourth embodiments of the present invention shown in FIGS. 5 and 6.

FIG. 8 is a view schematically showing the entire configuration of a combined propeller cap according to a fifth embodiment of the present invention.

FIG. 9 is a view comparing propulsion, torque, and
15 efficiency of a propeller equipped with a propeller cap of the related art and a propeller equipped with the combined propeller cap according to the fifth embodiment of the present invention shown in FIG. 8.

FIG. 10 is a view schematically showing the entire
20 configuration of a combined propeller cap according to a sixth embodiment of the present invention.

FIG. 11 is a view schematically showing the entire configuration of a combined propeller cap according to a
25 seventh embodiment of the present invention.

FIG. 12 is a view comparing efficiency of a propeller equipped with a propeller cap of the related art and a propeller equipped with the combined propeller cap according to the seventh embodiment of the present invention shown in FIG. 11.

5 FIG. 13 is a view schematically showing the entire configuration of a combined propeller cap according to an eighth embodiment of the present invention.

FIG. 14 is a view schematically showing the entire configuration of a combined propeller cap according to a ninth
10 embodiment of the present invention.

FIG. 15 is a view schematically showing the entire configuration of a combined propeller cap according to a tenth embodiment of the present invention.

FIG. 16 is a view comparing propulsion, torque, and
15 efficiency of a propeller equipped with a propeller cap of the related art and a propeller equipped with the combined propeller cap according to the ninth embodiment of the present invention shown in FIG. 14.

20 **Best Mode**

Hereinafter, detailed embodiments of a combined propeller cap for reducing rotational flow and hub vortex and improving propulsive efficiency according to the present invention are described with reference to accompanying drawings.

It should be understood that the following description is just an example for accomplishing the present invention and the present invention is not limited thereto.

Further, it should be understood that components that is
5 determined as being the same as or similar to those in the related art or as being easily understood and achieved by those skilled in the art are not described in detail for simple description in the following description about embodiments of the present invention.

10 Further, in the following description about embodiments of the present invention, it should be understood that the same or similar components are given the same reference numerals and are not described in detail for simple description.

Further, as described below, the present invention relates
15 to a combined propeller cap for reducing rotational flow and hub vortex and improving propulsive efficiency, the combined propeller cap being capable of reducing hub vortex cavitation that is generated behind a propeller by using a combined propeller cap structure in which a diffusion type propeller cap
20 is coupled to the end of a contraction type propeller cap in order to solve the problem with a PBCF (Propeller Boss Cap Fin) in the related art, whereby manufacturing is difficult and expensive due to precise machining for designing and manufacturing fins caused by a configuration of attaching a
25 plurality of small fins to a propeller cap to reduce hub vortex

cavitation, and being capable of being easily manufactured with a low cost in a simple structure as compared with the PBCF.

Further, as described below, the present invention relates to a combined propeller cap for reducing rotational flow and hub vortex and improving propulsive efficiency that is configured not only to reduce hub vortex cavitation that is generated behind a propeller through a combined propeller cap structure in which a diffusion type propeller cap is coupled to the end of a contraction type propeller cap, but also to additionally reduce hub vortex cavitation by attaching plate-shaped guide fins to the contractive section or between the contractive section and the diffusive section of the propeller cap, whereby it is possible to reduce rotational flow and hub vortex cavitation that are generated behind a propeller, to easily manufacture the propeller cap at a low cost in a simple configuration, as compared with the existing PBCF, to reduce noise and vibration in a vessel and prevent erosion and corrosion of a rudder, and to save fuel by improving propulsive efficiency.

Hereinafter, detailed embodiments of a combined propeller cap for reducing rotational flow and hub vortex and improving propulsive efficiency according to the present invention are described with reference to accompanying drawings.

First, referring to FIG. 1, FIG. 1 is a view schematically showing the structure of a propeller cap of the related art.

As shown in FIG. 1, generally, a propeller cap of the related art can be largely classified into three types: a contraction type propeller cap shown in FIG. 1a, a straight type propeller cap shown in FIG. 1b, and a diffusion type propeller cap shown in FIG. 1c.

In detail, the contraction type propeller cap has high propulsive efficiency, but large hub vortex cavitation is caused by concentration of motion of the hub in the cap, so noise and vibration are increased and erosion and corrosion of a rudder may become severe.

On the other hand, the diffusion type propeller cap has low propulsive efficiency, but hub vortex cavitation is weakened, so noise and vibration can be reduced and erosion and corrosion of a rudder can be attenuated.

Accordingly, in general, vessels that sail at high speeds such as a container ship are usually equipped with the diffusion type propeller cap due to the problem of corrosion of a rudder due to hub vortex cavitation and are additionally equipped with an additional device such as a PBCF to overcome reduction of propulsive efficiency, thereby improving the propulsive efficiency and coping with hub vortex cavitation.

On the contrary, tank ships that sail low speeds are usually equipped with the contraction type propeller cap because they generate weak hub vortex cavitation.

When a container ship using a diffusion type propeller is equipped with a PBCF that is a device for saving fuel to prevent reduction of propulsive efficiency, the fins of the PBCF are designed and manufactured in the same way as the existing
5 propellers, so the manufacturing cost is high relative to the size.

Therefore, the inventor(s) has proposed a new propeller cap structure that can improve propulsive efficiency with low hub vortex cavitation, similar to the PBCF, and can achieve an
10 effect similar to the PBCF even at a very low manufacturing cost in comparison to the manufacturing cost of the PBCF by simplifying the configuration.

Further, referring to FIG. 2, shown is a view schematically showing the entire configuration of a combined
15 propeller cap 20 according to a first embodiment of the present invention.

In detail, as shown in FIG. 2, the combined propeller cap 20 according to the first embodiment of the present invention includes a contraction section 21 of which the diameter
20 decreases as it goes away from a propeller and a diffusive section 22 that extends from the contractive section and of which the diameter increases as it goes away from the propeller.

That is, the combined propeller cap 20 according to the first embodiment of the present invention, as shown in FIG. 2,
25 has a shape of which the diameter gradually decreases from the

end of a propeller and increases at the end portion of the propeller cap.

The inclination angle α of the contractive section 21 may be set, for example, to $0 \sim 40^\circ$.

5 When the inclination angle of the contractive section 21 exceeds 40 degrees, the performance rapidly drops due to flow separation, that is, when flow separation is generated, pressure is not recovered on the propeller cap, so resistance increases.

10 In more detail, referring to the following Table 1, Table 1 shows changes in performance due to changes in the inclination angle α of the contractive section 22.

[Table 1]

15

Angle (α)	10	20	30	40	50	60
Performance change (%)	+1.0	+1.0	+0.9	+0.7	+0.2	+0.2

The result in Table 1 shows estimated values of propulsive performance according to changes in the inclination angle α of the contractive section 22, as compared with a propeller
20 equipped with a diffusion type propeller cap of the related art.

