IMPROVED JACKUP OIL RIG AND SIMILAR PLATFORMS

Field of the Invention

[0001] The present invention relates to elevating or jackup oil rigs and similar platforms.

[0002] In particular, this invention relates to a method and system for jackup oil rigs and similar platforms to allow them to be used in more severe environments than prior oil rigs, such as bodies of water with thin surface ice.

[0003] More particularly, this invention relates to a method and system utilizing the built-in jackup capabilities of such platforms to drive piles into the seabed to anchor the jackup oil rig or similar platforms without the need for dedicated pile drivers. This will reduce the initial and recurrent costs of operating such rigs.

[0004] Another aspect of the present invention extends the built-in jackup capability of such rigs in the breakup of ice formation around the rig in cold operating environments.

Background of the Invention

[0005] Oil rigs are offshore structures that are used to extract petroleum and other naturally-formed hydrocarbon deposits (eg., natural gas) from the seabed. However, many oil fields are found in inhospitable locations. These locations may have extreme environmental conditions such as storms and ice at certain times of the year.

[0006] To maximize their output or productivity, oil rigs are operated for as long as possible in the window of opportunity afforded by the milder months. This window may be as short as three months in the higher latitudes. When the

environmental conditions change for the worse, these rigs may be temporarily abandoned or if they are mobile, displaced to another safer location.

[0007] To enable such mobility, oil rigs may be self-propelled or may be towed to the desired site, and anchored. The means of anchoring are well known in the art. These may include legs that reach to the seabed enabled by jacking systems such as in US Pat No. 6,076,996 and in the oil rigs designed and built by the applicant of the present invention (US Pat No. 6,030,149). Alternatively, oil rigs may be submersible or semi-submersible by having ballast tanks that may be flooded to anchor the oil rig as exemplified by US Pat No. 5,292,207.

[0008] Besides having to be securely anchored during use, there is the danger posed by ice formations to oil rigs in arctic conditions. Currently, icebreaker ships may be employed to break up ice formation around an oil rig to prevent the ice build-up from damaging the rig. In the case of US Pat No. 5,292,207 or US Pat No. 6,371,695, the rigs may possess built-in means or provide a crush-resistant structure against encroaching ice, obviating the need for icebreaker ships.

[0009] These built-in ice breaking means are usually heavily sloped plates or plates installed around the support legs of a rig. The idea behind such approach is that by flexing the ice will cause it to fracture. Thus, as the ice sheet is formed and moves against the rig, the ice sheets slide up the slope of the plate. As the angle of the slope is sharp, the rigid ice sheet does not bend and instead fractures. As such, damage from ice sheets building up around the supporting leg is prevented. In another approach, US Pat No. 4,102,144, the ice breaking means is raised along the supporting leg to break the ice. The shield may be heated to melt ice pieces adhering to it, dislodging them.

[0010] These approaches show that means to anchor an oil rig or similar structure are important, as are means to prevent damage from ice build-up.

[0011] Therefore, there is a continued need for means to allow an oil rig or similar structure to operate in harsher environments such as rough seas or icy conditions to tap the hydrocarbon reservoirs in these regions. An invention that can withstand such conditions will extend the window of operation for oil rigs, increase the production capacity while reducing costs, and hence improve the profitability of the rig. Such an invention will be welcome in the industry.

Summary of the Invention

[0012] The present invention discloses, in a first embodiment, a jackup rig comprising: a hull having a jackup module and at least one leg, wherein the jackup module is operable to jack up or down the at least one leg; a mat connected below the hull via the at least one leg, wherein the jackup module is operable to lower the mat relative to the hull for resting the mat on a seabed for supporting the hull above a sea level; and an ice-breaking member disposed around the at least one leg on the underside of the hull.

[0013] The ice breaking member is operable to break ice by jacking down the hull of the oil rig against the ice. The ice breaking member may be suspended from the hull. In another embodiment, the oil rig may comprise another ice breaking member being disposed around the at least one leg on the mat.

