Propeller arrangement, in particular for watercraft

The invention relates to a propeller arrangement, in particular for a drive system of a watercraft, for example, a ship, comprising a propeller that is rotatable about a propeller axis.

Most watercraft comprise a drive system which comprises a propeller that is rotatable about a propeller axis. When the water flows through the propeller surface spanned by the rotating propeller, it is accelerated and twisted. As a result, turbulence can occur in the propeller backwash. It is generally known that this turbulence is usually particularly high in the area of the hub or downstream of the hub when viewed in the direction of travel of the ship. This turbulence is also known as "hub vortex" and has a negative effect on the drive power.

In order to reduce the hub vortex and thus increase the efficiency of the propeller, it has been proposed, for example, in EP 0 255 136 A1 to provide fixed fins or flow guiding fins on the hub cap disposed downstream of the propeller in the direction of travel of the ship, i.e. in the propeller hub end region, which fins are firmly connected to the propeller hub and co-rotate with this. The radial extension of the fins is substantially restricted to the hub region. By providing these fixed fins on the hub cap which co-rotate with the propeller, a weakening of the hub vortex and therefore an improvement in the drive power of the propeller can be achieved.

Embodiments~~It is now the object~~ of the present invention seek to provide a propeller arrangements with which the hub vortex can be further reduced and the efficiency therefore further improved.

According to an aspect of the present invention, there is provided a propeller arrangement, in particular for a drive system of a watercraft, comprising a propeller, said propeller being rotatable about a propeller axis, wherein at least one rotor fin is provided which is disposed freely rotatably about the propeller axis, wherein the diameter of a circular path described by the rotation of the at least one rotor fin is less than the diameter of the propeller.

There is disclosed~~This object is solved with~~ a propeller arrangement, in particular for a drive system of a watercraft, comprising a propeller that is rotatable about a propeller axis, where at least one rotor fin is further provided. The rotor fin is expediently

configured to be blade-like and disposed freely rotatably about the propeller axis. Accordingly, the rotor fin is configured to be freely rotating or driveless, i.e. it has no separate drive for the rotation about the propeller axis but is optionally driven by the respectively prevailing ambient conditions, in particular by the prevailing water flow, for rotation about the propeller axis. Expediently the at least one rotor fin is disposed on the propeller backwash side, i.e. in the backwash of the (ship's) propeller. In other words, the at least one rotor fin is located downstream of the propeller in the direction of travel of the ship. It may~~is~~ thus be achieved that the backwash of the propeller impinges upon the at least one rotor fin and this is expediently configured in such a manner that it is thereby set in rotation.

The rotor fin is configured such that it influences the propeller backwash in such a manner that the vortex formation in the region of the hub, i.e. the so-called hub vortex is reduced. This can be achieved, for example, whereby the rotor fin generates a counter-twist with respect to the twisting applied by the propeller in the flow in the region of the hub, which then results overall in a homogenisation of the propeller flow in the hub region and consequently in a laminar flow. This effect may be~~is~~ achieved in particular due to the freely rotatable configuration of the rotor fin. Compared with the fins known from the prior art, which are attached firmly on the hub cap and necessarily co-rotate with the propeller, the freely rotatable fin according to embodiments of the invention has a variable rotational speed which depends on the configuration of the mounting and the inflow, for example, speed of the inflow, degree of twisting etc. An improved flow pattern of the propeller backwash may~~is~~ thereby be established in the region of the hub and therefore a better overall efficiency. As a result, the overall drive power of the propeller may be~~is~~ permanently improved. Usually the rotational speed of the freely rotating at least one rotor fin will be lower than that of the propeller. However, this need not necessarily be the case in every operating state.

Since the at least one rotor fin is intended to substantially exclusively influence the propeller flow in the hub region, it is further provided that the diameter of a circular path described by the rotation of the at least one rotor fin is smaller

than the diameter of the propeller. The circular path is here described by the outermost tip of the rotor fin, when viewed in the radial direction from the propeller axis. This merely conceptually formed circular path is produced by one complete revolution of the rotor fin. In other words, the rotor fin surface spanned by the at least one rotor fin during a complete revolution is smaller than or has a smaller diameter than the propeller surface spanned by the propeller. Accordingly, the length of the rotor fin is shorter than the length of the propeller blades. The restriction to a smaller rotor fin diameter than the propeller diameter has the result that the influence on the propeller backwash is substantially concentrated on the hub region and possibly undesirable and disadvantageous influences on the propeller backwash do not occur in other regions. In this connection, it may beis particularly advantageous that the diameter of the circular path of the at least one rotor fin is less than 75%, particularly less than 55% and in particular less than 35% of the diameter of the propeller. If the diameter of the rotor fin were larger and therefore the individual rotor fin blades were larger when viewed in the radial direction, a negative influence on the propeller flow could possibly occur and strength problems could arise at the at least one rotor fin.