Further, referring to FIG. 3, FIG. 3 is a view schematically showing the entire configuration of a combined propeller cap 30 according to a second embodiment of the present invention.

5 In the following description of the second embodiment of the present invention, the same or similar components as in the first embodiment are not described and only other different components are described for simple description.

That is, as shown in FIG. 3, the combined propeller cap
10 30 according to the second embodiment of the present invention has a contractive section 31 of which the diameter decreases as it goes away from a propeller and a diffusive section 32 that extends from the contractive section 31 and of which the diameter increases as it goes away from the propeller, which
15 is the same as the first embodiment shown in FIG. 2. However, the propeller cap 30 according to the second embodiment of the present invention is characterized in that the contractive section 31 is not formed straight, as in the first embodiment, but curved with a predetermined curvature.

20 That is, the combined propeller cap 30 according to the second embodiment of the present invention is characterized in that the contractive section 31 is curved to be convex outwardly with a predetermined curvature, as shown in FIG. 3a, or is curved to be convex inwardly with a predetermined curvature,
25 as shown in FIG. 3b.

The curvature of the contractive section 31 can be appropriately determined, depending on the type or the use of a propeller or a ship, and other parts are the same as those in the first embodiment, so they are not described in detail.

5 Accordingly, as the propeller cap is formed in a shape of which the diameter decreases and increases again, when a propeller is operated, pressure is recovered and propulsive efficiency is improved by the shape of which the diameter decreases to the contractive sections 21 and 31 at the middle
10 portion of the propeller caps 20 and 30 and a strong rotational flow (vortex) is weakened by the shape of which the diameter increases over the diffusive sections 22 and 32 at the end of the propeller caps 20 and 30, whereby it is possible to reduce hub vortex cavitation.

15 Further, energy loss due to hub vortex and a cap shape is prevented accordingly, so the propulsive efficiency can be improved in comparison to the existing diffusion type propellers (1 ~ 3%), vibration and noise due to hub vortex can be reduced, and erosion and corrosion of a rudder can be
20 prevented in comparison to the existing contraction type propeller caps.

In more detail, referring to FIG. 4, shown is a view comparing propulsive efficiency of a propeller equipped with a propeller cap of the related art and a propeller equipped with

the combined propeller cap 20 according to the first embodiment of the present invention shown in FIG. 2.

That is, it can be seen from FIG. 4 that the propeller equipped with the combined propeller cap 20 according to the first embodiment of the present invention had propulsive efficiency similar to that of the contraction type propeller cap of the related art, but side effects due to hub vortex cavitation can be greatly reduced and the propulsive efficiency was considerably improved as compared with the diffusion type propeller cap.

That is, as described above, according to the configuration of the combined propeller caps 20 and 30 of the first and second embodiments of the present invention, the propulsive efficiency is improved by pressure recovery due to the shape from a propeller to the contractive sections 21 and 31 and a strong rotational flow (vortex) is weakened by the diffusive sections 22 and 32 while the flow from the propeller passes over the ends of the caps, whereby hub vortex cavitation can be suppressed. Accordingly, energy loss due to hub vortex and a cap shape is prevented, so the propulsive efficiency of a vessel can be improved by about 1 ~ 3% in comparison to the existing diffusion type propeller. Further, vibration and noise due to hub vortex cavitation can be reduced, and erosion and corrosion of a rudder can be prevented, as compared with the contraction type propeller caps.

Further, according to the configuration of the combined propeller caps 20 and 30 of the first and second embodiments of the present invention described above, there is an advantage that it is possible to reduce hub vortex cavitation, similar
5 to the existing diffusion type propeller caps used for container ships, and it is possible to improve propulsive efficiency in comparison to the existing diffusion type propeller cap. Further, there is another advantage that it is possible to obtain propulsive efficiency similar to the
10 contraction type propeller caps when it is applied to tank ships, but it is possible to greatly reduce hub vortex cavitation.

Further, since the shapes of the combined propeller caps 20 and 30 of the first and second embodiments of the present
15 invention described above are simple in structure, they can be easily manufactured, so there is also an advantage that it is possible to remarkably decrease the manufacturing cost, which was over one hundred million South Korean won due to precise machining of the fins of the PBCF in the related art, to within
20 thirty million South Korean won similar to the existing propeller caps.

Further, referring to FIG. 5, FIG. 5 is a view schematically showing the entire configuration of a combined propeller cap 50 according to a third embodiment of the present
25 invention.

In detail, the combined propeller cap 50 according to the third embodiment of the present invention has a first diffusive section 51 of which the diameter increases from the end of a propeller, a straight section 52 that horizontally extends from
5 the first diffusive section 51, a contractive section 53 that extends from the straight section 52 and of which the diameter decreases as it goes away from the propeller, and a second diffusive section 54 that extends from the contractive section 53 and of which the diameter increases again as it goes away
10 from the propeller.

That is, the combined propeller cap 50 according to the third embodiment of the present invention, as shown in FIG. 5, has a shape of which the diameter gradually decreases from the end of a propeller to a predetermined portion, but increases
15 at the end portion of the propeller cap.

In more detail, since the combined propeller cap 50 according to the third embodiment of the present invention is convexly formed at the front portion by the first diffusive section 51, as shown in FIG. 5, the pressure at the pressure
20 side of the propeller increases, thereby improving the propulsive efficiency.

That is, the propeller cap 50 according to the third embodiment of the present invention for reducing hub vortex cavitation and improving propulsive efficiency is additionally
25 improved in propulsive efficiency by pressure recovery due to

the shape from the propeller to the contractive section 53 at the middle portion, as shown in FIG. 5, and can reduce hub vortex cavitation by decreasing a strong rotational flow (vortex) through the second diffusive section 54 while the flow
5 from the propeller passes over the end of the diffusive cap.

Further, as hub vortex cavitation is reduced, as described above, it is possible to improve propulsive efficiency in comparison to the existing diffusion type propeller caps and it is also possible to prevent vibration and noise due to hub
10 vortex cavitation and erosion and corrosion of a rudder. Further, it is possible to more efficiently prevent vibration and noise and, erosion and corrosion of a rudder and to improve propulsive efficiency, as compared with the existing contraction type propeller caps.

15 The inclination angles α and β of the contractive section 1 and the second diffusive section 54, respectively, may be set, for example, to $0 \sim 40^\circ$.

When α and β exceed 40 degrees, the performance rapidly drops due to flow separation, that is, when flow separation is
20 generated, pressure is not recovered on the propeller cap, so resistance increases.

