

CARBON REINFORCED HYDRODYNAMIC ELEMENT WITH AN ELASTOMER SURFACE

FIELD OF THE INVENTION

The present invention relates to a hydrodynamic device comprising at least one
5 hydrodynamic element made from carbon fibre reinforced polymer, wherein one
or more surfaces of the hydrodynamic elements which is/are exposed to water,
such as sea water, during use of the hydrodynamic element comprising a surface
layer applied onto the carbon reinforced polymer, said surface layer is made from
an elastomer.

10

BACKGROUND OF THE INVENTION

Hydrodynamic elements such as propeller blades are during use exposed to large
forces, such as bending, torsion, compressing and/or stressing forces. To provide
a long service life for such hydrodynamic elements, they are most often made
15 from metal.

Use of metal for hydrodynamic elements provides a long service life but makes
the elements heavy. While a high weight of a hydrodynamic element can be dealt
with if the hydrodynamic element is used in a stationary configuration, a high
20 weight is a drawback when hydrodynamic elements are used in a non-stationary
configuration.

One example of a non-stationary configuration is where hydrodynamic elements
are used to provide propulsion to a vessel. During the last decades, thrusters for
25 vessels (ships) have emerged and are today often preferred over traditionally
propellers. Such thrusters are desired to be able change rotational speed of the
rotor blades fast. However, there is a limit on how fast a change in rotational
speed can feasible be introduced due to the high mass to be rotated (moment of
inertia). While more powerful motors may be used to mitigate resistance to
30 change rotational speed, such larger motors themselves have a larger moment of
inertia and a larger motor may become overpowered during steady-state
operation of the vessel.

Besides that a hydrodynamic element is exposed to large forces, hydrodynamic
35 elements are often exposed to cavitation. Cavitation is characterised by formation

of small vapour bubbles which implode, and the imploding may result in erosion of the surface of the hydrodynamic element. Thus, while it may be tempting to reduce the mass of the hydrodynamic element by use of a lightweight fibre reinforced material, such materials are generally brittle offering a very limited
5 resistance against surface erosion by cavitation.

Hence, an improved hydrodynamic element would be advantageous, and in particular lightweight hydrodynamic element would be advantageous.

10 OBJECT OF THE INVENTION

In particular, it may be seen as an object of the present invention to provide a hydrodynamic element forming part of a hydrodynamic device that solves the above-mentioned problems of the prior art with regards to mass and/or surface erosion due to cavitation.

15

It is a further object of the present invention to provide an alternative to the prior art.

SUMMARY OF THE INVENTION

20 Thus, the above described objects and several other objects are intended to be obtained in a first aspect of the invention by providing a hydrodynamic device comprising at least one hydrodynamic element made from fibre reinforced polymer, such as from carbon fibre reinforced polymer, wherein one or more surfaces of the hydrodynamic elements which is/are exposed to water, such as
25 sea water, during use of the hydrodynamic element comprising a surface layer applied onto the carbon reinforced polymer, said surface layer is made from an elastomer.

One or more surfaces of the hydrodynamic elements which is/are exposed to
30 water, typically refer to surfaces which would be exposed to water if not having a surface layer made from elastomer.

A hydrodynamic device is in preferred embodiments, a hydrodynamic device for a waterborne vessel, such as a boat, a ship, a hover craft, a planning vessel, a
35 submersible vessel or a submarine. In such embodiments, a hydrodynamic device

may be configured and used for propelling the vessel by rotating at least the at least one hydrodynamic element. Waterborne vessel typically refers to a vehicle designed for travel across or through a body of water.

5 In many preferred embodiments, the fibre reinforced polymer is a carbon fibre reinforced polymer, although other fibres, such as Kevlar, glass fibres or even combinations thereof are used in other embodiments. It is further noted that a hydrodynamic element may not be made massively or entirely from fibre reinforced polymer, as a hydrodynamic element may be a core structure, e.g. with
10 a hollow core.

