

CLEANING HEAD FOR CLEANING A SURFACE, DEVICE COMPRISING SUCH CLEANING HEAD, AND
METHOD OF CLEANING

The present invention relates to a cleaning head for
5 cleaning a surface, such as a ship's hull. The cleaning head
can also be used for cleaning a storage tank and other
surfaces including a surface of a ship's lock door.

Offshore and marine industry, including transport by
ships, involve large (steel) structures that are exposed to
10 a wide range of conditions for relatively long periods of
time. To secure a correct operation of these structures
maintenance and care is important. For example, a ship's
hull is fouled with marine organisms that increase the drag
of the ship thereby increasing fuel consumption and engine
15 wear, and decreasing the manoeuvrability of the ship.
Already a small layer of fouling, such as a slime layer, is
sufficient to cause aforementioned negative effects. In
addition, the emission of gasses such as NO_x, SO_x and CO₂ is
increased by this fouling. Cleaning is mostly done in
20 outside ports or in dry docks, or alternatively, to some
extent during loading and unloading of the ship. As cleaning
requires the removal of fouling on surfaces both under and
above water, in practice ships are regularly subjected to
cleaning and inspection. Similar cleaning and inspection is
25 required for offshore structures, dry docks, and bridge
columns.

In the field of cleaning devices for surfaces that are
subject to the environment there are several types of
cleaning robots, either remotely controlled or autonomous.

30 EP 1886904 discloses a climbing cleaning robot with
high adherence magnets to attach to the metal surface, four
drive wheels that are grouped in a rectangular configuration
and a cleaning mechanism and the magnets located between the

wheels. The magnets can be turned in an inactive state due to the connection of the magnets with a cylinder fixed to the chassis, which is able to move the magnets to the inactive state. Due to the specific configuration of the wheels in relation to the magnets and the cleaning mechanism, the robot is suited for flat surfaces instead of surfaces that are curved in three dimensions.

EP 1 216 761 discloses a device for hydrodynamic cleaning of surfaces. The device comprises a collector, a stator, a rotor comprising radial piping and high pressure-flow generators. The housing appears as a hollow shaped disk with at least one lower shaped surface and partially filled with a shifting ballast.

Relating to the attachment of a device to a surface, GB1270117 discloses a carriage or trolley for travel along an upright wall of magnetisable material. The device comprises magnetic means for attachment to the surface, that is kept at a fixed distance from the surface due to the runner wheels on the device.

Embodiments of the present invention seek to obviate or at least reduce the above stated problems.

According to a first aspect of the present invention, there is provided a cleaning head for cleaning a surface, such as a ship's hull, the cleaning head comprising:

- a frame comprising a nozzle shaft;
- one or more nozzles for cleaning the surface that are directly or indirectly connected to the nozzle shaft of the frame for providing a fluid to the surface to be cleaned;
- magnetic positioning means for positioning the head relative to the surface that are provided or attached to the frame; and

- an activating element for manipulating the distance between the surface and the positioning means, the activating element being connected to the positioning means,

5 wherein the magnetic positioning means are movable between at least a first state wherein the head is in a free movable state, and an active second state wherein the head is movably connected to the surface and can be put to operation, and

10 further comprising rotating means such that the nozzles are rotatable around the magnetic positioning means, and wherein the cleaning head is integrally provided with the magnetic positioning means, such that the capability to follow a curvature of the surface is provided.

15 By providing magnetic positioning means, including both ferromagnetic and electromagnetic positioning means, a cleaning head can be positioned relative to the surface to be cleaned. This surface to be cleaned can be above or below water and may comprise a ships's hull, a tank surface, doors or gates for
20 ships lock, and relatively static constructions in the offshore industry. The fouling on these structures increases drag forces on the structure and deterioration of the coating and construction. Cleaning involves removal of fouling, paint, surface layers, etc. Regular cleaning according to embodiments
25 of the present invention would decrease environmental loads and the need for maintenance of the parts of the construction being exposed to the environment.