In more detail, referring to the following Table 2, Table 2 shows changes in performance due to changes in the inclination angles α and β of the second diffusive section 54.

25

[Table 2]

Angle (α)	10	20	30	40	50	60
Performance change (%)	+1.1	+1.1	+1.1	+1.0	+0.7	+0.7
Angle (β)	10	20	30	40	50	60
Performance change (%)	+1.1	+1.1	+1.1	+0.8	+0.3	+0.2

In Table 1, when α was changed, β was fixed at 30 degrees, while when β was changed, α was fixed at 30 degrees. Further, the result in Table 2 shows estimated values of propulsive performance according to angle changes, as compared with a propeller equipped with an existing diffusion type propeller cap.

Further, referring to FIG. 6, FIG. 6 is a view schematically showing the entire configuration of a combined propeller cap 60 according to a fourth embodiment of the present invention.

In the following description of the fourth embodiment of the present invention, the same or similar components as in the third embodiment are not described and only other different components are described for simple description.

That is, as shown in FIG. 6, the combined propeller cap 60 according to the fourth embodiment of the present invention has a first diffusive section 61 of which the diameter increases

from the end of a propeller, a straight section 62 that horizontally extends from the first diffusive section 61, a contractive section 63 that extends from the straight section 62 and of which the diameter decreases as it goes away from the propeller, and a second diffusive section 64 that extends from the contractive section 63 and of which the diameter increases again as it goes away from the propeller, so the diameter increases from the end of the propeller to a predetermined portion, but increases again at the rear end portion of the propeller cap, which is the same as the third embodiment shown in FIG. 5.

However, in the combined propeller cap 60 according to the fourth embodiment of the present invention, the contractive section 63 is not straight as in the third embodiment shown in FIG. 5, but is curved with a predetermined curvature.

That is, the combined propeller cap 60 according to the fourth embodiment of the present invention is characterized in that the contractive section 63 is curved to be convex outwardly with a predetermined curvature, as shown in FIG. 6a, or is curved to be convex inwardly with a predetermined curvature, as shown in FIG. 6b.

The curvature of the contractive section 63 can be appropriately determined, depending on the type or the use of a propeller or a ship, and other parts are the same as those in the third embodiment, so they are not described in detail.

Therefore, according to this configuration, it is possible to not only reduce hub vortex cavitation with a simple configuration, but further improve propulsive efficiency in comparison to propeller caps in the related art.

5 In more detail, referring to FIG. 7, shown is a view comparing efficiency of a propeller equipped with a propeller cap of the related art and a propeller equipped with the combined propeller caps 50 and 60 according to the third and fourth embodiments of the present invention shown in FIGS. 5
10 and 6.

That is, it can be seen from FIG. 7 that the efficiency of the propellers equipped with the propeller caps 50 and 60 according to embodiments of the present invention was improved, as compared with the existing contraction type propeller cap
15 and the diffusion type propeller cap.

As described above, according to the combined propeller caps 50 and 60 of the third and fourth embodiments of the present invention, since the first diffusive sections 51 and 61 are formed such that the front portions of the propeller caps
20 are convexly formed, the pressure at the pressure side of a propeller increases and the propulsive efficiency is improved. Further, the propulsive efficiency is further improved by pressure recovery due to the shapes of the contractive sections 53 and 63 at the middle portions.

Further, as a strong rotational flow (vortex) is weakened by the second diffusive sections 54 and 64 while the flow from the propeller passes over the diffusive cap end, hub vortex cavitation can be reduced, the propulsive efficiency of a vessel can be improved about 1 ~ 3% in comparison to the existing diffusion type propeller, vibration and noise due to hub vortex cavitation can be reduced, and erosion and corrosion of a rudder can be prevented in comparison to the existing contraction type propeller caps.

That is, according to the configuration of the combined propeller caps 50 and 60 of the third and fourth embodiments of the present invention described above, there is an advantage that it is possible to reduce hub vortex cavitation, similar to the existing diffusion type propeller caps used for container ships, and it is possible to improve propulsive efficiency in comparison to the existing diffusion type propeller cap. Further, there is another advantage that it is possible to obtain propulsive efficiency similar to the contraction type propeller caps when it is applied to tank ships, but it is possible to greatly reduce hub vortex cavitation.

Further, since the shapes of the combined propeller caps 50 and 60 of the third and fourth embodiments of the present invention described above are simple in structure, they can be easily manufactured, so there is also an advantage that it is

possible to remarkably decrease the manufacturing cost, which was over one hundred million South Korean won due to precise machining of the fins of the PBCF in the related art, to within thirty million South Korean won similar to the existing
5 propeller caps.

Further, referring to FIG. 8, FIG. 8 is a view schematically showing the entire configuration of a combined propeller cap 80 according to a fifth embodiment of the present invention.

10 In more detail, as shown in FIG. 8, the combined propeller cap 80 according to the fifth embodiment of the present invention has a contractive section 81 of which the diameter decreases as it goes away from a propeller, a diffusive section 82 that extends from the contractive section 81 and of which
15 the diameter increases as it goes away from the propeller, and a plurality of guide fins 83 that is formed in a thin plate shape having a rectangular or curved cross-section with a predetermined uniform thickness and is disposed with regular intervals between the contractive section 81 and the diffusive
20 section 82.

That is, in the combined propeller cap 80 according to the fifth embodiment of the present invention, as shown in FIG. 8, the diameter gradually decreases from the end of a propeller and increases again at the rear end portion, in which the guide
25 fins 83 having a triangular plate shape are added at the

contractive section 81 or between the contractive section 81 and the diffusive section 82 of the propeller cap 80.

In this configuration, the inclination angle α of the contractive section 81 may be, for example, set to $0 \sim 40^\circ$, and
5 when the inclination angle of the contractive section 81 exceeds 40 degrees, the performance rapidly drops due to flow separation. Further, when flow separation is generated, pressure is not recovered on the propeller cap, so resistance increases.

10 In more detail, referring to the following Table 3, Table 3 shows changes in performance due to changes in the inclination angle α of the contractive section 82.

[Table 3]

15

Angle (α)	10	20	30	40	50	60
Performance change (%)	+1.2	+1.2	+1.1	+0.9	+0.3	+0.2

The result in Table 3 shows estimated values of propulsive performance according to changes in the inclination angle α of the contractive section 82, as compared with a propeller
20 equipped with a diffusion type propeller cap of the related art.

Accordingly, as the propeller cap is formed in a shape of which the diameter decreases and increases again, when a propeller is operated, pressure is recovered and propulsive efficiency is improved by the shape of which the diameter
5 decreases to the contractive section 81 at the middle portion of the propeller cap 80 and a strong rotational flow (vortex) is weakened by the shape of which the diameter increases over the diffusive section 82 at the end of the propeller cap 80, whereby it is possible to reduce hub vortex cavitation.