In preferred embodiments, the entire outer shape of the hydrodynamic element is provided by fibre reinforced polymer. Hence, in such embodiments, a trailing edge, a leading edge and regions connecting the leading edge and trailing edge
15 are provided by fibre reinforced polymer.

Compared with e.g. CFRP surface, a surface made from elastomer has been found to provide a better resistance against erosion, resulting e.g. from cavitation and/or against foreign objects impacting the surface. By this, the surface may
20 remain intact, may maintain its smoothness and/or reduce fouling on the hydrodynamic elements.

By applying an elastomer forming an outer surface, which surface may be described as a coating, on the hydrodynamic elements, a surface may be provided
25 requiring no or little treatment to meet a smoothness required for hydrodynamic elements.

"CFRP" is used herein as an abbreviation for carbon fibre reinforced polymer.

30 BRIEF DESCRIPTION OF THE FIGURES

The invention and preferred embodiments thereof will now be described in more details with regard to the accompanying figures. The figures show ways of implementing the present invention and are not to be construed as being limiting to other possible embodiments falling within the scope of the attached claim set.

35

Fig. 1 is a photograph showing a propeller where the propeller blades and an outer rim is made from CFRP. An inner surface of the rim and the part of the propeller blades exposed to water during use of the propeller have a surface layer made from an elastomer applied onto the carbon fibre reinforced polymer.

5

Fig. 2A is a photograph illustrating a cavitation test on a CFRP surface with no surface layer applied, and Fig. 2B is a photograph illustrating a cavitation test on a CFRP element having a surface layer made from an elastomer.

10 DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Reference is made to Fig. 1 illustrating a propeller 1 according to a preferred embodiment. The propeller has a number of propeller blades 2. The propeller blades extend between a hub 4 and a rim 3. The hub 4 is made from stainless steel, but may be made from other another material, such as CFRP or a
15 combination of materials. The propeller blades 2 are each made from CFRP. The rim 3 is also made from CFRP, but may be made from another material, such as stainless steel. In a typical use case, the propeller 1 forms part of a rim drive azimuth thruster (RD-AZ) or a rim drive tunnel thruster (RD-TT). In such
thrusters and other uses of the propeller 1, the propeller 1 is rotatable arranged
20 by the hub 4 in a non-rotatable housing and permanent magnets (not illustrated) are arranged on the outside of the rim 3. Electrical coils (not illustrated) are arranged in the housing to provide a rotation of the propeller by the magnets and electrical coils being configured as an electrical motor.

25 The mass of a rotating body influences the body's moment of inertia as $L \sim M$, that is the moment of inertia, L , is proportional to the mass, M . For propellers it is often an advantage that the rotational speed can be changed rapidly, and the rate at which a rapid change can be introduced is inter alia dependent on the moment of inertia. Thus, the weight of the rotating mass could advantageously be low to
30 provide for such rapid change. The inventors have realized that the propeller blades 2 and the rim 3 can be made from CFRP and still have sufficient mechanical strength for use in propulsion devices, such as RD-AZ and RD-TT propulsion devices.

However, cavitation often occurs on the suction side of the propeller blades 2 and while traditional propeller blades made from metal is capable of withstanding cavitation without cavitation impairing the surface, or the structural integrity of the propeller blades, CFRP is a brittle material having only limited resistance
5 against the forces acting on the surface resulting from cavitation.

With reference to Fig. 2A, a deteriorating effect (erosion) of cavitation on a CFRP surface is illustrated. The experiment carried out resulting in the photograph of Fig. 2A is an experiment during which the CFRP surface is exposed to cavitation.
10 As it is clear from Fig. 2A, ruptures 5 occur on the surface and the carbon fibres are laid open clearly being a disadvantage since the propeller blade loses both its structural strength and hydrodynamic properties (due to change in shape) over time.

15 The illustrated propeller blade is an example on a hydrodynamic element, and the inventors have realized that the deteriorating effects of cavitation on a hydrodynamic element can, at least partly, be reduced and often avoided by providing a surface layer to the hydrodynamic element. While such a surface layer is found to enhance a surface's ability to withstand cavitation, the inventors
20 envisages that such a surface layer may also enhance the surface ability to withstand other actions, such as enhancing an impact resistance of the CFRP.

