ICE WORTHY JACK-UP DRILLING UNIT

FIELD OF THE INVENTION

[0001] This invention relates to mobile offshore drilling units, often called "jack-up" drilling units or rigs that are used in shallow water, typically less than 400 feet, for drilling for hydrocarbons.

BACKGROUND OF THE INVENTION

[0002] In the never-ending search for hydrocarbons, many oil and gas reservoirs have been discovered over the last one hundred and fifty years. Many technologies have been developed to find new reservoirs and resources and most areas of the world have been scoured looking for new discoveries. Few expect that any large, undiscovered resources remain to be found near populated areas and in places that would be easily accessed. Instead, new large reserves are being found in more challenging and difficult to reach areas.

[0003] One promising area is in the offshore Arctic. However, the Arctic is remote and cold where ice on the water creates considerable challenges for prospecting for and producing hydrocarbons. Over the years, it has generally been regarded that six unprofitable wells must be drilled for every profitable well. If this is actually true, one must hope that the unprofitable wells will not be expensive to drill. However, in the Arctic, little, if anything, is inexpensive.

[0004] Currently, in the shallow waters of cold weather places like the Arctic, a jack-up or mobile offshore drilling unit (MODU) can be used for about 45-90 days in the short, open-water summer season. Predicting when the drilling season starts and ends is a game of chance and many efforts are undertaken to determine when a jack-up may be safely towed to the drilling location and drilling may be started. Once started, there is considerable urgency to complete the well to avoid having to disconnect and retreat in the event of ice incursion. Even during the few weeks of open water, ice floes present a significant hazard to jack-up drilling rigs where the drilling rig is on location and legs of the jack-up drilling rig are exposed and quite vulnerable to damage.

[0005] Jack-up rigs are mobile, self-elevating, offshore drilling and workover platforms equipped with legs that are arranged to be lowered to the sea floor and then to

lift the hull out of the water. Jack-up rigs typically include the drilling and/or workover equipment, leg-jacking system, crew quarters, loading and unloading facilities, storage areas for bulk and liquid materials, helicopter landing deck and other related facilities and equipment.

[0006] A jack-up rig is designed to be towed to the drilling site and jacked-up out of the water so that the wave action of the sea only impacts the legs which have a fairly small cross section and thus allows the wave action to pass by without imparting significant movement to the jack-up rig. However, the legs of a jack-up provide little defense against ice floe collisions and an ice floe of any notable size is capable of causing structural damage to one or more legs and/or pushing the rig off location. If this type of event were to happen before the drilling operations were suspended and the well was suitably secured, a hydrocarbon leak would possibly occur. This type of risk is completely unacceptable in the oil and gas industry, to the regulators and to the public.

[0007] Thus, once it is determined that a potentially profitable well has been drilled during this short season, a very large, gravity based production system, or similar structure may be brought in and set on the sea floor for the long process of drilling and producing the hydrocarbons. These gravity based structures are very large and very expensive, but are built to withstand the ice forces year around.

BRIEF SUMMARY OF THE DISCLOSURE

[0008] The invention more particularly relates to an ice worthy jack up rig for drilling for hydrocarbons in potential ice conditions in offshore areas including a flotation hull having a relatively flat deck at the upper portion thereof. The flotation hull further includes an ice bending shape along the lower portion thereof and extending around the periphery of the hull where the ice bending shape extends from an area of the hull near the level of the deck and extends downwardly near the bottom of the hull along with an ice deflecting portion extending around the perimeter of the bottom of the hull to direct ice around the hull and not under the hull. The rig includes at least three legs that are positioned within the perimeter of the bottom of the hull wherein the legs are arranged to be lifted up off the seafloor so that the rig may be towed through shallow water and also extend to the sea floor and extend further to lift the hull partially or fully out of the water. A jack up device is associated with each leg to both lift the leg from the sea bottom so

that the ice worthy jack up rig may float by the buoyancy of the hull and push the legs down to the seafloor and push the hull partially up and out of the water when ice floes threaten the rig and fully out of the water when ice is not present.