10 Further, energy loss due to hub vortex is prevented accordingly, so the propulsive efficiency can be improved in comparison to the existing diffusion type propellers, vibration and noise due to hub vortex cavitation can be reduced, and erosion and corrosion of a rudder can be prevented in comparison
15 to the existing contraction type propeller cap.

Further, the guide fins 83, as shown in FIG. 8, for example, are formed in a thin triangular plate shape to be fitted in the recession between the contractive section 81 and the diffusive section 82 of the propeller cap 80 and attached
20 with regular intervals simply by welding. Accordingly, a vortex induced by rotation of a propeller not only weakens over the diffusive section 82, but weakens in advance before the diffusive section 82 of the propeller cap 30, so the vortex due to the rotation of the propeller changes into a straight flow

in the rotational axial direction, whereby hub vortex cavitation can be additionally reduced.

The number of the guide fins 83 may be appropriately changed, for example, within 2 ~ 8 and the size of the guide
5 fins may be determined in accordance with the diameter of the diffusive section 82 to avoid an increase in resistance due to the guide fins.

Further, the guide fins 83 are attached with a manufacturing tolerance of +20 ~ -20 degrees, preferably +10 ~
10 -10 degrees with respect to 0 degree when seen from vertically above.

In more detail, according to the propeller cap 80 of the fifth embodiment of the present invention, the propulsive efficiency is improved by pressure recovery due to the shape
15 from the propeller to the contractive section 81 at the middle portion and a strong rotational flow (vortex) is weakened by the diffusive section 82 while a flow from the propeller passes over the diffusive cap end, so hub vortex cavitation can be reduced. Further, since the guide fins 83 having a triangular
20 plate shape are attached between the contractive section 81 and the diffusive section 82 of the propeller cap 80, as described above, a vortex induced by rotation of the propeller is weakened by the guide fins 83 before it reaches the diffusive section 82 of the propeller cap 80, so the vortex by the rotation of
25 the propeller is changed into a straight flow in the rotational

axial direction, whereby hub vortex cavitation can be further reduced, thus rotational flow and hub vortex cavitation by rotation of the propeller both can be reduced. Accordingly, energy loss due to hub vortex is prevented, so the propulsive efficiency of a vessel can be improved about 1 ~ 3% in comparison to the existing diffusion type propellers, vibration and noise due to hub vortex cavitation can be reduced, and erosion and corrosion of a rudder can be prevented in comparison to the existing contraction type propeller caps.

That is, according to the principle of the combined propeller cap 80 of the fifth embodiment of the present invention having the configuration described above, the propulsive efficiency is improved by pressure recovery from the propeller to the contractive section 81 at the middle portion by the shape and a strong rotational flow (vortex) is weakened by the diffusive section 82 while the flow generated by the propeller flows over the end of the cap, so hub vortex cavitation is reduced. Further, since the guide fins 83 having a plate shape are attached between the contractive section 81 and the diffusive section 82 of the propeller cap 80, the vortex induced by rotation of the propeller is weakened by the guide fins 83 before reaching the diffusive section 82 of the propeller cap 80, so the vortex by the rotation of the propeller is changed into a straight flow in the rotational axial

direction, thus rotational flow and hub vortex cavitation can be reduced.

Therefore, according to the combined propeller cap 80 of the fifth embodiment of the present invention having the configuration described above, not only hub vortex cavitation is reduced by the diffusive section 82 of the propeller cap 80, but the vortex induced by rotation of a propeller is slightly weakened by the guide fins 83 before reaching the diffusive section 82 of the propeller cap 80, thereby changing the vortex by the rotation of the propeller into a straight flow in the rotational axial direction, so hub vortex cavitation can be additionally reduced. Accordingly, it is possible to improve propulsive efficiency by preventing energy loss due to hub vortex, reduce vibration and noise due to hub vortex cavitation, and prevent erosion and corrosion of a rudder.

Further, since the combined propeller cap 80 according to the fifth embodiment of the present invention having the configuration described above has a very simple shape and structure and, the guide fins 83 are formed in a simple plate shape, so they can be easily manufactured and attached by simple welding, it is possible to considerably decrease the high manufacturing cost due to precise machining of the fins of a PBCF in the related art.

In more detail, referring to FIG. 9, shown is a view comparing propulsive efficiency of a propeller equipped with a

propeller cap of the related art and a propeller equipped with the combined propeller cap 80 according to the fifth embodiment of the present invention shown in FIG. 8.

That is, it can be seen from FIG. 9 that the propeller
5 equipped with the propeller cap 80 according to the fifth embodiment of the present invention had propulsive efficiency higher than that of the contraction type propeller of the related art and side effects due to hub vortex can be greatly reduced and, the propulsive efficiency was considerably
10 improved as compared with the diffusion type propeller cap.

That is, according to the propeller cap 80 of the fifth embodiment of the present invention, the propulsive efficiency is improved by pressure recovery due to the shape from the propeller to the contractive section 81 at the middle portion
15 and a strong rotational flow (vortex) is weakened by the diffusive section 82 while a flow from the propeller flows over the diffusive cap end, so hub vortex cavitation can be reduced. Further, since the guide fins 83 having a triangular plate shape are attached between the contractive section 81 and the
20 diffusive section 82 of the propeller cap 80, as described above, a vortex induced by rotation of the propeller is weakened by the guide fins 23 before it reaches the diffusive section 82 of the propeller cap 80, so the vortex by the rotation of the propeller is changed into a straight flow in the rotational
25 axial direction, whereby hub vortex cavitation can be further

reduced, thus rotational flow and hub vortex cavitation by rotation of the propeller both can be reduced. Accordingly, energy loss due to hub vortex is prevented, so the propulsive efficiency of a vessel can be improved about 1 ~ 3% in
5 comparison to the existing diffusion type propellers, vibration and noise due to hub vortex cavitation can be reduced, and erosion and corrosion of a rudder can be prevented in comparison to the existing contraction type propeller caps.

That is, according to the configuration of the propeller
10 cap 80 of the fifth embodiment of the present invention, similar to diffusion type propeller caps that are used container ships in the related art, hub vortex cavitation can be reduced and the propulsive efficiency is greatly improved as compared with the diffusion type propeller caps of the related art. Further,
15 the propulsive efficiency is high and hub vortex cavitation can be remarkably reduced in comparison to the existing contraction type propeller caps when the propeller cap 80 is applied to tank ships. Further, as described above, since the guide fins 83 having a triangular plate shape are attached between the
20 contractive section 81 and the diffusive section 82 of the propeller cap 80, rotational flow and hub vortex cavitation are additionally reduced, so vibration and noise due to hub vortex cavitation can be reduced and erosion and corrosion of a rudder can be prevented.

