

System for use with a crane on a surface vessel

The invention relates to a system for use with a crane e.g. on a surface vessel, such as a ship or jack-up barge, and to a method of installing an on- or offshore installation, such as a foundation for a wind turbine.

5 Typical offshore cranes have a set of slings to connect to e.g. hooks on tools (equipment) or components such as piling equipment and foundation parts. For a change of tool or component, the main crane hook has to be lowered to deck level to connect and disconnect the slings, which,
10 moreover, requires at least three staff member to (dis)connect the slings, and costs much time and deck space. After placing or employing a tool or component, the slings are typically put back on deck.

Also, as a result of lowering the crane hook to
15 deck level the hoisting cable and the winch for the cable are subjected to considerable wear, especially when the crane hook is lifted from deck without a load. This occurs e.g. when the slings of a tool, such as a noise mitigation screen or NMS, or component are lifted over a considerable
20 vertical distance until they are taut. The hoist cable is very expensive and time consuming to replace.

It is an object of the present invention to facilitate the hoisting of tools and components during installing of an offshore installation, such as a
25 foundation, e.g. a monopile or jacket, for a wind turbine.

To this end, the present invention provides a system for use with a crane on a surface vessel, comprising a crane tool attached or attachable to a hoisting cable of the crane and one or more, e.g. a plurality of, adaptors
30 attached or attachable to one or more tools, e.g. a plurality of mutually different tools, for carrying out operations, e.g. lifting and manoeuvring equipment, such as a noise mitigation screen and/or a pile driver, and/or to one or more, e.g. a plurality of, components, such as a

monopile or a transition piece, of an offshore installation, the crane tool comprising a connector and at least one of the adaptors, e.g. a plurality of the adaptors, comprising a connector-counterpart.

5 In an embodiment, the connector or the at least one connector-counterpart is a male connector, e.g. a pin or cylindrical block, and the other is a female connector, e.g. a bucket.

10 The connector and connector-counterpart provided by the present invention require less personnel, costs and/or time to connect, by mating the connector and the connector-counterpart, a hoisting cable to a tool or component, to disconnect the hoisting cable from a tool or component, to connect the hoisting cable to a further tool or component, 15 require less or no hoisting slings, occupy less deck space and/or are safer for personnel on deck. Depending on the configuration, illustrated in an example below, the connection according to the present invention enables reducing travel of the hoisting cable.

20 Besides, the speed of the operations that can be performed with the system will increase, while the cost of these operations are reduced.

25 In an embodiment, the at least one connector-counterpart faces upwards and/or is adjustable, e.g. rotatable, towards a position where it faces upwards.

30 Thus, the direction of connection of the connector and connector-counterpart can be aligned and the connector of the crane tool can be dropped in or over the connector-counterpart of the adaptor, facilitating connecting the hoisting cable to a tool or a component.

 To further facilitate establishing a connection, in particular by dropping in or over, in an embodiment, the connector and/or the at least one connector-counterpart is rotationally symmetrical.

Thus, the rotational orientation of the crane tool and the tool or component is no longer critical or at least less critical than with the traditional hook and slings.

In a straightforward embodiment of this concept,
5 the connector or the at least one connector-counterpart comprises one or more latches, preferably radially movable elements, such as wedges or spheres, which are resiliently mounted and/or operatively coupled to an actuator, and the other comprises a notch or a rim, e.g. a circumferential
10 flange, for the latch or latches to hook in or behind.

In another embodiment, one or more of the adaptors comprises, in addition to the connector-counterpart, a transition element, such as a spreader bar or connecting rods, to couple the connector-counterpart to the tool or
15 component.

In another embodiment, the connector and/or connector-counterpart comprises guiding elements, such as a conical portion, e.g. a stabbing cone, on one part and a circular opening or funnel on the other part.

20 In a further embodiment, the crane tool comprises measuring equipment, preferably a global positioning system (GPS), an imaging device, e.g. a camera and video image processing unit, and/or an inclination sensor, e.g. to measure verticality of the crane tool and optionally of the
25 tool or component connected to the crane tool.