By providing an activating element the distance between the surface and the positioning means can be manipulated. The
30 activating element moves the positioning means between at least two different states. In a first state, the cleaning head moves freely from the surface and can be positioned at a surface location requiring cleaning for example. In an active second state the actual cleaning of the surface is performed, wherein
35 the cleaning head can be put to operation. In this second state the magnetic

positioning means are magnetically attached to the surface to be cleaned.

The activating means manipulate the distance or gap between the (permanent) magnetic positioning means and the surface to be cleaned. A small gap may provide a relatively strong connection between the head and the surface to be cleaned, and enable moving the device over the surface to be cleaned. In case the alternative electromagnets are used the level of the supplied electrical power determines the strength of the attachment of the device according to embodiments of the invention with the surface to be cleaned.

Optionally, intermediate states could be arranged. For example, in such intermediate state some connection between the cleaning head and the surface to be cleaned is still maintained, however, this connection is less strong as compared to the second state wherein the actual cleaning is performed. Such intermediate state would enable a more easy movement of the cleaning head over the surface without completely disconnecting the cleaning head from the surface.

The cleaning head is provided with one or more nozzles that channel the pressurized fluid on to the surface.

The nozzles are directly or indirectly connected to the nozzle shaft. For example, in a presently preferred embodiment the nozzles are attached to nozzle arms that are connected to a rotatable housing that is capable of rotating around the nozzle shaft.

This fluid may comprise water and/or air. Additionally, the fluid may comprise abrasives and/or other components. The pressurized fluid removes the fouling and/or paint and/or other components from the surface to be cleaned. Preferably, the nozzles are provided on a rotating ring that rotates the nozzles around the nozzle shaft of the frame corresponding to an axis of the cleaning head. This

may increase the surface area that can be cleaned in one position of the cleaning head.

The cleaning head further comprises rotating means such that the nozzles are rotatable around the magnetic positioning means. By having the nozzles rotated when the cleaning head is in use a larger surface area can be cleaned. Preferably the nozzles are provided on a ring that rotates around these magnetic positioning means.

The cleaning head is integrally provided with the positioning means. By integrally providing the magnetic positioning means may provide the capability to follow the curvature of the surface. For example, such curvature is relevant for a ship's hull. This may significantly improve the applicability of the cleaning head according to the invention.

According to embodiments of the invention the functions of cleaning curved surfaces and the attachment of the device to the surface are combined. Due to the integration of cleaning technology with magnetic attachment means, embodiments of the present invention may provide a solution for the specific requirements when cleaning surfaces, especially including curved surfaces, while the device may be able to achieve high cleaning speeds and may optionally be optimized to capture the removed debris as well.

In an advantageous preferred embodiment according to the present invention the activating element comprises a hydraulic or pneumatic control cylinder wherein the positioning means is movable between the at least first and second state.

By providing a pneumatic or hydraulic cylinder the air gap between the magnetic element of the positioning means and the surface to be cleaned can be controlled. In the first state, the air gap is relatively large such that the

cleaning head can be moved freely from the surface, while in the second state the air gap is relatively small such that the cleaning head is more or less fixed to the surface to be cleaned. In both states the air gap can ensure that the surface
5 to be cleaned is not damaged by a cleaning head. This may maintain the protective performances of coatings and the fouling layers, for example.

Preferably, the positioning means comprises a permanent magnet. The use of a permanent magnet can guarantee that the
10 cleaning head stays connected to the ship's hull both above and under water even in case of malfunctioning of the electric supply. Furthermore, permanent magnets have a high attachment force/magnet weight or size ratio as compared to electromagnets. In addition, in a presently preferred
15 embodiment a metal strip provided on at least one side of the permanent magnet may increase the magnetic field and thereby enhance the capabilities of handling the cleaning head relative to the surface. This may reduce the number of magnets that are required thereby making handling of the cleaning head more easy
20 and reducing the costs associated with the cleaning head according to embodiments of the invention.