Further, precise machining for manufacturing the fins of a PBCF was a problem because it increased the manufacturing cost, but the propeller cap 80 according to the fifth embodiment of the present invention can be easily manufactured in simple shape and structure, so there is also an advantage that it is possible to remarkably decrease the manufacturing cost, which was over one hundred million South Korean won due to precise machining of the fins of the PBCF in the related art, to within thirty million South Korean won similar to the existing propeller caps.

Further, referring to FIG. 10, shown is a view schematically showing the entire configuration of a combined propeller cap 100 according to a sixth embodiment of the present invention.

In the following description of the sixth embodiment of the present invention, the same or similar components as in the fifth embodiment are not described and only other different components are described for simple description.

That is, as shown in FIG. 10, the combined propeller cap 100 according to the sixth embodiment of the present invention has a contractive section 101 of which the diameter decreases as it goes away from a propeller, a diffusive section 102 that extends from the contractive section 101 and of which the diameter increases as it goes away from the propeller, and guide fins 103 that are attached between the contractive

section 101 and the diffusive section 102, which is the same as the fifth embodiment shown in FIG. 8.

However, in the combined propeller cap 100 according to the sixth embodiment of the present invention, the contractive
5 section 101 is not straight as in the fifth embodiment shown in FIG. 8, but is curved with a predetermined curvature.

That is, the combined propeller cap 100 according to the sixth embodiment of the present invention is characterized in that the contractive section 101 is curved to be convex
10 outwardly with a predetermined curvature, as shown in FIG.10a, or the contractive section 101 is curved to be convex inwardly with a predetermined curvature, as shown in FIG. 10b.

The curvature of the contractive section 101 can be appropriately determined, depending on the type or the use of
15 a propeller or a ship, and other parts are the same as those in the fifth embodiment, so they are not described in detail.

Further, a combined propeller cap according to a seventh embodiment of the present invention is described with reference to FIG. 11.

20 That is, referring to FIG. 11, shown is a view schematically showing the entire configuration of a combined propeller cap 110 according to the seventh embodiment of the present invention.

In detail, as shown in FIG. 11, the combined propeller
25 cap 110 according to the seventh embodiment of the present

invention has a first diffusive section 111 of which the diameter increases from the end of a propeller, a straight section 112 that horizontally extends from the first diffusive section 111, a contractive section 113 that extends from the straight section 112 and of which the diameter decreases as it goes away from the propeller, a second diffusive section 114 that extends from the contractive section 113 and of which the diameter increases again as it goes away from the propeller, and a plurality of guide fins 115 that is formed in a thin plate shape and disposed with regular intervals between the contractive section 113 and the second diffusive section 114.

That is, in the combined propeller cap 110 according to the seventh embodiment of the present invention, as shown in FIG. 11, the diameter first gradually increases and decreases from the end of a propeller to a predetermined portion and then increases again at the rear end portion, in which the guide fins 115 having a triangular plate shape are added between the contractive section 113 and the second diffusive section 114 of the propeller cap 110.

The inclination angle α and β of the first diffusive section 111 and the contractive section 113 respectively, may be set, for example, to $0 \sim 40^\circ$.

When α and β exceed 40 degrees, the performance rapidly drops due to flow separation, that is, when flow separation is

generated, pressure is not recovered on the propeller cap, so resistance increases.

In more detail, referring to the following Table 4, Table 4 shows changes in performance due to changes in the inclination angles α and β of the first diffusive section 111 and the contractive section 113.

[Table 4]

Angle (α)	10	20	30	40	50	60
Performance change (%)	+1.3	+1.3	+1.3	+1.2	+0.9	+0.9
Angle (β)	10	20	30	40	50	60
Performance change (%)	+1.3	+1.3	+1.3	+1.0	+0.4	+0.4

In Table 4, when α was changed, β was fixed at 30 degrees, while when β was changed, α was fixed at 30 degrees. Further, the result in Table 4 shows estimated values of propulsive performance according to angle changes, as compared with a propeller equipped with an existing diffusion type propeller cap.

Therefore, according to the combined propeller cap 110 of the seventh embodiment of the present invention, as shown in FIG. 11, since the front portion of the propeller cap is convexly formed by the first diffusive section 111, the pressure at the pressure side of a propeller increases and the propulsive

efficiency is improved. Further, the propulsive efficiency is further improved by pressure recovery due to the shape of the contractive sections 113 at the middle portion.

Further, the combined propeller cap 110 according to the seventh embodiment of the present invention is additionally improved in propulsive efficiency by pressure recovery due to the shape from the propeller to the contractive section 113 at the middle portion, as shown in FIG. 11, and can reduce hub vortex cavitation by decreasing a strong rotational flow (vortex) through the second diffusive section 114 while the flow from the propeller passes over the end of the diffusive cap.

Further, energy loss due to hub vortex is prevented accordingly, so the propulsive efficiency of a vessel can be improved about 1 ~ 3% in comparison to existing diffusion type propellers, vibration and noise due to hub vortex cavitation can be reduced, and erosion and corrosion of a rudder can be prevented in comparison to the existing contraction type propeller caps.

Further, the guide fins 115, as shown in FIG. 11, for example, are formed in a thin triangular plate shape to be fitted in the recession between the contractive section 113 and the second diffusive section 2 of the propeller cap 110 and attached with regular intervals simply by welding. Accordingly, a vortex induced by rotation of a propeller not

only weakens over the second diffusive section 114, but weakens in advance before the second diffusive section 114 of the propeller cap 110, so the vortex due to the rotation of the propeller changes into a straight flow in the rotational axial direction, whereby hub vortex cavitation can be additionally reduced.

The number of the guide fins 115 may be appropriately changed, for example, within 2 ~ 8 and the size of the guide fins may be determined in accordance with the diameter of the second diffusive section 114 to avoid an increase in resistance due to the guide fins.

Further, the guide fins 115 are attached with a manufacturing tolerance of +20 ~ -20 degrees, preferably +10 ~ -10 degrees with respect to 0 degree when seen from vertically above.

In more detail, according to the principle of the propeller cap 110 for reducing a rotational flow and hub vortex and improving propulsive efficiency of the seventh embodiment of the present invention, the propulsive efficiency is improved by pressure recovery due to the shape from the propeller to the contractive section 113 at the middle portion and a strong rotational flow (vortex) is weakened by the second diffusive section 114 while a flow from the propeller passes over the diffusive cap end, so hub vortex can be reduced. Further, since the guide fins 115 having a triangular plate shape are

attached between the contractive section 113 and the second diffusive section 114 of the propeller cap 110, as described above, a vortex induced by rotation of the propeller is weakened by the guide fins 115 before it reaches the second diffusive
5 section 114 of the propeller cap 110, so the vortex by the rotation of the propeller is changed into a straight flow in the rotational axial direction, whereby hub vortex cavitation can be further reduced, thus rotational flow and hub vortex cavitation by rotation of the propeller both can be reduced.
10 Accordingly, energy loss due to hub vortex is prevented, so the propulsive efficiency of a vessel can be improved about 1 ~ 3% in comparison to the existing diffusion type propellers, vibration and noise due to hub vortex cavitation can be reduced, and erosion and corrosion of a rudder can be prevented in
15 comparison to the existing contraction type propeller caps.

