# Pivotable Propeller Nozzle for A Watercraft

The present invention pertains to a pivotable propeller nozzle for watercraft, as well as to a nozzle shaft for pivoting the propeller nozzle for watercraft.

The term propeller nozzle refers to propulsion units of watercraft, particularly of ships, with a propeller that is surrounded or shrouded by a nozzle ring. Nozzle rings of this type are also referred to as "Kort nozzles." In this case, the propeller arranged in the interior of the nozzle ring is normally realized stationary, i.e., the propeller can only be pivoted about the drive or propeller axis. For this purpose, the propeller is connected to the hull by means of a rotatable, non-pivotable propeller shaft that extends along the propeller axis. The propeller shaft is driven by a drive arranged in the hull. The propeller, in contrast, is not (horizontally or vertically) pivotable.

In simply designed propeller nozzles, the nozzle ring surrounding the propeller is also stationary, i.e., non-pivotable, and has the sole function of increasing the thrust of the propulsion system. Propeller nozzles of this type therefore are frequently used in tugboats, supply vessels and the like that respectively need to generate high thrust. In order to steer a ship or watercraft featuring such a propeller nozzle with stationary nozzle ring, an additional steering arrangement, particularly a rudder, needs to be arranged downstream of the propeller, i.e., behind the propeller nozzle referred to the moving direction of the ship.

Embodiments of t~~T~~he present invention, in contrast, exclusively pertains to pivotable propeller nozzles and, in particular, pivotable propeller nozzles of the type featuring a stationary propeller and a nozzle ring that can be pivoted around the stationary propeller. Such a pivotable nozzle ring not only increases the thrust of the watercraft, but the propeller nozzle can be simultaneously used for steering the watercraft and therefore replace or eliminate the need for additional steering systems such as rudders. The direction of the propeller outflow can be changed and the ship can therefore be steered by pivoting the nozzle ring about the pivoting axis that normally extends vertically in the installed state. This is the

Figure 6 shows an exemplary embodiment of a Kort nozzle 200 according to the state of the art that can be pivoted about the rudder axis of a vessel and features a stationary propeller arranged therein. The Kort nozzle 200 is arranged around the stationary propeller 210 of a (not-shown) vessel. In this figure, the Kort nozzle is pivoted about the longitudinal axis 220 of the vessel by an angle α of approximately 30°. The arrow 221 represents the flow direction of the ocean or sea water. A stationary fin 230 is provided on the Kort nozzle 200 downstream of the propeller referred to the flow direction in order to positively influence the steering power of the Kort steering nozzle. The nozzle profile is chosen such that the intake region 201 of the Kort nozzle 200 (referred to the direction of the flow through the Kort nozzle 200) is widened. This means that the inside diameter of the intake region is larger than the inside diameter in any other region of the Kort nozzle 200. In this way, the water flow through the Kort nozzle 200 and toward the propeller 210 is increased and the propulsion efficiency of the Kort nozzle is improved.

The nozzle shaft of known pivotable propeller nozzles is realized in the form of a cylindrical shaft with solid cross section that normally has a diameter of approximately 250 mm and is connected to the nozzle ring on its end region by means of flange plates or the like. For this purpose, a corresponding counterpart, i.e., a flange plate and additional reinforcements or the like, needs to be arranged on the outer wall of the nozzle ring or formed of the wall material of the nozzle ring. This reinforcement and elaborate flanging with reinforcing plate is necessary because significant problems could otherwise arise at the interface between the relatively thin, massive shaft and the hollow body of the nozzle ring with its relatively thin profile and the connection could become unstable.

Embodiments~~It is therefore the objective~~ of the present invention seek to provide~~disclose~~ a propeller nozzle, in which the connection between the nozzle shaft and the nozzle ring is constructively simplified, as well as realized in a torsionally rigid fashion and able to withstand high bending moments.

~~This objective is attained with a nozzle shaft with the characteristics of Claim 1 and with a propeller nozzle with the characteristics of Claim 7.~~

According to a first aspect of the present invention, there is provided a nozzle shaft for pivotable propeller nozzles with stationary propeller for watercraft, particularly pivotable Kort nozzles, wherein the nozzle shaft is realized in the form of a hollow body, particularly in the form of a hollow cylinder, and has a constant diameter over its entire length in the axial direction, wherein the nozzle shaft has a diameter between 60 cm and 150 cm, preferably between 75 cm and 125 cm, particularly between 90 cm and 110 cm, and wherein the wall thickness of the nozzle shaft lies between 1 cm and 10 cm, preferably 2 cm and 8 cm, particularly 3 cm and 5 cm, wherein the nozzle shaft is at least sectionally arranged and supported in a trunk pipe and wherein the propeller nozzle is supported by means of the nozzle shaft only and does not feature any other support.