The rotor fin can in principle be made of any suitable material. Preferably stainless steel or another suitable material is used to manufacture the rotor fin. In principle, any flow guiding body which is configured to actively influence the flow in a not-insignificant manner can be used as rotor fin. In particular, it is expedient to configure the rotor fin to be blade-like or fin-like. For example, the rotor fin can be configured in the form of a guide fin. Furthermore, the rotor fin can be configured with or without a hydrofoil profile. When formed with a hydrofoil profile, the fin has a pressure side and a suction side, where the suction side is then in particular curved outwards in a circular arc shape and the pressure side can be configured to be substantially flat. In principle, however, a plate-shaped configuration having a substantially flat profile on both sides or a curved configuration on both fin sides is also possible. The profile of the rotor fin can furthermore be uniform or different when viewed over its length. In par-

ticular, the profile of the rotor fin can be turned into itself, i.e. twisted, when viewed in the longitudinal direction of the fin.

It is further preferred that the at least one rotor fin has one free end. The end of the rotor fin opposite the free end is in this case expediently fastened on a pivot bearing which enables rotation about the propeller axis. The free end is therefore usually furthest away from the propeller axis when viewed in the radial direction from the propeller axis. The term "free end" is to be understood such that this end region of the rotor fin is not fastened on another component. In particular it is preferred that no nozzle or turbine ring is provided around the free end region of the rotor fin, i.e. the at least one rotor fin is not disposed inside a nozzle or turbine ring.

The propeller arrangement according to embodiments of the invention is in particular suited for fixed propellers. The term "fixed propeller" is understood in the present case to be those propellers which are indeed rotatable about the propeller axis but are not pivotable about a rudder axis for steering the watercraft.

Expediently the at least one rotor fin is disposed on or in the region of the propeller hub of the propeller. Usually the at least one rotor fin is also mounted on the hub so that it is fixed freely rotatably on the hub. Alternatively the at least one rotor fin can also be disposed on a component placed on the hub, for example, a separate hub end piece or similar. In particular, it is expedient that the rotor fin is disposed in the region of the (free) hub end.

In a preferred embodiment, in addition to the at least one freely rotatable rotor fin, at least one stator fin co-rotating with the propeller is provided. Expediently the at least one stator fin is disposed between the freely rotatable rotor fin and the propeller. Accordingly, in a preferred embodiment, the at least one stator fin is disposed in the axial direction downstream of the propeller and in turn the at least one rotor fin is disposed downstream of the at least one stator fin. The term "co-rotating" is to be understood in the present case such that the stator fin necessarily rotates in common mode with the propeller, i.e. at the same

speed and frequency. Expediently, the stator fin is therefore directly connected to the propeller or to the propeller hub. It is advantageous here that as a result of a corresponding configuration of the stator fin in relation to its shape and angle of attack, a certain untwisting of the propeller flow may beis achieved in the area of the hub region, before the flow impinges upon the rotor fin which is driven by said flow and the flow is thereby further laminarised or untwisted.

The at least one stator fin comprises a fin, i.e. a guide fin for non-insignificant influencing of the flow. With regard to its material, its shape or other geometrical configuration, it can advantageously also be configured as described hereinbefore for the rotor fin. In particular, as with the rotor fin, it is expedient that the length of the fin or fin blade of the at least one stator fin is not longer than the length of the propeller blade. In particular, a circular path described by the stator fin during rotation can therefore have a smaller diameter than the diameter of the propeller. The circular path of the stator fin is preferably less than 75%, particularly preferably less than 55%, in particular less than 35% of the diameter of the propeller. Also the length of the stator fin can correspond to the length of the rotor fin - in each when viewed in the radial direction. In addition, other dimensioning and configuration aspects such as the angle of attack or the depth of the fin in the axial direction can be similar or the same as the rotor fin or even different from this.