[0014] The invention also discloses, in a second embodiment, a jackup rig comprising a collar on the hull for aligning and guiding a pile to be driven into the seabed for anchoring the oil rig or for extraction of a pile previously driven into the seabed. In another embodiment, the collar comprises a locking means, which work in cooperation with the collar to engage and grip the pile during piling or extraction.

[0015] When the jackup oil rig is operable to drive a pile into the seabed, the step of engaging the pile with the collar and locking means, lowering the jackup module, disengaging the pile, raising the hull and re-engaging the pile are repeated until the pile is driven to a desired depth. When the jackup oil rig is

operable to extract the pile, the step of lowering the hull, engaging the pile with the collar and locking means, raising the hull, disengaging the pile and lowering the hull are repeated to extract the pile.

Brief Description of the Drawings

[0016] A preferred embodiment of the present invention will now be more fully described, by way of example, with reference to the drawings of which:

[0017] FIGs. 1A-1C illustrate a method by which the legs of a jackup oil rig of the prior art are put into place; FIG. 1D illustrates a method by which piles of a jackup oil rig of a prior art are put into place;

[0018] FIG. 2A illustrates the collar and locking means for the piles while FIG. 2B is the plan view of an oil rig showing the disposition of the piles around the perimeter of an oil rig with a triangular configuration;

[0019] FIGs. 3A-3F illustrate a sequence by which piles are driven by the method of the present invention.

[0020] FIGs. 4A-C illustrate a sequence by which the piles are extracted by the method of the present invention;

[0021] FIGs. 5A-5B, 6A-6B, 7A-7B and 8A-8B illustrate embodiments of the present invention for breaking ice utilizing the built-in jackup capability of jackup rigs and similar platforms.

Detailed Description

[0022] In accordance with the detailed descriptions, a preferred embodiment of the invention is described, together with a few variations to illustrate the versatility of the invention. In the following description, details are provided to describe the preferred embodiment. It shall be apparent to one skilled in the art, however, that the invention may be practiced without such details. Some of these details may not be described at length so as not to obscure the invention.

[0023] There are many advantages of the preferred embodiment of the invention. One advantage of the preferred embodiment is that it is resistant against the impact of ice. Another advantage is that additional supports for a jackup oil rig in the form of piles may be driven in place and subsequently extracted without the need for a dedicated pile driver or winch.

[0024] Another advantage is that ice formation around such rigs or similar platforms may be broken up using novel and inventive means based on the built-in jackup capability of such rigs and platforms.

[0025] Referring now to FIG. 1, the method of putting an oil rig of the prior art into operation is described. Such an oil rig is exemplified by a model designed and built by the applicant of the present invention.

[0026] Such an oil rig is first moved into position by one or more barges (FIG. 1A). The oil rig comprises an jackup hull **100** connected to a lower structure, a buoyant watertight mat **200**, by one or more legs **300**. When in position, ballast tanks in the mat are flooded and the mat sinks until it reaches the seabed **400** (FIG. 1B).

[0027] Thereafter, the rig's built-in jacking system, itself comprising of complementary jackup modules **500** of elevating units of jacks and locks working in unison, is used to raise the jackup hull **100** above sea level for a predetermined distance (FIG. 1C). This may be done in one continuous operation or a series of operations until an air gap **410** is achieved. The air gap is the height or distance of the bottom of the jackup hull above sea level.

[0028] The oil rig is now largely ready to begin actual drilling operations with the volume of water in the mat acting as ballast to anchor and stabilize the rig. However, it may be desirable, for example, in rough seas, to have additional supports comprising piles **600** driven into the seabed to further anchor the oil rig (FIG. 1D). Under the prior art, this is done by erecting a dedicated pile driver **700** to drive the piles into the seabed **400**. When it is time to displace the oil rig, a

winch or vibratory pile extractor (such as those manufactured by the International Construction Equipment company) is needed to remove the piles from the seabed.

[0029] Under the present invention, a novel and inventive method is taught whereby use of a dedicated pile driver and pile extractor is obviated. The system of the present invention is a jackup oil rig or similar structure possessing the capability and means described and practicing the invention according to the methods as taught below.