According to a second aspect of the present invention, there is provided a propeller nozzle for watercraft, particularly a Kort nozzle, with a stationary propeller and a nozzle ring that shrouds the propeller and can be pivoted by means of a nozzle shaft, wherein the nozzle shaft is realized in the form of a hollow body, particularly in the form of a cylindrical pipe, wherein an end region of the nozzle shaft that faces the nozzle ring is rigidly connected to the nozzle ring by means of welding and wherein the end region of the nozzle shaft that faces the nozzle ring is inserted into the wall of the nozzle ring and preferably abuts on the inner wall of the nozzle ring with its end face, wherein the nozzle shaft is at least sectionally arranged and supported in a trunk pipe, and wherein the propeller nozzle is supported by means of the nozzle shaft only and does not feature any other support.

According to embodiments of the present invention, the nozzle shaft of the pivotable propeller nozzle, about which the propeller nozzle pivots, is realized in the form of a hollow body or hollow cylinder, particularly in the form of a cylindrical pipe. The hollow body preferably has a constant diameter over its entire length in the axial direction, i.e., along the pivoting axis. However, the

hollow body could, in principle, also be realized conically or stepped with several successive sections of different diameter or similarly. It was nevertheless determined that the straight design with constant diameter represents the version that can be manufactured most easily and is most favorable with respect to torsional and bending stresses. The nozzle shaft realized in the form of a hollow body makes it possible to pivot the nozzle ring that is arranged around and shrouds the stationary propeller of the propeller nozzle.

In contrast to embodiments of the present invention, the nozzle shaft was until now always realized massively, particularly of forged steel. These massive nozzle shafts with solid cross section have a relatively small diameter because they would otherwise be excessively heavy. The relatively small diameter results in the initially mentioned problems in the connection between the nozzle shaft and the thin-walled nozzle ring.

Unlike the massive nozzle shafts known from the state of the art, the nozzle shaft in the form of a hollow cylinder has a significantly larger diameter. The diameter is, in particular, at least twice as large as that of conventional massive nozzle shafts known from the state of the art. The hollow cylinder has a diameter in the range between 600 mm and 1500 mm, preferably 750 mm to 1250 mm, particularly 900 mm to 1100 mm. The cited ranges usually refer to the outside diameter of the nozzle shaft. However, the inside diameter could, in principle, also lie within the cited ranges. In this respect, ~~it is advantageous that~~ the large diameter of the hollow cylinder makes it possible to achieve a very high torsional rigidity and to furthermore absorb high bending moments. This is

realized with less material input than that required for massive nozzle shafts. The interface or the connection between the nozzle shaft and the nozzle ring can furthermore be realized in a much more stable and simpler fashion. Due to the larger diameter, the forces engaging in the connecting region are distributed over a larger area such that it is not necessary to provide special reinforcements such as the reinforcing plates or similar elements used on conventional propeller nozzles. All in all, embodiments of the present invention provideproposes a propeller nozzle that may haverespectively has an improved torsional rigidity and can absorb higher bending moments and simultaneously may havehas a simple construction, particularly in the connecting region between the nozzle shaft and the nozzle ring.

Alternatively or additionally to the above-cited dimensions for the nozzle shaft diameter, the wall thickness of the hollow cylinder lies between 10 mm and 100 mm, preferably 20 mm to 80 mm, particularly 30 mm to 50 mm. Calculations and tests carried out by the applicant have shown that particularly favorable results with respect to the torsional rigidity and the connection to the nozzle ring can be achieved and that the material input required for the manufacture of the nozzle shaft can be simultaneously maintained as low as possible if the diameter and the wall thickness of the nozzle shaft respectively lie in the above-cited ranges.

The hollow body or the hollow cylinder is preferably manufactured of steel. In this case, the hollow cylinder may be realized, in particular, in the form of a steel pipe. In this way, a particularly simple construction of the nozzle shaft can beis achieved. If it does not have a stepped or conical design, the hollow cylinder preferably has a constant wall thickness over its entire length.

The nozzle shaft may be advantageously realized in one piece, i.e., it may comprise a single pipe that is fixed to a nozzle ring of a propeller nozzle with one end and to a pivot drive with the other end.