Such sensors can be employed e.g. to measure or show on a screen the position of the crane tool relative to the adaptor and assist the crane operator in establishing a connection. Also, vessels and operations nowadays are being
30 digitalized. Although operators know the position of the crane (rotation, height of the boom tip, length of the hoisting cable), they cannot know the exact position of the end of the hoisting cable. When the crane tool comprises measuring equipment, such as GPS, the position of the crane
35 tool is known, making digitalization of the operation more

precise. If the XYZ coordinates of the crane tool and of the counterparts on the tools and/or components are known, automation of at least part of the operations, in addition to the docking, is facilitated. This can improve operational efficiency and deck layout. Further, such sensors can be employed e.g. to ensure that not only the crane tool and a counterpart, such as a bucket, on a tool and/or component are aligned, but also that the hoisting cable and boom tip are vertically aligned. Such vertical alignment helps in reducing or avoiding a swinging effect when the tool or component is lifted.

The sensors can also be used during operation of the working tool, for example during positioning or driving a pile. Also, the crane tool and the connected tool can be configured in such a way that they can communicate with each other. For instance, when the crane tool and a hammer adaptor provided with a calendaring system are connected, information about the calendaring could be communicated to the crane tool, which can then store this information locally or transmit it to a receiver in a control system.

In an embodiment, the system comprises a pile driver and an adaptor attached to the pile driver, wherein the adaptor comprises a sliding element indicative of displacement, preferably in the direction of pile driving, i.e. typically in the vertical direction, of the pile driver relative to the crane tool.

The sliding element can provide information about displacement e.g. in terms of the distance that the pile has moved at any stage. E.g., it can be employed to measure the distance (penetration) per hammer blow in order to compare the effect of individual blows and also to enable proper operation of the system.

In a refinement, the adaptor comprises a (first) cylindrical element, e.g. a bucket, fixed or configured to be fixed relative to the pile driver and a further

cylindrical element, e.g. a further bucket, slidably fitted in or over the (first) bucket and preferably fixed relative to the crane tool. Thus, the crane tool can be maintained at a constant position (height) by means the hoisting cable and/or, if the tool is provided with a GPS, the exact position of the crane tool measured and displacement of the sliding element, e.g. of the (first) bucket relative to the further bucket, can be observed or measured accurately, providing an effective calendar measuring system. This system can even be configured to measure pile penetration per blow of the pile driver and thus e.g. calculate the energy required for the next blow and/or establish sooner than with conventional calendar system when the pile has reached the stage referred to as "refusal", i.e. when pile driving is completed.

To facilitate visually monitoring of the progress of pile driving, the outer wall of the further bucket is provided with one or more markings, e.g. a coloured and/or illuminated ring that is gradually exposed with increasing penetration of the pile and resulting lowering of the pile driver and the first (outer) bucket.

In another embodiment, the system comprises a pile driver and an adaptor attached to the pile driver, wherein the adaptor comprises a sliding element allowing dampened displacement, preferably in the direction of pile driving, i.e. typically in the vertical direction, of the pile driver relative to the crane tool.

In a refinement, the adaptor comprises a cylindrical element fixed relative to the pile driver and a further cylindrical element slidably fitted in or over the (first) cylindrical element and preferably fixed or configured to be fixed relative to the crane tool.

In a further refinement, the adaptor comprises a (first) cylindrical element, e.g. a bucket, fixed relative to the pile driver and a further cylindrical element, e.g. a

further bucket, slidably fitted in or over the (first) bucket and preferably fixed or configured to be fixed relative to the crane tool. The buckets are coupled via one or more elements for generating friction. In a refinement, one or both buckets are provided with flanges or seals defining a chamber, which chamber is filled with a fluid, e.g. hydraulic oil. Flow resistance can be generated e.g. by an obstruction, such as a flange attached to one of the buckets and moving within the chamber, or by a flow restriction, such as a choking valve at an outlet of the chamber.

Thus, in case of freefall of the pile and pile driver, e.g. when the tip of the pile reaches a ground layer providing low resistance, acceleration of the pile and driver is reduced, in turn reducing the sudden load on the crane and providing some time for the crane operator to respond.

It is noted that these sliding elements can be used independent of the connector and connector-counterpart, e.g. between a pile driver and a conventional hook or shackle, providing the same advantages. In addition, the sliding elements to some extent decouple the crane tool and instruments in it from vibrations in the pile driver.