[0030] In the present invention, the mass and jacking system of the oil rig are used to drive in the piles. To extract the piles, the jacking system and the buoyancy of the rig is used. As the jacking system is already part of a jackup rig's built-in machinery, no additional cost for a dedicated pile driver or extractor are needed. This cuts costs significantly as, in the prior art, the dedicated pile driver and extractor are only needed at the beginning and end of a rig's operational period at any particular site. While such rig is in operation, the pile driver and extractor remain essentially idle and does not contribute to productivity while contributing to the cost of the rig.

[0031] The only additional features required to practice the invention are the installation of a piling sub-system **800** comprising collars **810** (FIG. 2A) that align and guide the piles and locking means that work in conjunction with the collars to engage and grip the piles during insertion and extraction, and the piles **600** to be driven in. These features are in addition to the supporting legs **300** and jackup modules **500** already present in a jackup rig. At least one such collar **810** with its accompanying locking means, here shown as a pin **820** as an example, is used for each pile **600** to be driven in (FIG. 2A). The locking means comprises at least one pin driven to engage or withdraw from a complementary recess in the pile. These complementary recesses are found at intervals along each pile.

[0032] As an example, for an oil rig of a triangular configuration of 240 ft length by 220 ft width, eight to 10 piles **600** evenly disposed around the perimeter

of the oil rig is recommended (FIG. 2B). This is only an illustration and the number and disposition of the collars and piles may be varied according to the configuration of the rig and the conditions under which they operate.

[0033] The collars and locking means may be readily retrofitted into existing oil rigs or included in the constructions of new ones. If desired, the piles may also be further supported by guides or bores **210** built into the mat such that the alignment of the pile is substantially perpendicular to the horizontal plane of the mat **200** or jackup hull **100** (FIG. 1D).

[0034] FIG. 3 shows how piles are driven in by the method of the present invention. The oil rig of the present invention is first moved into position (FIG. 3A). On the rig are elements of the piling sub-system **800** (comprising a plurality of the collars and locking means) and piles **600** previously described. The lower ends of the piles are substantially flushed with the bottom of the mat.

[0035] The mat **200** is then lowered (FIG. 3B) by blowing its ballast tanks and letting in water until the mat rests on the seabed. The jackup hull **100** remains at the level of the water surface as it is buoyant. As the locking means are not engaged, friction with the bores **110**, **210** and their own mass allow the piles **600** to be brought down with the lowering of the mat to the seabed **400**. The arrows in the figures indicate the movement of the piles.

[0036] The rig or structure's jacking system is then engaged to raise the jackup hull **100** (FIG. 3C) to a predetermined height above the level of the water. It may be seen that the lower ends of the piles remain in contact with the seabed **400** during this operation as the piles are not being gripped or engaged by the locking means **800**. As such, they slide freely within the collars **810**, and the bores **110**, **220** as the jackup hull is raised.

[0037] Thereafter, depending on capability of the jacking system, the number of piles present, and the type and condition of soil in the seabed, one or

more piles may be locked by their respective locking means **800** in preparation for being driven into the seabed.

[0038] The jacking system is then engaged in the reverse direction to lower the jackup hull **100** (FIG. 3D), driving any piles **600** that are locked into the seabed **400** a predetermined distance. A person skilled in the art will appreciate that in this driving operation, both the jacking force generated by the jacking system and the mass of the jackup hull are harnessed to drive in the pile. This total force of the jackup system alone may be as high as 46,800 kips for the rig example cited and is considerably greater than that generated by most marine pile drivers in use. A person skilled in the art will appreciate that the number of piles that may be driven in simultaneously depends on a variety of factors such as the mass of the jackup hull, the power of the jacking system, and the seabed conditions.

[0039] Once a pile is driven in, the jackup hull **100** is then jacked up again with the locking means **800** released or disengaged, allowing the collars to freely slide up the piles, leaving the piles that were just driven in position, unmoved (FIG. 3E).