[0009] The invention further relates to a method for drilling wells in ice prone waters. The method includes providing a flotation hull having a relatively flat deck at the upper portion thereof and an ice bending shape along the lower portion thereof where the ice bending shape extends from an area of the hull near the level of the deck and extends downwardly near the bottom of the hull and an ice deflecting portion extending around the perimeter of the bottom of the hull to direct ice around the hull and not under the hull. At least three legs are positioned within the perimeter of the bottom of the hull. Each leg is jacked down in a manner that feet on the bottom of the legs engages the sea floor and lifts the hull up and fully out of the water when ice is not threatening the rig while the rig is drilling a well on a drill site. The hull is further lowered into the water into an ice defensive configuration so that the ice bending shape extends above and below the sea surface to bend ice that comes against the rig to cause the ice to submerge under the water and endure bending forces that break the ice where the ice flows past the rig.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] A more complete understanding of the present invention and benefits thereof may be acquired by referring to the follow description taken in conjunction with the accompanying drawings in which:

[0011] Figure 1 is an elevation view of a first embodiment of the present invention where the drilling rig is floating in the water and available to be towed to a well drilling site;

[0012] Figure 2A is an elevation view of the first embodiment of the present invention where the drilling rig is jacked up out of the water for open water drilling through a moon pool;

[0013] Figure 2B is an elevation view of the first embodiment of the present invention where the drilling rig is jacked up out of the water for conventional open water drilling with a cantilever derrick positioned to drill over the edge of the deck;

[0014] Figure 3 is an elevation view of the first embodiment of the present invention where the drilling rig is partially lowered into the sea, but still supported by its legs, in a defensive configuration for drilling during potential ice conditions;

[0015] Figure 4A is an enlarged fragmentary elevation view showing one end of the first embodiment of the present invention in the Figure 3 configuration with ice moving against the rig;

[0016] Figure 4B is an enlarged fragmentary view of a second embodiment of the hull configuration;

[0017] Figure 4C is an enlarged fragmentary view of a third embodiment of the hull configuration;

[0018] Figure 4D is an enlarged fragmentary view of a fourth embodiment of the hull configuration;

[0019] Figure 5A is a top view of the first embodiment of the present invention where a cantilever derrick is positioned to drill through a moon pool;

[0020] Figure 5B is a top view of the first embodiment of the present invention where a cantilever derrick is positioned to drill over the edge of the deck; and

[0021] Figure 6 is a top view of a fifth embodiment of the present invention.

DETAILED DESCRIPTION

[0022] Turning now to the detailed description of the preferred arrangement or arrangements of the present invention, it should be understood that the inventive features and concepts may be manifested in other arrangements and that the scope of the invention is not limited to the embodiments described or illustrated. The scope of the invention is intended only to be limited by the scope of the claims that follow.

[0023] As shown in Figure 1, an ice worthy jack-up drilling rig is generally indicated by the arrow 10. In Figure 1, jack-up drilling rig 10 is shown with its hull 20 floating in the sea and truss form legs 25 in a lifted arrangement where much of the length of the legs 25 extend above the deck 21 over the hull 20. The legs may have a triangular shape when viewed from above or a rectangular shape comprising long vertical posts at the corners and many cross members connected to the vertical posts to form a strong, relatively lightweight truss structure. On the deck 21 is a derrick 30 which is used to drill wells in the conventional manner. Not shown is the conventional ancillary equipment for

drilling wells on a drilling rig. In the configuration shown in Figure 1, the jack-up rig 10 may be towed from one prospect field to another and to and from shore bases for maintenance and other shore service.