Further, while it may be preferred to apply the surface layer made from an elastomer to all surfaces of the hydrodynamic element, it may be preferred to
25 apply the surface layer to CFRP surfaces which will be exposed to e.g. cavitation and/or impact.

Accordingly, preferred embodiments of the invention comprises a hydrodynamic device having at least one hydrodynamic element made from carbon fibre
30 reinforced polymer. A hydrodynamic element is preferably an element shaped to provide a hydrodynamic lift to produce thrust. In such embodiments, one or more surfaces of the hydrodynamic elements exposed to water, such as sea water, during use of the hydrodynamic element is provided with a surface layer applied onto the carbon reinforced polymer, where the surface layer is made from an
35 elastomer. During use here refers to the use of a propeller in a propulsion device.

"Surface layer" preferably refers to that the layer is the outermost surface of hydrodynamic element. When other components, such as the rim 3 disclosed above, is provided with a surface layer made from an elastomer, such a surface
5 layer preferably also refers to an outermost layer. The surface layer preferably covers all surfaces made from CFRP which otherwise would be exposed.

Fig. 2B is a photograph of a CFRP element having a surface layer from an elastomer. The CFRP element has been exposed to the same experiment as for
10 Fig. 2A. From the photograph, it clear that the surface layer does not change due to the cavitation.

In preferred embodiments, the elastomer is epoxy.

15 To enhance adherence of the surface layer to the element made from CFRP, it may be preferred that the one or more surfaces is/are pre-treated prior to having said surface layer applied to enhance adherence of said surface layer. Such a pre-treatment may be a mechanical and/or chemical surface treatment to remove e.g. residues from a casting process and/or increase the surface roughness of the
20 element.

In a preferred embodiment, the surface treatment comprises abrading the one or more surfaces to increase a surface roughness of the one or more surfaces. Increase here refers to that the surface after abrading has a higher surface
25 roughness compared to the surface roughness of the element immediately after casting of the element. The surface roughness may be quantified by a method being ordinary to a skilled person within the area of surface roughness of components.

30 An abrading is typically carried out with a relatively coarse abrasive as the purpose is to increase the surface roughness and not provide a polishing of the surface. In preferred embodiments, the abrading being provided by an abrasive, such as an emery paper, with a grit between 120 and 300, such as between 200 and 250. It is generally aimed at that a surface after abrading has an essentially
35 uniform surface roughness, which may be identified visually and/or tactile.

An efficient way to apply the elastomer is by use of a spray gun, such as a pressure pot spray gun. By such a method, the elastomer may be sprayed onto the surface in consecutively thin layers wet-in-wet whereby a greater control of the thickness of the surface layer can be obtained, whereby the surface layer becomes essentially non-laminated. It is generally preferred that an essentially even thickness of the elastomer layer is applied. This is due to that when surface layer is applied onto a hydrodynamic element shaped to provide a designed hydrodynamic effect, the surface layer should not or at least have a reduced influence of the hydrodynamic effect provided by shape of the hydrodynamic element.

The thickness of surface layer made from the elastomer preferably should be sufficiently small to avoid negatively affecting the hydrodynamic properties provided by the shape and at the same time be sufficiently larger to withstand negative effects of e.g., cavitation. A preferred thickness may be between 0.2 mm and 0.8 mm, such as between 0.25 mm and 0.7 mm, preferably between 0.3 mm and 0.5. In embodiments, where the elastomer is applied by a spray gun – or by other application methods - the thickness is determined during application with a WFT (wet film thickness) gauge.

In preferred embodiments, the hydrodynamic device is a propeller comprising propeller blades made of carbon fibre reinforced polymer.

In preferred embodiments, the hydrodynamic device is a rim drive azimuth thruster made at least partly of carbon fibre reinforced polymer.