[0040] The locking means for the pile just driven in may be re-engaged and the hull lowered again to further drive in the pile until the appropriate depth is desired. A person skilled in the art of pile driving will appreciate that this operation may be repeated as many times as necessary until the pile has been driven to the desired depth. A person skilled in the art will also appreciate that, with the present invention, a number of piles may be simultaneously driven in to save time and cost. This is a huge increase in efficiency over the use of a pile driver to sequentially drive in the piles one by one. When driving in multiple piles at the same time, it is apparent to one skilled in the art that it will be best to drive in the piles such that the total force generated (jacking force and mass of the hull) be evenly and symmetrically distributed to the piles being driven. For example, piles at the apices of an oil rig with a triangular configuration may be driven in at the same time.

[0041] Once the last pile has been driven in, the hull is then raised to the desired height above the sea level (air gap **410**) and the oil rig can then begin its drilling and extraction operations (FIG. 3F).

[0042] When it is time to displace the rig due to avoid extreme conditions, or when the location has been exhausted of its hydrocarbon deposits, the present invention may be used to extract the piles without the need for a dedicated extractor or winch. It will be apparent to one skilled in the art that reversing the process of driving in the piles will extract the piles, except that now, it is the buoyancy, not the mass, of the jackup hull, that work in conjunction with the jackup system in this extraction operation.

[0043] As shown in FIG. 4A, the locking means **800** for all the piles **600** are released. The jackup system is then engaged in reverse to lower the jackup hull **100**, preferentially until part of it is below the waterline. In most rigs, the jackup hull is watertight and is thus positively buoyant. Thereafter, the locking means for one or more piles to be extracted are engaged and the hull jacked up to a predetermined height (FIG. 4B). The raising of the hull will pull up any engaged piles and the buoyancy of the hull is tapped to assist in the extraction of the piles.

[0044] The locking means that were engaged are now released and the hull lowered again (FIG. 4C). Then the locking means for the partially extracted piles **600** are re-engaged and the hull raised. This operation is repeated until the all the piles are extracted. Even if the hull is not buoyant, the considerable force generated by the jacking system itself is greater than that of a winch or vibratory extractor. As such, multiple piles may be extracted simultaneously instead of sequentially as with technology of the prior art. This saves time and cost for the installation or rental of a dedicated extractor.

[0045] It will be appreciated that the sequence of operations (locking and unlocking the piles, raising and lowering the jackup hull, etc) may be done manually or automatically. The degree of automation desired may be obtained

by installing a suitable control sub-system to coordinate the locking and unlocking of the locking means with the jackup operation. A person skilled in the art will appreciate that such a control sub-system may be readily implemented and as such, details of this control sub-system is not described so as not to obscure the invention.

[0046] Also, the operation of the locking means may be powered by any suitable means of motive force, such as those supplied by electrical, mechanical, electromechanical, hydraulic or pneumatic means. Such motive means and control sub-systems come under the scope of the present invention.

[0047] It will be apparent to a person skilled in the art that variations to the guiding of the piles may be done while keeping within the scope and spirit of the invention. For example, we have described and illustrated that the piles are already in place in their collars at the start of the driving operation. It is clear that the piles need not be pre-positioned and may also be inserted into place after the rig has arrived and the mat lowered into position. Such preparatory details are not essential in this invention. What is essential is the idea to use the built-in capabilities of the jacking system of a jackup rig to replace a dedicated pile driver and extractor. This extended use of the jackup system and capability of jackup rigs and similar structures are hitherto untapped in rigs of the prior art.

[0048] The present invention also provides for a method and system to break up ice formation around the rig using the jackup system of the rig; it maximizes the capabilities of the jackup system, thereby extending the useful operating window of the rig in icy or arctic conditions.

[0049] The ice breaking means of the present invention is a heavy three-dimensional metal structure, preferably resembling a three-dimensional heavily-sloped trapezoidal or pyramidal structure **900** with sharp corners (FIGs. 5, 6, 7 and 8). The ice breaking means is also preferentially disposed circumferentially around, or near the legs **300** of the jackup rig. This is because ice sheets **420** pose great risk to the legs of an oil rig.

[0050] The ice breaking means may be located on the underside of the jackup hull **100** (FIG. 5) or on the upper surface of the mat **200** (FIG. 6), depending on the depth of water the rig is operating in. In very shallow water, the ice breaking means may be arranged on the mat such that the ice breaking means is at or near the surface of the water where the ice sheets will form.