Preferably, the positioning means is provided at or around a shaft of the cleaning head. As mentioned before, providing a cleaning head integrated with the positioning means may improve
25 the capability of cleaning surfaces with a relatively large curvature. In a presently preferred embodiment the shaft is positioned at or close to the central axis of the cleaning head. Preferably, one or more of the supplies for the activating element are positioned in the internal of the shaft.
30 This may prevent additional pipes or hoses to be used.

In an advantageous preferred embodiment according to the present invention the rotating means comprise a

rotatable housing with arms to which the nozzles are attached.

By providing a rotatable housing with arms with nozzles attached to these arms in use a larger surface area can be cleaned. As mentioned before, the nozzles are preferably
5 provided on a type of ring, or other circular shape, that rotates around these magnetic positioning means.

Preferably, the nozzles are provided at a non-perpendicular angle to the surface such that a rotating movement is achieved when the cleaning head is in use. By
10 providing the nozzles with an inclination relative to a perpendicular line of the surface to be cleaned, the nozzles power the rotational movement of the ring such that no external drive, or at least a reduced drive, is required.

In a further advantageous preferred embodiment according
15 to the present invention the cleaning head comprises three support-and-moving means.

By providing three support-and-moving means a stable construction may be achieved. Preferably, these means involve wheels and/or rollers that enable moving the cleaning head over
20 the surface to be cleaned.

In a presently preferred embodiment the support-and-moving means are attached or connected to the shaft such that the nozzles may rotate around the shaft and the support-and-moving means. In this embodiment the positioning means, preferably
25 comprising a permanent magnet, is also connected to the shaft such that the nozzles may also rotate around the positioning means.

Optionally, the support-and-moving means comprise connecting means for connecting to a power source for driving the cleaning
30 head. When the nozzles rotate around the shaft and the support-and-moving means at the same time,

the cleaning head substantially moves over a clean surface when in use.

Preferably, the cleaning head comprises suction means. The suction means remove loose parts from the surface. Such parts
5 may relate to fouling and/or paint that is removed by the nozzles. By providing suction means it can be prevented that such parts enter the environment. Preferably, the suction means is incorporated in a housing of the cleaning device. This housing involves a double-walled housing with the suction means
10 provided between the inner and outer wall.

According to a second aspect of the present invention, there is provided a cleaning device for cleaning a surface, such as a ship's hull, comprising:

- a frame with one or more cleaning heads as described above; and
15 - a drive for moving the device.

Such a cleaning device may provide the same effects and advantages as described for the cleaning head. The cleaning device can be used for cleaning a surface that is partly above and partly under water by providing relevant parts with a water
20 tight casing.

Applying more than one cleaning head for a device may significantly improve the cleaning performance due to the multiple head configuration as compared to a circumferential cleaning, for example.

25 Preferably, the cleaning device comprises one or more units that each are provided with one or more cleaning heads. Providing the one or more units with more than one cleaning head may enable the use of a central suspension that provides more balance to the device according to embodiments of the
30 invention.

More preferably, the cleaning head is provided with three cleaning heads, that are connected to a triangular sub

frame. In a presently preferred embodiment according to the invention the cleaning heads are capable of rotating relative to the sub frame. The sub frame is connected to the frame that houses the drive for moving the device, using a cylinder or
5 other suspension that may result in a flexible suspension for the three cleaning heads. This can ensure that the cleaning heads will perfectly follow curved surfaces. In addition, the unit comprising the three cleaning heads will exert a force on the cleaning heads away from the surface to be cleaned. Due to
10 the magnetic positioning means in the cleaning heads, in their active state, the frame that is attached to the unit comprising the cleaning heads will stay connected to the surface to be cleaned. Optionally, extra magnetic positioning means can be attached to the frame thereby creating an even higher
15 attachment force to the surface.

In a presently preferred embodiment of the cleaning device the device comprises inspection means and/or paint spray means. This may enable inspection of the surface. The inspection means may comprise a camera or sensor to measure the thickness of the
20 surface, coating thickness, and corrosion inspection, for example. The paint spray means enable providing a coating or other layer on the surface.