Further, in a refinement, explained in more detail below, the sliding element for the calendar and the sliding element providing freefall protection are combined, e.g. in a telescopic configuration comprising three buckets.

The invention also relates to a method of installing an installation, e.g. an offshore installation, such as a wind turbine, using a crane, e.g. on the ground or on a surface vessel, and having a hoisting cable, a crane tool attached to the hoisting cable and having a connector, and one or more, e.g. a plurality of, tools and/or components having a connector-counterpart, the method comprising the steps of

lowering the crane tool with its connector into or onto a connector-counterpart of one of the tools or components and establishing a connection between the two, lifting the tool or component with the hoisting
5 cable.

In an embodiment, the crane tool is subsequently, e.g. after positioning the tool or component, disconnected from the tool or component and then lowered with its connector into or onto a connector-counterpart of a further, e.g. another and different, tool or component, and a
10 connection is established between the two. The further tool or component is then lifted with the hoisting cable.

In another embodiment, the connection is established above ground level or deck level, preferably at least 5 meters above ground or deck level, thus requiring
15 less paying out and taking in of the hoisting cable.

Another embodiment comprises the steps of connecting a tool, e.g. transition piece lifting tool to a component, e.g. to a transition piece,
20 hoisting the tool and component, positioning the component in or on the offshore installation, removing the tool from the component, moving the tool to a similar or identical component on the deck of the vessel,
25 connecting the tool to or placing the tool on that component, and, disconnecting the crane tool from the connector-counterpart on the tool.

30 Thus, the overall number of steps is reduced.

For the sake of completeness, attention is drawn to the following prior art.

EP 2 500 473 relates to a method involving "lowering a component (1) which is in form of tubular hollow
35 structure, from floating position with horizontally oriented

longitudinal axis, so that reduction takes place down to sea floor (3) or upto defined position. The component is held by manipulation device (8) in vertical position."

EP 1 640 508 relates to a device having "a frame
5 (1) fastened on a ship-jack-up rig for encompassing and guiding a post (5), when ramming the post in a benthic division. A nozzle assembly (7) of a blowing device, which can be lowered from an upper standby position underneath the frame into an operating position at the benthic division, is
10 attached at the frame."

WO2008/106964 relates to a releasable coupling between a heavy object and a locking arrangement and to a method of engaging and disengaging a heavy object and the use of one or more couplings in a pile driver, crusher,
15 demolition hammer, stone or aggregate crusher. With this invention "it may be possible to achieve around 7 strokes per minute or more with the heavy object."

EP 3 034 860 relates to an assembly comprising a tool with a stem having a first end having a projecting
20 portion such as a ring, and a second end adapted to be engaged by a lifting equipment. In the example, "When the hub 500 of the wind turbine has been lifted, the crane is disengaged from the through bore 145 of the second end 140 of the stem 120 and the tool 110 is removed by the operator
25 from the hub 500. Once the tool 110 has been removed, the stem receiving portion 150 may be properly sealed or covered preventing water, dirt, objects, etc. from entering the stem receiving portion 150."

EP 2 752 361 relates to a hoisting system
30 comprising a hoisting crane having a hoisting cable, a craft, and a connector catch assembly for interconnecting the hoisting crane and the craft or a load/cargo on the craft.

GB 2 417 233 relates to an apparatus for
35 automatically coupling and uncoupling an overhead lifting

device to a load, which apparatus comprises a first part for connection to the overhead lifting device, and a second part for connection to the load.

The invention will now be explained in more detail with reference to the Figures, which show a preferred embodiment of the present method and system.

Figure 1 shows a jack-up barge, comprising a crane and a hoisting cable, for installing a monopile.

Figure 2 illustrates the travel of the hoisting cable required during a conventional procedure for installing a monopile and transfer piece.

Figures 3A to 3F show a crane tool and a pile driver adapting piece according to the present invention.

Figure 4 shows a crane tool and an adaptor according to the present invention connected to a rail frame of a noise mitigation screen.

Figures 5 and 6 show a crane tool and an adaptor according to the present invention connected to a pile upending tool and a transition piece lifting tool.