[0024] When the jack-up rig 10 is towed to a drilling site in generally shallow water, the legs 25 are lowered through the openings 27 in hull 20 until the feet 26 at the bottom ends of the legs 25 engage the seafloor 15 as shown in Figures 2A and 2B. In a preferred embodiment, the feet 26 are connected to spud cans 28 to secure the rig 10 to the seafloor. Once the feet 26 engage the seafloor 15, jacking rigs within openings 27 push the legs 25 down and therefore, the hull 20 is lifted out of the water. With the hull 20 fully jacked-up and out of the water, any wave action and heavy seas more easily break past the legs 25 as compared to the effect of waves against a large buoyant object like the hull 20. As shown in Figures 2A and 2B, well drilling operations may commence in the ordinary course while there is no ice in the area. The configuration in shown in Figure 2A is for drilling when there is the potential for ice while drilling. The configuration shown in Figure 2B is for drilling when ice is not expected to be a threat during the drilling operation. For example, when drilling a first well in open water, ice will be less of a threat then when starting to drill a well late in the operational time window. Thus, when ice begins to form on the sea surface 12, the risk of an ice floe contacting and damaging the legs 25 or simply bulldozing the jack-up rig 10 off the drilling site becomes a significant concern for conventional jack-up rigs and such rigs are typically removed from drill sites by the end of the open water season.

[0025] The ice-worthy jack-up drilling rig 10 is designed to resist ice floes by assuming an ice defensive, hull-in-water configuration as shown in Figure 3. In Figure 3, ice tends to dampen waves and rough seas, so the sea surface 12 appears less threatening, however, the hazards of the marine environment have only altered, and not lessened. When the ice-worthy jack-up rig 10 assumes its ice defensive, hull-in-water configuration, the hull 20 is lowered into the water to contact same, but not to the extent that the hull 20 would begin to float. A significant portion of the weight of the rig 10 preferably remains on the legs 25 to hold the position of the rig 10 on the drill site against any pressure an ice floe might bring. The rig 10 is lowered so that an inwardly sloped, ice-bending surface 41 bridges the sea surface 12 or extends from above the sea surface

12 down into the water below the sea surface 12 to engage any floating ice that may come upon the rig 10.

[0026] As best seen in Figure 4A, the sloped ice-bending surface 41 runs from shoulder 42, which is above the sea surface so therefore some considerable distance above the bottom of the hull 20 and near the perimeter of the deck 21, down to neckline 44. The neckline 44 is very near the bottom of the hull or perhaps below the bottom of the hull and spaced inwardly from the shoulder 42 entirely around the perimeter of the hull 20. Ice deflector 45 extends downward from neckline 44 either straight down or at some small angle from vertical. If the ice deflector 45 is to be angled from the vertical, it is preferably angled outwardly. Thus, when an ice floe, such as shown at 51 in Figure 4A comes to the rig 10, the ice-bending surface 41 causes the leading edge of the ice floe 51 to submerge under the sea surface 12. A significant bending force is applied by the weight of the rig 10 on the end of the ice floe against the ice-bending surface 41, the flotation force of the water pressing up on the middle of the ice floe and the weight of the ice floe at the end away from the rig 10. Ice is less strong against bending then in pure compression such that the ice tends to break from large ice floes into smaller, less damaging, less hazardous bits of ice. For example, it is conceivable that an ice floe being hundreds of feet and maybe miles across could come toward the rig 10. If the ice floe is broken into bits that are less than twenty feet in the longest dimension, and preferably smaller, such bits are able to pass around the rig 10 with much less concern.

[0027] It should be noted that in describing the ice-bending surface, orientation is key. The ice-bending surface slopes downwardly and inwardly from the shoulder 42. It slopes upwardly and outwardly from neckline 44.

[0028] In Figure 4B, a first alternative shape of the hull is shown with a slightly off vertical (-10°) ice deflector 145, wherein the ice bending shape 141 is slightly inset from the shoulder 142 and the area of the hull above shoulder 142 is also an outwardly and upwardly sloping surface. Figure 4C shows a second alternative embodiment having a convex shaped ice-bending surface 241 with an outward trending curved lip forming the ice deflector 245 for ice recoil. Figure 4D shows a third alternative embodiment having a concave shaped ice-bending surface 341 with an outwardly and downwardly curved ice deflector 345.