In preferred embodiments, the hydrodynamic device is a rim drive tunnel thruster made at least partly of carbon fibre reinforced polymer.

30

In preferred embodiments, the hydrodynamic device is a propeller nozzle for a ducted propeller wherein the propeller nozzle is made at least partly of carbon fibre reinforced polymer.

In preferred embodiments, the hydrodynamic device is a rudder comprising one or more rudder blades made of carbon fibre reinforced polymer.

5 Although the present invention has been described in connection with the specified embodiments, it should not be construed as being in any way limited to the presented examples. The scope of the present invention is to be interpreted in the light of the accompanying claim set. In the context of the claims, the terms "comprising" or "comprises" do not exclude other possible elements or steps. Also,
10 the mentioning of references such as "a" or "an" etc. should not be construed as excluding a plurality. The use of reference signs in the claims with respect to elements indicated in the figures shall also not be construed as limiting the scope of the invention. Furthermore, individual features mentioned in different claims, may possibly be advantageously combined, and the mentioning of these features
15 in different claims does not exclude that a combination of features is not possible and advantageous.

LIST OF REFERENCE SYMBOLS USED

1	Propeller
20 2	Propeller blades
3	Rim
4	Hub
5	Rupture

CLAIMS

1. A hydrodynamic device comprising at least one hydrodynamic element made from carbon fibre reinforced polymer, wherein
 - 5 • one or more surfaces of the hydrodynamic elements which is/are exposed to water, such as sea water, during use of the hydrodynamic element comprising a surface layer applied onto the carbon reinforced polymer, said surface layer is made from an elastomer.
- 10 2. A hydrodynamic device according to claim 1, wherein said elastomer is epoxy.
3. A hydrodynamic device according to claim 1 or 2, wherein said one or more surface prior to having said surface layer applied is pre-treated to enhance adherence of said surface layer.
- 15 4. A hydrodynamic device according to claim 3, wherein said pre-treatment comprising abrading said one or more surfaces to increase a surface roughness of said one or more surfaces, said abrading being provided by an abrasive with a grit between 120 and 300, such as between 200 and 250.
- 20 5. A hydrodynamic device according to any one of the preceding claims, wherein the elastomer is applied by use of a spray gun, such as a pressure pot spray gun.
6. A hydrodynamic device according to any one of the preceding claims, the
25 surface layer is essentially non-laminated, provided by said elastomer is build up as layer applied wet-in-wet.
7. A hydrodynamic device according to any one of the preceding claims, wherein a thickness of the surface layer made from elastomer is between 0.2 mm and 0.8
30 mm, such as between 0.25 mm and 0.7 mm, preferably between 0.3 mm and 0.5.
8. A hydrodynamic device according to any one of the preceding claims, wherein an entire outer shape of the hydrodynamic element is provided by fibre reinforced polymer.

35

9. A hydrodynamic device according to any one preceding claims, wherein said hydrodynamic device is a hydrodynamic device for a waterborne vessel, such as a boat, a ship, a hover craft, a planning vessel, a submissible vessel or a submarine.

5

10. A hydrodynamic device according to any one of the preceding claims, wherein the hydrodynamic device is a propeller comprising propeller blades made of carbon fibre reinforced polymer.

10 11. A hydrodynamic device according to any one of the preceding claims, wherein the hydrodynamic device is a rim drive azimuth thruster made at least partly of carbon fibre reinforced polymer.

12. A hydrodynamic device according to any one of the preceding claims 1-10,
15 wherein the hydrodynamic device is a rim drive tunnel thruster made at least partly of carbon fibre reinforced polymer.

13. A hydrodynamic device according to any one of the preceding claims 1-10,
wherein the hydrodynamic device is a propeller nozzle for a ducted propeller
20 wherein the propeller nozzle is made at least partly of carbon fibre reinforced polymer.

14. A hydrodynamic device according to any one of the preceding claims 1-7,
wherein the hydrodynamic device is a rudder comprising one or more rudder
25 blades made of carbon fibre reinforced polymer.