The end region of the nozzle shaft that lies opposite of the nozzle ring is preferably realized in such a way that it can be connected to a pivot drive

arranged in the interior of the watercraft, particularly a steering gear, in order to transmit a torque. In one particularly preferred embodiment, the end region is realized such that it can receive a pivot drive for the nozzle shaft. This means that the pivot drive for the nozzle shaft is at least partially arranged in the interior of the nozzle shaft, i.e., in its hollow space. In this respect, it may beis advantageous if the outside dimensions of the pivot drive essentially correspond to the inside dimensions of the hollow cylinder such that the pivot drive can be inserted flush into the hollow cylinder. Accordingly, the pivot drive preferably has a circular cross section and its outside diameter essentially corresponds to the inside diameter of the nozzle shaft. In this way, the entire steering system can be realized in an altogether more compact fashion because the pivot drive is now arranged in the nozzle shaft such that a separate space for the pivot drive is no longer required within the hull. The assembly can beis also simplified because the nozzle shaft and the pivot drive can be supplied in the form of a module into directly installed. Corresponding mounting means need to be provided in order to mount the pivot drive. The pivot drive may be mounted directly on the nozzle shaft or on the hull, for example, by means of a flange or the like on the end of the nozzle shaft. It may beis particularly advantageous to realize the pivot drive in the form of a blade-type drive unit or blade-type steering gear. Such a pivot drive may havehas a compact design and therefore may beis particularly suitable for being inserted into the nozzle shaft.

The nozzle shaft furthermore may advantageously feature connecting means for connecting the nozzle shaft to a pivot drive normally arranged in a watercraft hull, particularly a blade-type drive unit or the like, on one of its two end regions. The nozzle shaft may, in principle, be realized integrally with the connecting means. However, the connecting means preferably are detachably arranged in the end region of the nozzle shaft, particularly by means of a screw connection. The connecting means may comprise, in particular, an arbor, a shaft stub or the like that is designed for being inserted into a corresponding counterpart of a pivot drive and transmits the torque from the pivot drive to the nozzle shaft.

The connecting means may furthermore comprise an axial bearing that supports the nozzle shaft in the axial direction. The axial support may be realized, for example, with a suitably designed mounting flange that is arranged on the end face of the nozzle shaft. The flange furthermore may be realized integrally with the arbor or shaft stub.

The end region of the nozzle shaft that faces the nozzle ring is rigidly connected to the nozzle ring. It is particularly preferred to produce this connection by means of welding. In the state of the art, in contrast, the massive nozzle shafts are detachably bolted to the nozzle ring by means of flange plates or the like. Due to the small diameter of known massive nozzle shafts, as well as the required detachability of the nozzle shafts, a welded connection or other rigid connection could not be used until now. The ~~inventive~~ propeller nozzle preferably has compact dimensions such that it can be detached at the dock.

In order to produce the rigid connection, the end region of the nozzle shaft that faces the nozzle ring is furthermore extended into the nozzle ring, i.e., into the nozzle body, particularly up to the inner nozzle profile region. In other words, the nozzle shaft does not simply contact the outer surface of the nozzle ring, but is inserted into the structure of the nozzle ring, i.e., into its interior. The nozzle shaft is inserted into the wall of the nozzle ring in such a way that a section of the end region of the nozzle shaft that faces the nozzle ring is arranged in the interior of the nozzle ring with its complete nozzle shaft diameter. In other words, the entire end face of the nozzle shaft is completely incorporated into the nozzle ring wall. It is advantageous if the length of the nozzle shaft section inserted into the nozzle ring amounts to at least 25%, preferably at least 50%, particularly at least 75% of the nozzle ring thickness, i.e., the profile thickness of the nozzle ring. This end region of the nozzle shaft is preferably connected, i.e., welded and braced, on the inner side of the inner nozzle profile region. In this way, an extremely rigid connection may be~~is~~ produced that can withstand high loads.

The profile of a nozzle ring usually consists of an inner profile region and an outer profile region that are respectively formed of steel plates. Connecting

elements or connecting ribs and the like are provided in between for reinforcement purposes. In one preferred embodiment, the nozzle shaft therefore extends through the outer profile region or steel plate, as well as through the entire intermediate space between the outer and the inner profile region, before it is essentially abuts on or contacts the inner steel plate or inner wall. In this way, a particularly rigid connection can be easily produced. In this embodiment, the length of the inserted section of the nozzle shaft approximately corresponds to the profile thickness of the nozzle ring.

According to embodiments of the present invention, the nozzle shaft preferably extends continuously from the interior of the hull to the nozzle ring. In other words, the nozzle shaft is connected to the nozzle ring with one end region and to the steering gear arranged in the interior of the hull with its other end. In this case, it may beis particularly advantageous to realize the nozzle shaft in one piece. Consequently, the ~~inventive~~ propeller nozzle does not comprise any pipe sockets or similar connecting pieces that are arranged on the nozzle ring and into which a nozzle shaft engages, but the ~~inventive~~ nozzle shaft rather extends from the hull into the interior of the nozzle ring and therefore requires no additional connecting means such as, for example, pipe sockets, flange plates or the like.