According to a third aspect of the present invention, there is provided a method for cleaning a surface, such as a
25 ship's hull, the method comprising the steps of:

- providing a cleaning device as described above;
- positioning the device on the surface; and
- cleaning the surface.

Such a method may provide the same effects and
30 advantages as described for the cleaning device and/or the cleaning head.

In a presently preferred embodiment loose parts are removed by suction means as described above.

Further advantages, features and details of the invention will be elucidated on the basis of preferred
5 embodiments thereof, wherein reference is made to the accompanying drawings, in which:

- figure 1 shows a ship being cleaned by the device according to the invention;
- figure 2 A-C shows the device of figure 1;
- 10 - figure 3 A-D shows a cleaning head of the device of figure 1; and
- figure 4 A-E shows some details of the device of figure 1.

A ship 2 (figure 1) is partly below water 4. In the
15 illustrated embodiment ship 2 is positioned along a quay 6. Ship 2 is cleaned with cleaning device 8 and is provided with power supply 10, air supply 12, and water supply 14, in the illustrated embodiment all connected to supply device 15. Device 8 is optionally provided with a drain pipe (not
20 shown) and a housing 16.

Device 8 (figure 2 A-C) is provided with frame 18 that in use is covered by housing 16 (not shown). In the illustrated embodiment frame 18 comprises cleaning unit 20 that is provided with three cleaning heads 22. Device 8 is
25 movable using three wheels 24 over ships hull 26. In general, a ship's hull 26 is provided with a curvature 28. In the illustrated embodiment device 8 is also provided with a corresponding curvature 29 that is similar to the curvature of ship's hull 26. Optionally, adjusting means
30 (not shown) are provided enabling adjustment of curvature 29 of device 8 to bring it into conformity with that of ship's hull 26.

Cleaning head 22 (figures 3 A-D), using connecting part 30, is attached to unit 20 and frame 18. Cleaning head 22 is provided with shaft 32, motor 34, power supply 36 and water supply 38. Motor 34 drives belt 40 and therewith a number of
5 nozzles 44 that perform the actual cleaning. Magnets 46 are provided in a housing 42. Cleaning head 22 is attached to a ship's hull with magnets 46 and movable over such ship's hull with wheels 48. In the illustrated embodiment each cleaning head 22 is provided with a number of permanent
10 magnets that are provided in an alternating North-South configuration.

In a first state (figure 3 C) cleaning head 22 can be moved freely. In a second attached state (figure 3 D) cleaning head 22 is attached to a ship's hull with magnets
15 46. Shaft 32 is attached to a cylinder 50 with a piston 52. In the illustrated embodiment magnets 46 are attached to piston 52. Above magnets 46 there is provided a metal strip 56 to enhance the magnetic field. Arm 58 for nozzles 44 are rotatable with rotating housing 60 around shaft 32 using
20 bearings 62.

In the preferred embodiment each cleaning head 22 is provided with four nozzles 44 (figure 3 C-D). The nozzles rotate with about 500-2000 rpm and preferably operate with a pressure in the range of about 0-1000 bar. The cleaning head
25 22 is provided with a cover 64 comprising an outer part 66 and an inner part 68. Part 66, 68 are spaced apart thereby performing a suction channel 70 for removal of parts from the ship's hull that are removed with nozzles 44. These parts are removed by drain or outlet 72.

30 In the illustrated embodiment shaft 32 (figure 4 A-E) is provided with supply and return channels 54 that can be used for manipulating the position of piston 52. In fact, shaft 32 is provided with three channels, two for air supply

and return 54 and one for water supply 74. Nozzles rotate around shaft 32 and are provided with water from outlet 76. In the illustrated embodiment piston 52 is moved pneumatically by supply of air through outlets 78, 80 with opening 82. Alternatively, piston can be moved hydraulically or otherwise. In the illustrated embodiment room 84 is provided for wheels 48. Optionally, wheels 48 are provided on the outer periphery of cylinder 50 (not shown).