The Figures are schematic in nature and details that are not necessary for understanding the present invention may have been omitted and/or have not been discussed.

Figure 1 shows an embodiment of a system 1 for installing a monopile 2 in an underwater ground formation, e.g. a seabed. The system 1 comprises a jack-up barge 3 comprising a crane 4 having a hoisting cable 5, and a winch below deck (and thus not shown) for paying out and taking in the cable. The hoisting cable 5 is attached to a spreader bar 6 carrying hooks 7 via forerunners. The barge 3 carries a number of monopiles 2 (MP), positioned horizontally on deck, transition pieces 10 (TP), positioned upright on deck, a noise mitigation screen 11 (NMS), positioned upright on the deck of the barge and at its top provided with a rail frame 12, shown in more detail in Figure 4, to facilitates

handling and accurate positioning of the NMS, a pile upending tool 13 (UET; Figure 5), a transition piece lifting tool 14 (TPLT; Figure 6) for moving the TP, and a hydraulic pile driver, e.g. an IHC Hydrohammer S-1800.

5 Figure 2 illustrates an example of installing a monopile (MP) and transition piece (TP) of a wind turbine. This example involves the following steps: lowering the hook at the end of the hoisting cable of the crane to deck level (DL) to pick up slings from deck and start lifting a noise
10 mitigation screen (NMS). Positioning the NMS on the seabed and putting the slings back on deck. Next, the hook is connected to the pile upending tool (UET), which is then coupled to the monopile, to erect, manoeuvre and place the MP inside the NMS. Subsequent steps include: picking up
15 slings and placing the hammer. Placing back the hammer and NMS. Collecting a transition piece lifting tool (TPLT) for moving the TP. All or most of these steps involve returning the end of the hoisting cable to deck level and require personnel on deck to attach and detach the hooks and slings.

20 In accordance with the present invention, instead of a hook, a crane tool 15 is attached to the hoisting cable 5 of the crane 4. Further, an adaptor 16 is attached to each of the tools, in the example above an adaptor is attached to each of the following: the rail frame 12, the pile upending
25 tool (UET), the transition piece lifting tool (TPLT), and the hydraulic pile driver.

 The crane tool comprises a connector 17 and the adaptor comprises a connector-counterpart 18. In example shown in Figures 3A to 3F, the cable tool 15 comprises an
30 attachment eye 19 for the hoisting cable of the crane, a circle cylindrical main body 20 comprising a plurality of latches 21 evenly distributed over the circumference of the main body, thus rendering it rotationally symmetrical, and at its lower end (seen when suspended from the hoisting
35 cable) a stabbing cone 22. The latches are pivotal about

axes extending horizontally and tangentially through their lower ends, enabling the latches to deflect inwards when the crane tool is inserted in an adaptor. Hydraulic actuators (hidden from view) are located inside the main body to actively retract the latches, e.g. to release the crane tool from an adaptor.

The adaptor 16 in Figures 3A to 3F is attached to the hydraulic pile driver 25 via a transition cylinder 26 that clears the lifting eye of the driver, without significant changes to the driver. Attached to the cylinder is a first bucket 27, fixed relative to the pile driver. A second bucket 28 is slidably fitted inside the first bucket. A third bucket 29 is slidably fitted in the second bucket. Each of the three buckets has an outwardly extending flange at its lower rim and an inwardly extending flange at its top rim, providing a telescoping arrangement. The outwardly extending flange on the first bucket serves to attach, e.g. bolt, the telescoping arrangement to the transition cylinder. The inwardly extending flange 35 on the third bucket defines an insertion opening for the receiving the crane and provides a rim for the latches to lock behind. The remaining flanges define first and second chambers between the buckets, which are filled with a hydraulic oil. The second chamber (between the second or middle and third or inner buckets) is provided with one or more choking valves. The outer wall of the second (and middle) bucket is provided with one or more markings, in this example a coloured ring 36 (best seen in Figures 3C and 3F) having a height of e.g. 30 cm.

The skill person will appreciate that the second bucket can be employed as (part of) a calendar measuring system, a blow measuring device, and/or a positioning device.