According to embodiments of the invention, the hollow space of the nozzle shaft is not realized in the form of a conduit for conveying water or oil. Furthermore, no separate lines are provided in the interior of the nozzle shaft. Consequently, the nozzle shaft is used exclusively for supporting the nozzle ring and as a means for pivoting the nozzle ring and not as a hollow conduit body.

According to embodiments of the invention, the nozzle shaft of the propeller nozzle can only be pivoted about its (vertical) longitudinal axis, but not pivoted or tilted about a horizontal axis or other axis. In other words, the nozzle shaft is respectively realized or arranged stationary and can only be pivoted about its own axis. The maximum pivoting angle, by which the nozzle shaft can be pivoted, is 180°, preferably no more than 140°, particularly no more than 90° or even no more

than 60°. The ~~inventive~~ propeller nozzle therefore cannot be turned by 360°, particularly due to the stationary propeller.

The nozzle ring preferably encloses the propeller on all sides. The ~~inventive~~ propeller nozzle particularly does not consist of a tunnel rudder.

Due to the particularly rigid connecting point between the nozzle ring and the nozzle shaft, as well as the high torsional rigidity and flexural strength of the nozzle shaft according to embodiments of the present invention, the propeller nozzle may be supported by means of the nozzle shaft only in one preferred embodiment and require no additional support, particularly no support in the sole piece in the lower region of the nozzle ring. In this way, the construction of the entire propeller nozzle may be~~is~~ simplified because the lower bearing is eliminated. Furthermore, the propeller outflow may be~~is~~ fluidically improved because the lower bearing in the sole piece needs to be connected to the hull and the flow against the sole piece extending out of the hull frequently generates unfavorable turbulences at this location.

It is furthermore preferred to provide at least two openings that are essentially arranged opposite of one another in the wall of the nozzle ring. The openings respectively extend through the entire wall and therefore consist of an inner and an outer region and a center region that connects these two regions to one another. In this way, ocean or sea water can flow from outside the nozzle ring into the interior of the nozzle ring through the at least two openings. This may be~~is~~ advantageous with respect to preventing flow recirculations that could occur without such openings in the outer region of the propeller and directly downstream of the propeller when the nozzle ring is turned or pivoted. In order to prevent these recirculations in a particularly effective fashion, it is practical that the two openings are respectively arranged in a lateral area of the nozzle ring in the installed state. In this case, the remaining area of the nozzle ring is closed and not provided with any other opening. Referred to the flow direction, the at least two openings furthermore should preferably be arranged at the propeller or downstream thereof.

In order to additionally improve the stability and the flexural strength of the nozzle shaft, it may be is advantageous that the nozzle shaft is at least sectionally arranged and supported in a trunk pipe. The trunk pipe is rigidly connected to the structure of the watercraft and may be arranged completely within the watercraft or also partially outside thereof. It may be is particularly advantageous to respectively provide a bearing between the trunk pipe and the nozzle shaft in the upper and in the lower region of the trunk pipe. In this respect, it is preferred to provide at least one sliding bearing, particularly a cylindrical sliding bearing, between the trunk pipe and the nozzle shaft. The region of the nozzle shaft that faces the nozzle ring may advantageously protrudes from the trunk pipe such that its end region can be connected to the nozzle ring. Trunk pipes basically are sufficiently known from the state of the art and typically realized in the form of a hollow cylinder, the inside diameter of which approximately corresponds to the outside diameter of the nozzle shaft.

It is generally preferred that the pivotable nozzle shaft is only supported on its outer surface and does not feature internal bearings or the like.

The invention is described in greater detail below with reference to the different embodiments that are illustrated in the drawings. In these schematic drawings:

Figure 1 shows a perspective front view of a nozzle ring with an external pivot drive and a fin arranged on the rear side,

Figure 2 shows a perspective front view of a propeller nozzle with a fin arranged on the rear side and its arrangement on a hull of a twin-screw vessel, wherein the propeller shaft and the stern tube are not illustrated in this figure,

Figure 3 shows a longitudinal section through a propeller nozzle,

Figure 4 shows a longitudinal section through the upper end region of the nozzle shaft with a pivot drive arranged in the nozzle shaft, and

Figure 5 shows a schematic illustration of a hull stern section with propeller nozzle and propeller shaft.