[0051] To break up forming ice sheets **420**, the jackup system of the present invention is engaged to lower the upper hull **100** until the lower surface of the upper hull forces against the ice sheets. Regardless of whether the ice breaking means **900** is located on the underside of the upper hull (FIG. 5) or on the upper surface of the mat (FIG. 6), the mass and shape of the ice breaking means, the mass of the upper hull and the power of the jackup system, provide sufficient force to fracture the ice **430** (FIGs. 5B and 6B; arrows indicate the direction of movement of the jackup hull).

[0052] It is clear that an ice breaking means with sharp corners will be better at fracturing the ice although smooth rounded shapes will also work. To facilitate the housing of the ice breaking means while the rig is in transit, corresponding recesses **960**, **970** may be constructed in the opposing surface to contain the ice breaking means.

[0053] It can be seen that the breaking of ice in the present invention is to use the jackup system of the oil rig to move the jackup hull **100** against a fixed structure such as the mat **200** or the ice breaking means **900**. As such, in another embodiment (FIG. 7), the ice breaking means **910** may be fixed around each supporting leg of the rig, at the surface of the water. As the jackup hull **100** is lowered, ice **430** is broken by being sandwiched between the jackup hull **100** and the ice breaking means **910** (FIG. 7B).

[0054] Unlike the ice breaking method of US Pat No. 4,102,144, wherein the ice breaking shield is raised to break ice, the ice breaking means in yet another embodiment (FIG. 8) of the present invention can break ice when it is

both raised or lowered, as it is sloped on both the upper **930** and lower **940** surfaces, making it more efficient than that of the prior art.

[0055] In this embodiment, the ice breaking means **910**, being heavy, is held by a suspension means **950** such as chains or ropes to the underside of the upper hull, and is preferentially disposed around or near each supporting leg **300** of the rig (FIG. 8A).

[0056] Referring again to FIG. 8A, the length of the suspension means **800** supporting the ice breaking means is adjusted after the oil rig is deployed and operational so that the ice breaking means is held at a "resting" position. This resting position is near (above or below), or at the waterline. As ice sheets build up, raising or lowering the ice breaking structure **910** will break the ice sheets **430**.

[0057] If the ice breaking structure was "resting" above the waterline (FIG. 8A), lowering it a short distance will fracture ice sheets **430** that are building up below it (FIG. 8B). Conversely, a person skilled in the art will appreciate that if the ice breaking means is suspended above the waterline, lowering it (by lowering the entire jackup hull) will break the ice. Unlike the other ice breaking embodiments of the present invention, the mass of the upper hull is not used. Rather, the ice breaking means relies on its own mass to break the ice when it is lowered with the lowering of the jackup hull **100**.

[0058] Also unlike the prior art, the suspension means **950** is not involved in the raising or lowering of the ice breaking means but rather, it is merely to maintain the ice breaking means at the desired resting position.

[0059] This resting position is a matter of choice. If the ice breaking means is held just under the surface of the water, the raising of the ice breaking means will utilize both the power of the jackup system and the shape of the ice breaking means to perform this function. As such, this embodiment (FIG. 8) works when the ice breaking means is raised or lowered. In addition, by the ice breaking

means being suspended, the distance by which the upper hull has to be moved is reduced. This aspect of the present invention essentially improves the efficiency of breaking ice by over one fold over methods of the prior art in an inventive and non-obvious way.

[0060] This method is non-obvious as prior art members such as US Pat No. 4,102,144 are shaped and configured to break ice only when the ice breaking means is raised. That member does not perform its function when lowered to its "resting position".

[0061] Again, as with the other embodiments, concave recesses **960**, **970** in the jackup hull **100** and mat **200** respectively (see example in FIG. 8) receive the ice breaking structure in a stowed position during transit.

[0062] A person skilled in the art will appreciate that unlike the first embodiment of the ice breaking means, the means do not necessarily have to move along the supporting legs. They merely need to be affixed to either the bottom of the jackup hull or the top of the mat and the complementary recesses **960**, **970** are provided to receive the ice breaking structures during transit.