In Figure 3A, the pile driver 25 is in sea-fastened position on the deck of the barge 3. The crane tool 15 is

being lowered into the third (and innermost) bucket 29, during which the stabbing cone 22 passively centers the crane tool relative to the adaptor 16, and the latches are deflected inwards by the inward extending flange 35 on the bucket, to establish a connection between the crane tool and the adaptor and thus between the crane and the pile driver. When or after the position shown in Figure 3B has been reached the operator locks the crane tool inside the adaptor by remote control for safe lifting. The choking valves in the second chamber are closed, locking the hydraulic oil inside the chamber and thus locking the third (inner) bucket relative to the second (middle) bucket. When the pile driver is lifted, as shown in Figure 3C, the third and second buckets are pulled out from the first (outer) bucket until the second bucket reaches end of travel. At end of travel, fluid pressure will build up in the second chamber and the pile driver is lifted.

In Figure 3D, the pile driver has been placed on the monopile and the choking valves are opened, enabling dampened sliding of the third (inner) bucket inside the second (middle) bucket. The crane tool is lowered further, thus lowering the second bucket into the first (outer) bucket until the marking on the second bucket is no longer visible. Pile driving is started, causing the pile, the pile driver and thus the first (and outer) bucket to lower with each blow of the pile driver relative to the crane tool, gradually exposing the coloured ring 36. When the ring is entirely exposed, as shown Figure 3E, the crane tool is lowered by means of the crane until the ring is no longer visible.

Figure 3F illustrates what happens in the monopile and the pile driver are freefalling, e.g. when the tip of the pile reaches a ground layer providing low resistance: the first (outer) bucket slides relative to the second (middle) bucket until end of travel and the second bucket

subsequently slides relative to the third (inner) bucket squeezing the hydraulic oil from the second chamber through the throttling/choking valves. This dampens the falling movement. The fluid oil is stored in a tank or accumulator
5 (not shown).

Figure 4 shows a crane tool 15 and an adaptor 16 connected to a rail frame 12 of a noise mitigation screen. The adaptor is attached to the rail frame 12 via a spreader bar 40, slings 41 and shackles 42, which in turn are
10 connected to existing lifting eyes on the rail frame. The spreader is sea-fastened in a dedicated support 43 attached to the rail frame and with the adaptor facing upwards, to enable the crane tool to be dropped in.

Figures 5 and 6 show a crane tool 15 and an adaptor 16 connected to a pile upending tool 13 (Figure 5) and a transition piece lifting tool 14 (Figure 6).

Since the monopiles are positioned horizontally on deck, the monopiles, after the pile upending tool 13 shown in Figure 5 has been inserted in and secured to one end of
20 the monopile, will, when hoisted, rotate to a vertical position. Accordingly, the adaptor 16 is rotatable relative to the rest of the pile upending tool 13, again to enable the crane tool 15 to be dropped into the adaptor 16.

In Figure 6, the adaptor 16 is attached to the transition piece lifting tool 14 via rods 50, one to each of
25 the clamps 51 of the lifting tool thus positioning the adaptor above the center of gravity of the lifting tool and with its insertion opening facing upwards.

The crane tool and adaptor require less personnel and time to connect a hoisting cable to a tool or component,
30 require less or no hoisting slings, occupy less deck space and/or are safer for personnel on deck. The illustrated example enables reducing total travel of the hoisting cable during installation of a wind turbine by more than 50%.

35 Also, because less slings and shackles are required and

travel of the tool and other parts is reduced, the so-called swinging effect is reduced as well.

The invention is not restricted to the embodiment described above and can be varied in numerous ways within
5 the scope of the claims. E.g., the method and system according to the present invention are also suitable to install smaller installations, such as jacket piles.

CLAIMS

1. System (1) for use with a crane (4) comprising
a crane tool (15) attached or attachable to a
hoisting cable (5) of the crane (4) and

one or more adaptors (16) attached or attachable to
5 one or more tools (11-14, 25) for carrying out operations
and/or to one or more components (2, 10), the crane tool
(15) comprising a circle cylindrical main body (20) and a
connector (17) and at least one of the adaptors (16)
comprising a connector-counterpart (18), wherein the
10 connector (17) comprises a plurality of latches (21) evenly
distributed over the circumference of the main body (20) and
the connector-counterpart (18) comprises a notch or a rim
(35) for the latches (21) to hook in or behind, and wherein
the latches (21) are pivotal about axes extending
15 horizontally and tangentially through their lower ends,
enabling the latches (21) to deflect inwards when the crane
tool (15) is inserted in one of the adaptors (16), wherein
hydraulic actuators are located inside the main body (20) to
actively retract the latches (21) by rotation about their
20 axes to release the crane tool (15) from the one of the
adaptors (16).