In a further preferred embodiment, the at least one stator fin is arranged offset by an angle with respect to the propeller blades of the propeller when viewed in the axial direction. Consequently, when viewed over the circumference of the propeller hub, the stator fin is attached at different positions on the propeller hub than the propeller blades. If several stator fins are provided, advantageously all the stator fins should be arranged offset to the propeller blades and particularly preferably each at the same distance. As a result of the offset arrangement a more favourable hydrodynamic efficiency may beis achieved. Advantageously the stator fin is arranged in such a manner that when viewed in the circumferential direction, it is disposed approximately centrally between two propeller blades. "Approximately centrally" should be understood in the present

angle of attack and all the stator fins with a different predefined angle of attack. The adjustment of the stator fins and the rotor fins is preferably accomplished in the same direction, for example, both to port or both to starboard. It can also be preferred that one propeller blade is adjusted in the same direction as the stator fins and/or the rotor fins. The stator fins and/or the rotor fins can also have the same angle of attack as the propeller blades or different from this. If the individual rotor fins and/or stator fins are configured to be turned into themselves or twisted, different angles of attack for the individual fins are also obtained in sections. In particular, the angle of attack can be between 10° and~~und~~ 80°, preferably 25° to 70°, particularly preferably 40° to 60°. The stator fins and/or the rotor fins are preferably arranged fixed with respect to their angle of attack. In principle, an adjustable arrangement which allows an adjustment of the angle of attack is, however, also feasible. By providing an angle of attack, a specific influencing of the flow and therefore a particularly efficient untwisting can thus be achieved in a simple manner. The optimal angles of attack can vary from one propeller arrangement to another depending on the particular circumstances (e.g. propeller size, propeller speed, propeller blade profile etc.).

Expediently the at least one rotor fin and/or the at least one stator fin run radially to the propeller axis.

In a preferred embodiment a stator body is provided which is disposed on the front end side, i.e. at the free end, on the propeller hub of the propeller and is firmly connected to the propeller hub. The at least one stator fin is disposed on this stator body and is expediently also fastened to this. The at least one stator fin and the stator body can be formed as a one-piece unit. The manufacture of the propeller arrangement is simplified as a result since the stator fins need not be design in one piece or monolithically with the propeller hub, but manufactured as a separate component and should only be connected to the propeller hub by means of suitable connecting means such as, for example, bolts. This also provides the possibility for a relatively simple retrofitting.
The bearing for the at least one rotor fin is expediently configured to be water-lubricated. Accordingly it is not oil-lubricated and also not configured to be

closed or sealed. This has the advantage that no complex lubrication/sealing system needs to be provided which may reduces the manufacturing and maintenance expenditure of the bearing. Furthermore, the bearing is preferably configured as a combined axial and radial bearing. In principle, however the provision of two or more separate bearings for mounting the rotor fin in the radial and axial direction is also possible.

The bearing is preferably configured as a friction bearing and provided on the propeller hub or on the stator body. Particularly preferably the bearing can be configured to be self-lubricating. Self-lubrication bearings are also called "dry friction bearings" since dry friction generally occurs at these. This is caused by a self-lubricating property of one of the bearing partners or one of the two bearing elements. These bearings manage without additional lubrication or lubricants since solid lubricants are provided embedded in the material they are manufactured from, whereby the solid lubricants, as a result of microwear during operation, may reach the surface and consequently reduce friction and wear. Expediently one of the two bearing elements movable with respect to one another is made of plastic or plastic composite and/or of ceramic structural materials to form the self-lubricating bearing. Preferably a part of the bearing or one of the bearing elements of the bearing can be formed from PTFE or ACM. The use of graphite-containing materials is also possible. The other bearing part or the bearing partner is preferably formed from metal, for example, bronze or brass. By this means the structure of the bearing is simplified since no additional means need to be provided to provide a lubricating film or the like and no external lubricants need be provided. From ecological aspects, this is also advantageous since no lubricants, for example grease, can enter into the sea from the bearing. The movable second bearing part or bearing partner can preferably be configured as a bearing ring, in particular a bronze ring, where the at least one rotor fin is expediently firmly attached to this second bearing element.

In a further preferred embodiment, the at least one rotor fin is disposed in the axial direction at a short distance from the propeller. In particular the distance can be a maximum of 0.8 times the propeller diameter, preferably a maximum