[0063] It will be appreciated that the sequence of operations (monitoring of the ice build-up and the raising and lowering the ice breaking means, etc) may be done manually or automatically. The degree of automation desired may be obtained by the installation of a suitable control system.

[0064] Additionally, the driving of the various mechanical aspects of the present invention (eg locking means, adjustment of the suspension means of the ice breaking means, etc) may be obtained by suitable electrical, pneumatic, hydro-pneumatic or hydraulic actuators and devices. A person skilled in the art will appreciate that such devices are easily implemented. As such, further description of such devices is not provided so as not to obscure the invention.

[0065] The present invention therefore provides, in one aspect, a method of driving and extracting piles for a jackup rig and similar structures without the need for dedicated pile drivers or extractors. In another aspect, the present invention is a jackup oil rig or similar structures possessing capability afforded by the elements and features described for driving and extracting piles, and practicing the methods taught.

[0066] In yet another aspect, the present invention provides a jackup oil rig or similar structure with an ice breaking capability exemplified by the several embodiments of a novel and innovative built-in ice protection means taught.

[0067] It is apparent to one skilled in the art that, while the ice breaking aspect of the present invention are described, such ice breaking means are not necessary for practicing the invention of driving and extracting piles in warmer waters where there is no danger from ice sheets.

[0068] While the present description is for an oil rig, it is apparent to one skilled in the art, that the present invention may be applied to structures similar to jackup oil rigs such as geological survey vessels and wreck recovery ships. Additionally, while a marine oil rig is described, oil rigs and similar structures used for other bodies of water (e.g., lakes, rivers, etc) also come within the scope and spirit of the present invention.

[0069] It will be appreciated that although only a few preferred embodiments have been described in detail, various modifications and improvements can be made by a person skilled in the art without departing from the scope of the present invention.

[0070] The present invention is novel and inventive as there is nothing in the prior art to suggest the use of jackup systems in an oil rig or similar platforms, to drive and extract piles, or to break up ice formation. Jackup oil rigs and similar platforms have always used separate means such as pile drivers and extractors for piles and separate ice-breaking means to handle ice sheets. It is clear that, with this application, the invention is non-obvious, even to persons skilled in the art.

CLAIMS:

1. A jackup oil rig comprising:

a hull having a jackup module and at least one leg, wherein the jackup module is operable to jack up or down the at least one leg;

a mat connected below the hull via the at least one leg, wherein the jackup module is operable to lower the mat relative to the hull for resting the mat on a seabed for supporting the hull above a sea level; and

an ice-breaking member disposed around the at least one leg on the underside of the hull.

2. A jackup oil rig according to claim 1, wherein the ice breaking member is operable to break ice by jacking down the hull of the oil rig against the ice.

3. A jackup oil rig according to claim 1 or 2, further comprising another ice breaking member being disposed around the at least one leg on the mat.

4. A jackup oil rig according to claim 1 or 2, wherein the ice breaking member is suspended from the hull.

5. A jackup oil rig according to claim 4, wherein the ice breaking member comprises a metal structure having sloped upper and lower surfaces for breaking ice with its mass when the hull is jacked up or down.

6. A jackup oil rig according to any one of claims 1-5, wherein the hull or mat further comprising recesses to house the ice breaking member.

7. A jackup oil rig according to any one of claims 1-6, further comprising a collar on the hull for aligning and guiding a pile to be driven into the seabed for anchoring the oil rig or for extraction of a pile previously driven into the seabed.

8. A jackup oil rig according to claim 7, wherein the collar comprises a locking means, which work in cooperation with the collar to engage and grip the pile during piling or extraction.

9. A jackup oil rig according to claim 7 or 8, wherein when the jackup oil rig is operable to drive a pile into the seabed, the step of engaging the pile with the collar and locking means, lowering the jackup module, disengaging the pile, raising the hull and re-engaging the pile are repeated until the pile is driven to a desired depth.

10. A jackup oil rig according to claim 7 or 8, wherein when the jackup oil rig is operable to extract the pile, the step of lowering the hull, engaging the pile with the collar and locking means, raising the hull, disengaging the pile and lowering the hull are repeated to extract the pile.