2. System (1) according to claim 1, wherein the
connector (17) or the at least one connector-counterpart
(18) is a male connector and the other is a female
25 connector.

3. System (1) according to claim 1 or 2, wherein
the at least one connector-counterpart (18) faces upwards
and/or is adjustable towards a position where it faces
upwards.

30 4. System (1) according to any one of the preceding
claims, wherein the connector (17) and/or the at least one
connector-counterpart (18) is rotationally symmetrical.

5. System (1) according to any one of the preceding claims, wherein one or more of the adaptors (16) comprises a transition element (26; 40; 50) to couple the connector-counterpart (18) to the tool (11-14, 25) or component (2, 10).

6. System (1) according to any one of the preceding claims, the connector (17) and/or connector-counterpart (18) comprises guiding elements (22).

7. System (1) according to any one of the preceding claims, wherein the crane tool (15) comprises measuring equipment, preferably a global position system, an imaging device and/or an inclination sensor.

8. System (1) according to any one of the preceding claims, comprising a pile driver (25) and an adaptor (16) attached to the pile driver (25), wherein the adaptor comprises a sliding element (28) indicative of displacement of the pile driver (25) relative to the crane tool (15).

9. System according to claim 8, wherein the sliding element (28) is provided with at least one marking (36) that is gradually exposed with increasing penetration of the pile and resulting lowering of the pile driver (25).

10. System (1) according to any one of the preceding claims, comprising a pile driver (25) and an adaptor (16) attached to the pile driver (25), wherein the adaptor (16) comprises a sliding element (29) allowing dampened displacement of the pile driver (25) relative to the crane tool (15).

11. System (1) according to any one of claims 8 to 10, wherein the adaptor (16) comprises a cylindrical element (27) fixed relative to the pile driver (25) and a further cylindrical element (28, 29) slidably fitted in or over the cylindrical element (27) and preferably fixed or configured to be fixed relative to the crane tool (15).

12. Method of installing an installation, such as a wind turbine, using a crane (4) having a hoisting cable (5),

a crane tool (15) attached to the hoisting cable (5) and having a circle cylindrical main body (20) and a connector (17), and one or more tools (11-14, 25) and/or components (2, 10) having a connector-counterpart (18), wherein the
5 connector (17) comprises a plurality of latches (21) and the connector-counterpart (18) comprises a notch or a rim (35) for the latches (21) to hook in or behind, and wherein the latches (21) are pivotal about axes extending horizontally and tangentially through their lower ends, enabling the
10 latches (21) to deflect inwards when the crane tool (15) is inserted into or onto a connector-counterpart (18), wherein hydraulic actuators are located inside the main body (20) to actively retract the latches (21) by rotation about their axes to release the crane tool (15) from the connector-
15 counterpart (18), the method comprising the steps of
lowering the crane tool (15) with its connector (17) into or onto a connector-counterpart (18) of one of the tools (11-14, 25) or components (2, 10) and establishing a connection between the two,
20 lifting the tool (11-14, 25) or component (2, 10) with the hoisting cable (5).
13. Method according to claim 12, wherein the connection is established above ground level or deck level, preferably at least 5 meters above ground or deck level.
25 14. Method according to claim 12 of 13, comprising the steps of
connecting a tool (11-14, 25) to a component (2, 10),
hoisting the tool (11-14, 25) and component (2,
30 10),
positioning the component (2, 10) in or on the installation,
removing the tool (11-14, 25) from the component (2, 10),

moving the tool (11-14, 25) to a similar or identical component (2, 10) on the ground or on the deck of a vessel (3),

connecting the tool (11-14, 25) to or placing the
5 tool (11-14, 25) on that component (2, 10), and,

disconnecting the crane tool (15) from the connector-counterpart (18) on the tool (11-14, 25).