That is, according to the principle of the combined propeller cap 110 of the seventh embodiment of the present invention having the configuration described above, the propulsive efficiency is improved by pressure recovery from the
20 propeller to the contractive section 113 at the middle portion by the shape and a strong rotational flow (vortex) is weakened by the second diffusive section 114 while the flow generated by the propeller flows over the end of the cap, so hub vortex is reduced. Further, since the guide fins 115 having a
25 triangular plate shape are attached between the contractive

section 113 and the second diffusive section 114 of the propeller cap 110, the vortex induced by rotation of the propeller is weakened by the guide fins 115 before reaching the second diffusive section 114 of the propeller cap 110, so the
5 vortex by the rotation of the propeller is changed into a straight flow in the rotational axial direction, thus rotational flow and hub vortex cavitation can be reduced.

Therefore, according to the combined propeller cap 110 of the seventh embodiment of the present invention having the
10 configuration described above, not only hub vortex cavitation is reduced by the second diffusive section 114 of the propeller cap 110, but the vortex induced by rotation of a propeller is slightly weakened by the guide fins 115 before reaching the second diffusive section 114 of the propeller cap 110, thereby
15 changing the vortex by the rotation of the propeller into a straight flow in the rotational axial direction, so hub vortex cavitation can be additionally reduced. Accordingly, it is possible to improve propulsive efficiency by preventing energy loss due to hub vortex, reduce vibration and noise due to hub
20 vortex cavitation, and prevent erosion and corrosion of a rudder.

Further, since the combined propeller cap 110 according to the seventh embodiment of the present invention having the configuration described above has a very simple shape and
25 structure and, the guide fins 115 are formed in a simple plate

shape, so they can be easily manufactured and attached by simple welding, it is possible to considerably decrease the high manufacturing cost due to precise machining of the fins of a PBCF in the related art.

5 Further, referring to FIG. 12, shown is a view comparing efficiency of a propeller equipped with a propeller cap of the related art and a propeller equipped with the combined propeller cap according to the seventh embodiment of the present invention shown in FIG. 11.

10 That is, it can be seen from FIG. 12 that the propeller equipped with the propeller cap 110 according to the seventh embodiment of the present invention had propulsive efficiency higher than that of the contraction type propeller cap of the related art and side effects due to hub vortex can be greatly
15 reduced and, the propulsive efficiency was considerably improved as compared with the diffusion type propeller cap.

 That is, according to the combined propeller cap 110 of the seventh embodiment of the present invention, since the first diffusive section 111 is formed such that the front portion
20 of the propeller cap is convexly formed, the pressure at the pressure side of a propeller increases and the propulsive efficiency is improved. Further, the propulsive efficiency is further improved by pressure recovery due to the shapes of the contractive section 113 at the middle portion.

Further, since the strong rotational flow (vortex) is weakened by the second diffusive section 114 while the flow from the propeller passes the diffusive cap end, hub vortex cavitation can be reduced. Further, as described above, since
5 the guide fins 115 having a triangular plate shape are attached between the contractive section 113 and the second diffusive section 114 of the propeller cap 110, as described above, rotational flow and hub vortex cavitation can be additionally reduced. Accordingly, energy loss due to hub vortex is
10 prevented, the propulsive efficiency can be improved about 1 ~ 3% in comparison to the existing diffusion type propellers, vibration and noise due to hub vortex cavitation can be reduced, and erosion and corrosion of a rudder can be prevented in comparison to the existing contraction type propeller caps.

15 That is, according to the configuration of the combined propeller cap 110 of the seventh embodiment of the present invention, similar to diffusion type propeller caps that are used container ships in the related art, hub vortex cavitation can be reduced and the propulsive efficiency can be improved
20 as compared with the diffusion type propeller caps of the related art. Further, the propulsive efficiency is similar and hub vortex cavitation can be remarkably reduced in comparison to the existing contraction type propeller caps when the propeller cap 110 is applied to tank ships. Further, as
25 described above, since the guide fins 115 having a triangular

plate shape are attached between the contractive section 113 and the second diffusive section 114 of the propeller cap 110, rotational flow and hub vortex cavitation are additionally reduced, so vibration and noise due to hub vortex cavitation can be reduced and erosion and corrosion of a rudder can be prevented.

Further, precise machining for manufacturing the fins of a PBCF was a problem because it increased the manufacturing cost, but the combined propeller cap 110 according to the seventh embodiment of the present invention can be easily manufactured in simple shape and structure, so there is also an advantage that it is possible to remarkably decrease the manufacturing cost, which was over one hundred million South Korean won due to precise machining of the fins of the PBCF in the related art, to within thirty million South Korean won similar to the existing propeller caps.

Further, referring to FIG. 13, shown is a view schematically showing the entire configuration of a combined propeller cap 130 according to an eighth embodiment of the present invention.

That is, as shown in FIG. 13, the combined propeller cap 130 according to the eighth embodiment of the present invention has a first diffusive section 131 of which the diameter increases from the end of a propeller, a straight section 132 that horizontally extends from the first diffusive section 131,

a contractive section 133 that extends from the straight section 132 and of which the diameter decreases as it goes away from the propeller, a second diffusive section 134 that extends from the contractive section 133 and of which the diameter
5 increases again as it goes away from the propeller, and guide fins 135 that are coupled to an end of the second diffusive section 134, which is the same as the seventh embodiment shown in FIG. 11.

However, in the combined propeller cap 130 according to
10 the eighth embodiment of the present invention, the contractive section 133 is not straight as in the seventh embodiment shown in FIG. 11, but is curved with a predetermined curvature.

That is, the combined propeller cap 130 according to the eight embodiment of the present invention is characterized in
15 that the contractive section 133 is curved to be convex outwardly with a predetermined curvature, as shown in FIG. 13a, or the contractive section 133 is curved to be convex inwardly with a predetermined curvature, as shown in FIG. 13b.

The curvature of the contractive section 133 can be
20 appropriately determined, depending on the type or the use of a propeller or a ship, and other parts are the same as those in the seventh embodiment, so they are not described in detail.