When a ship's hull 26 needs to be cleaned a device 8 is provided at a desired location on ship's hull 26. Magnets 46 move from a free movable state to the attached state wherein device 8 is attached to ship 2. Next, cleaning starts by providing water to nozzles 44. Nozzles 44 are rotated by starting motor 34. Device 8 moves over surface 26 using wheels 24 to clean the entire surface by providing a water tight casing and/or waterproof part device 8 can move above and below water 4 thereby preventing the ship to be moved out of the water for cleaning purposes. Power is supplied by power supply 10. Alternatively, a battery is supplied in device 8.

In the illustrated embodiment cleaning head is provided with a diameter of about 50 cm and the total width of device 8 is about 1.5 m. Device 8 is manually controlled, or alternatively, controlled automatically using GPS, for example.

The present invention is by no means limited to the above described embodiments thereof. The rights sought are defined by the following claims, within the scope of which many modifications can be envisaged. For example, wheels 48 are provided within housing 42. In an alternative embodiment according to the present invention wheels 42 can also be provided outside housing 42, preferably in the area between nozzles 44 and housing 42. The control channels 44 are

provided within shaft 32. Alternatively, supply pipes or hoses can also be provided in a more conventional manner outside cylinder 50. In the illustrated embodiment the rotation is achieved with motor 34. Alternatively, arms 58
5 are provided under an angle with nozzles 44 such that a rotating movement is achieved when in use.

CLAIMS

1. Cleaning head for cleaning a surface, such as a ship's hull, the cleaning head comprising:

- a frame comprising a nozzle shaft;
- 5 - one or more nozzles for cleaning the surface that are directly or indirectly connected to the nozzle shaft of the frame for providing a fluid to the surface to be cleaned;
- 10 - magnetic positioning means for positioning the head relative to the surface that are provided or attached to the frame; and
- 15 - an activating element for manipulating the distance between the surface and the positioning means, the activating element being connected to the positioning means,

wherein the magnetic positioning means are movable between at least a first state wherein the head is in a free movable state, and an active second state wherein the head is movably connected to the surface and can be put to operation, and

20 further comprising rotating means such that the nozzles are rotatable around the magnetic positioning means, and wherein the cleaning head is integrally provided with the magnetic positioning means, such that the capability to follow a curvature of the surface is provided.

2. Cleaning head according to claim 1, wherein the activating element comprises a hydraulic or pneumatic controlled cylinder for moving the positioning means between the at least first and second state.

3. Cleaning head according to claim 1 or 2, wherein the positioning means comprises a permanent magnet and wherein at least one side of the magnet is provided with a metal strip.

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4. Cleaning head according to any of the foregoing claims, wherein the positioning means is provided at or around a shaft.

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5. Cleaning head according to claim 4, wherein a supply for the activating element is positioned in the internal of the shaft.

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6. Cleaning head according to one or more of the foregoing claims, wherein the rotating means comprise a rotatable housing with arms to which the nozzles are attached.

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7. Cleaning head according to claim 6, wherein the spray nozzles are provided at a non-perpendicular angle to the surface such that in operation a rotating movement is achieved when the cleaning head is in use.

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8. Cleaning head according to one or more of the foregoing claims, further comprising three support-and-moving means with the three support-and-moving means optionally comprising connecting means to connect to a power source.

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9. Cleaning head according to one or more of the foregoing claims, further comprising suction means to remove loose parts.

10. Cleaning device for cleaning a surface, such as a ship's hull, comprising:

- a frame with one or more cleaning heads according to one or more of the foregoing claims; and
- a drive for moving the device.

11. Cleaning device according to claim 10, further comprising a unit which is provided with one or more cleaning heads and comprising a combined suspension.

12. Cleaning device according to claim 10 or 11, further comprising inspection means and/or paint spray means.

13. Cleaning device according to claim 12, wherein a suction means is incorporated in a housing.

14. Method for cleaning a surface, such as a ship's hull, comprising the steps of:

- providing a cleaning device according to one or more of the foregoing claims 10-13;
- positioning the device on the surface; and
- cleaning the surface.