Further, referring to FIGS. 14 and 15, FIG. 14 is a view schematically showing the entire configuration of a combined
25 propeller cap according to a ninth embodiment of the present

invention and FIG. 15 is a view schematically showing the entire configuration of a combined propeller cap according to a tenth embodiment of the present invention.

In detail, although the guide fins are formed in a triangular shape and attached in the recession between the contractive section and the diffusive section, and have a size corresponding to the diameter of the diffusive section in order not to protrude at the end of the diffusive section in the fifth to eighth embodiments of the present invention, the present invention is not limited to this configuration, that is, the present invention may be configured, as shown in FIG. 14, such that guide fins 143 are formed in a not triangular, but thin pentagonal plate shape are attached by simple welding between the contractive section 141 and the diffusive section 143 of the propeller cap 140 to extend from an end of the diffusive section 142.

In this configuration, the size of the guide fins 143 may be determined such that the length L of the portion extending from the end of the diffusive section 142 is within two times the diameter D of the diffusive section (that is, $L \leq 2D$).

Alternatively, the present invention may be configured, as shown in FIG. 15, such that guide fins 153 are formed in a thin trapezoidal shape and attached to a contractive section 151 of a propeller cap 150 by simple welding.

In this configuration, the size of the guide fins 153 may be determined such that the length L2 of a shorter portion of the portions extending from the side of the contractive section 151 is within two times the diameter of the diffusive section 152 (that is, $L2 \leq 2D$), but other factors L1 and W are not specifically limited.

Further, the other configurations except the guide fins 143 and 153 can be achieved in the same way as the fifth to eighth embodiments, so they are not described in detail.

Examples of applying the guide fins 143 and 153 to the propeller cap according to the first embodiment shown in FIG. 2 are shown in FIGS. 14 and 15, but the present invention is not limited thereto, that is, it should be noted that the guide fins 143 and 153 shown in FIGS. 14 and 15 can be applied in the same way not only to the first embodiment shown in FIG. 2, but to the second to fourth embodiments.

Further, referring to FIG. 16, shown is a view comparing propulsion, torque, and efficiency of a propeller equipped with a propeller cap of the related art and a propeller equipped with the combined propeller cap 140 according to the ninth embodiment of the present invention shown in FIG. 14.

That is, it can be seen from FIG. 16 that the propeller equipped with the propeller cap 140 according to the ninth embodiment of the present invention had propulsive efficiency higher than that of the contraction type propeller cap of the

related art and side effects due to hub vortex can be greatly reduced and, the propulsive efficiency was considerably improved as compared with the diffusion type propeller cap. Further, it can be seen that the propulsive efficiency was
5 improve as compared with the first, fifth, and seventh embodiments too.

Therefore, according to the configuration, it is possible to achieve a combined propeller cap for reducing rotational flow and hub vortex and improving propulsive efficiency
10 according to the present invention.

Further, according to the present invention, as a combined propeller cap for reducing rotational flow and hub vortex and improving propulsive efficiency according to the present invention is achieved, it is possible to reduce hub vortex
15 cavitation that is generated behind a propeller through a combined propeller cap structure in which a diffusion type propeller cap is coupled to the end of a contraction type propeller cap, so a combined propeller cap that can be easily manufactured at a low cost in a simple configuration, as
20 compared with the existing PBCF, for reducing rotational flow and hub vortex and improving propulsive efficiency. Further, a plurality of small fins is attached to the propeller cap to reduce hub vortex cavitation, so it is possible to solve the problem with the existing PBCF (Propeller Boss Cap Fin) in that

manufacturing is difficult and the manufacturing cost is high due to precise machining for designing and manufacturing fins.

Further, according to the present invention, as described above, there is provided a combined propeller cap for reducing rotational flow and hub vortex and improving propulsive efficiency that is configured not only to reduce hub vortex cavitation that is generated behind a propeller through a combined propeller cap structure in which a diffusion type propeller cap is coupled to the end of a contraction type propeller cap, but also to additionally reduce hub vortex cavitation by attaching plate-shaped guide fins to the contractive section or between the contractive section and the diffusive section of the propeller cap. Accordingly, it is possible to reduce rotational flow and hub vortex cavitation that are generated behind a propeller, to easily manufacture the propeller cap at a low cost in a simple configuration, as compared with the existing PBCF, to reduce noise and vibration in a vessel and prevent erosion and corrosion of a rudder, and to save fuel by improving propulsive efficiency

Although combined propeller caps for reducing rotational flow and hub vortex and improving propulsive efficiency according to embodiments of the present invention were described above, the present invention is not limited to the embodiments and may be changed, modified, combined, and

replaced in various ways, depending on necessities in design and other various factors by those skilled in the art.

<Description of the Reference Numerals in the Drawings>

5	20: Propeller cap	21: Contractive section
	22: Diffusive section	30: Propeller cap
	31: Contractive section	32: Diffusive section
	50: Propeller cap	51: First diffusive section
	52: Straight section	53: Contractive section
10	54: Second diffusive section	
	60: Propeller cap	61: First diffusive section
	62: Straight section	63: Contractive section
	64: Second diffusive section	
	80: Propeller cap	81: Contractive section
15	82: Diffusive section	83: Guide fin
	100: Propeller cap	101: Contractive section
	102: Diffusive section	103: Guide fin
	110: Propeller cap	111: First diffusive section
20	112: Straight section	113: Contractive section
	114: Second diffusive section	
	115: Guide fin	130: Propeller cap
	131: First diffusive section	
	132: Straight section	133: Contractive section
25	134: Second diffusive section	

135: Guide fin 140: Propeller cap
141: Contractive section
142: Diffusive section 143: Guide fin
150: Propeller cap 151: Contractive section
5 152: Diffusive section 153: Guide fin

CLAIMS

1. A combined propeller cap for reducing rotational flow and hub vortex and improving propulsive efficiency, the
5 combined propeller cap having:

a contractive section having a diameter that decreases as it goes away from a propeller; and

a diffusive section extending from the contractive section and having a diameter that increases as it goes away from the
10 propeller,

wherein pressure of a flow from the propeller is recovered by the shape of the contractive section having the decreasing diameter, so propulsive efficiency is improved, and

rotational flow (vortex) is weakened by the shape of the
15 diffusive section having the increasing diameter at an end of the propeller cap.

2. The combined propeller cap of claim 1, wherein an inclination angle of the contractive section is set to $0 \sim 40^\circ$.
20

3. The combined propeller cap of claim 1, wherein a side of the contractive section is formed straight, or

the side of the contractive section is curved to be convex outwardly with a predetermined curvature, or

the side of the contractive section is curved to be convex inwardly with a predetermined curvature.

4. A combined propeller cap for reducing rotational flow
5 and hub vortex and improving propulsive efficiency, the combined propeller cap has:

a first diffusive section having a diameter that increases from an end of a propeller as it goes toward the propeller;

a straight section horizontally extending from the first
10 diffusive section;

a contractive section extending from the straight section and having a diameter that decreases as it goes away from the propeller; and

a second diffusive section extending from the contractive
15 section and having a diameter that increases as it goes away from the propeller,

wherein the combined propeller cap is convexly formed at a front portion by the first diffusive section, so pressure at a pressure side of the propeller increases and propulsive
20 efficiency is improved,

pressure of a flow passing the propeller cap from the propeller is recovered by the contractive section, so the propulsive efficiency is improved, and

rotational flow (vortex) of a flow from the propeller is weakened by the second diffusive section, so hub vortex cavitation is reduced.

5 5. The combined propeller cap of claim 4, wherein inclination angles of the first diffusive section and the second diffusive section are set to $0 \sim 40^\circ$.

6. The combined propeller cap of claim 4, wherein a side
10 of the contractive section is formed straight, or

the side of the contractive section is curved to be convex outwardly with a predetermined curvature, or

the side of the contractive section is curved to be convex inwardly with a predetermined curvature.

15

7. A combined propeller cap for reducing rotational flow and hub vortex and improving propulsive efficiency, the combined propeller cap having:

a contractive section having a diameter that decreases as
20 it goes away from a propeller;

a diffusive section extending from the contractive section and having a diameter that increases as it goes away from the propeller; and

a plurality of guide fins formed in a thin plate shape
25 having a rectangular or curved cross-section with a

predetermined uniform thickness and, disposed with regular intervals at the contractive section or between the contractive section and the diffusive section,

wherein pressure of a flow from the propeller is recovered
5 by the shape of the contractive section having the decreasing diameter, so propulsive efficiency is improved,

rotational flow (vortex) is weakened by the shape of the diffusive section having the increasing diameter at an end of the propeller cap, and

10 rotational flow by rotation of the propeller is changed into a straight flow in a rotational axial direction, so the hub vortex cavitation is further reduced.

8. The propeller cap of claim 7, wherein an inclination
15 angle of the contractive section is set to $0 \sim 40^\circ$.

9. The combined propeller cap of claim 8, wherein a side of the contractive section is formed straight, or

the side of the contractive section is curved to be convex
20 outwardly with a predetermined curvature, or

the side of the contractive section is curved to be convex inwardly with a predetermined curvature.

10. The combined propeller cap of claim 9, wherein the
25 guide fins are formed in a thin rectangular plate shape and

attached between the contractive section and the diffusive section of the propeller cap by simple welding, and

a size of the guide fins is determined to correspond to the diameter of the diffusive section in order to avoid an
5 increase in resistance due to the guide fins.

11. The combined propeller cap of claim 9, wherein the guide fins are formed in a thin pentagonal plate shape and attached between the contractive section and the diffusive
10 section of the propeller cap by simple welding, and

a length of a portion extending from an end of the diffusive section is within two times the diameter of the diffusive section.

15 12. The combined propeller cap of claim 9, wherein the guide fins are formed in a thin trapezoidal plate shape and attached between the contractive section and the diffusive section of the propeller cap by simple welding, and

a length of a shorter portion of portions extending from
20 a side of the contractive section is within two times the diameter of the diffusive section.

13. The combined propeller cap of claim 9, wherein two to eight guide fins are disposed at the contractive section or

between the contractive section and the diffusive section of the propeller cap, and

the guide fins are attached with a tolerance of $+10 \sim -10$ degrees or $+20 \sim -20$ degrees with respect to 0 degree when seen
5 from vertically above.

14. A combined propeller cap for reducing rotational flow and hub vortex and improving propulsive efficiency, the combined propeller cap having:

10 a first diffusive section having a diameter that increases from an end of a propeller as it goes toward the propeller;

a straight section horizontally extending from the first diffusive section;

a contractive section extending from the straight section
15 and having a diameter that decreases as it goes away from the propeller;

a second diffusive section extending from the contractive section and having a diameter that increases as it goes away from the propeller; and

20 a plurality of guide fins formed in a thin plate shape having a rectangular or curved cross-section with a predetermined uniform thickness and, disposed with regular intervals at the contractive section or between the contractive section and the diffusive section,

wherein the combined propeller cap is convexly formed at a front portion by the first diffusive section, so pressure at a pressure side of the propeller increases and propulsive efficiency is improved,

5 pressure of a flow passing the propeller cap from the propeller is recovered by the contractive section, so the propulsive efficiency is improved,

 rotational flow (vortex) of a flow from the propeller is weakened by the second diffusive section, so hub vortex
10 cavitation is reduced, and

 rotational flow by rotation of the propeller is changed into a straight flow in a rotational axial direction, so the hub vortex cavitation is further reduced.

15 15. The combined propeller cap of claim 14, wherein inclination angles of the first diffusive section and the contractive section are set to $0 \sim 40^\circ$.

 16. The combined propeller cap of claim 15, wherein a side
20 of the contractive section is formed straight, or

 the side of the contractive section is curved to be convex outwardly with a predetermined curvature, or

 the side of the contractive section is curved to be convex inwardly with a predetermined curvature.

25

17. The combined propeller cap of claim 16, wherein the guide fins are formed in a thin rectangular plate shape and attached between the contractive section and the second diffusive section of the propeller cap by simple welding, and
5 a size of the guide fins are determined to correspond to the diameter of the diffusive section in order to avoid an increase in resistance due to the guide fins.

18. The combined propeller cap of claim 16, wherein the
10 guide fins are formed in a thin pentagonal plate shape and attached between the contractive section and the second diffusive section of the propeller cap by simple welding, and
a length of a portion extending from an end of the second diffusive section is within two times the diameter of the second
15 diffusive section.

19. The combined propeller cap of claim 16, wherein the guide fins are formed in a thin trapezoidal plate shape and attached between the contractive section and the diffusive
20 section of the propeller cap by simple welding, and
a length of a shorter portion of portions extending from a side of the contractive section is within two times the diameter of the second diffusive section.

20. The combined propeller cap of claim 16, wherein two to eight guide fins are disposed at the contractive section or between the contractive section and the second diffusive section of the propeller cap, and

5 the guide fins are attached with a tolerance of $+10 \sim -10$ degrees or $+20 \sim -20$ degrees with respect to 0 degree when seen from vertically above.

21. A propeller for a vessel, which uses the combined
10 propeller cap of any one of claims 1 to 20, wherein as compared with existing propellers, energy loss due to hub vortex cavitation and a propeller cap shape is prevented and propulsive efficiency is improved, vibration and noise are reduced, and erosion and corrosion of a rudder by the hub vortex
15 cavitation are prevented, and

 in comparison to existing PBCFs, manufacturing cost is reduced.