[0029] The non-linear ice-bending surface 341 may be seen to provide greater bending force as ice slides further down along the ice-bending surface 341. The outwardly angled ice deflectors 245 and 345 are shaped to prevent any ice from slipping under the hull 20.

[0030] Ice has substantial compressive strength being in the range of 4 to 12 MPa, but is much weaker against bending with typical flexure strength in the range of 0.3 to 0.5 MPa. As shown, the force of the ice floe 51 moving along the sea surface 12 causes the leading edge to slide under the sea surface 12 and causes section 52 to break off. With the ice floe 51 broken into smaller pieces, such as section 52 and bit 53, the smaller sections tend to float past and around the rig 10 without applying the impacts or forces of a large floe. It is preferred that ice not be forced under the flat of bottom of the hull 20 and the ice deflector 45 turns ice to flow around the side of the hull 20. If really thick ice is anticipated in a drilling location, the rig may be provided with an ice deflector 45 that is arranged to extend much further below the bottom of the hull 20 and downwardly at a steeper angle than ice-bending surface 41 and will increase the bending forces on the ice floe. It should be recognized that the neckline may or may not be at the bottom of the flotation portion of the hull 20 such that the ice deflector 45 may extend down from the flat of bottom of the hull 20 or may extend down to the flat of bottom of the hull 20. Additionally, it should be recognized that the deck 21 may optionally be set off and spaced above the hull 20.

[0031] To additionally resist the forces that an ice floe may impose on the rig 10, the feet 26 of the legs may be arranged to connect to cans 28 set in the sea floor so that when an ice floe comes against the ice-bending surface 41, the legs 25 actually hold the hull 20 down and force the bending of the ice floe and resist the lifting force of the ice floe which, in an extreme case, may lift the near side of the rig 10 and push the rig over on its side by using the feet 26 on the opposite side of the rig 10 as the fulcrum or pivot. The cans in the sea floor are known for other applications and the feet 26 would include appropriate connections to attach and release from the cans, as desired.

[0032] It should probably be noted that shifting from a conventional open water drilling configuration as shown in Figure 2A to a hull-in-water, ice defensive configuration shown in Figure 3 may require considerable planning and accommodation

depending on what aspect of drilling is ongoing at the time. While some equipment can accommodate shifting of the height of the deck 21, other equipment may require disconnections or reconfiguration to adapt to a new height off the sea floor 15.

[0033] The ice-worthy jack-up drill rig 10 is designed to operate like a conventional jack-up rig in open water, but is also designed to settle to the water in an ice defensive position and then re-acquire the conventional stance or configuration when wave action becomes a concern. It is the shape of the hull 20 (as well as its strength) that provides ice bending and breaking capabilities.

[0034] Referring to Figure 5, the hull 20 (as viewed from above) may have a circular or oval configuration so as to present a shape that is conducive to steering the broken bits, pieces and sections of ice around the periphery of the rig 10 regardless of the orientation of the rig 10 or path of travel of the ice. The ice tends to flow with the wind and sea currents, which tend not to be co-linear, or some path reflecting influences of both sea and air.

[0035] As shown in Figure 6, the hull 20 may have a faceted or multisided shape that provides the advantages of a circular or oval shape, and may be less expensive to construct. The plates that make up the hull would likely be formed of flat sheets so that the entire structure comprises segments of flat material such as steel and is less complicated. The ice-breaking surface 41 preferably extends at least about five meters above the water level or sea surface 12, recognizing that sea levels shift up and down with tides and storms and perhaps other influences. The height above the sea surface 12 accommodates ice floes that are quite thick or include ridges that extend well above the sea surface 12. As the height of the shoulder 42 is well above the sea surface 12, tall ice floes are forced down as they come into contact with the rig 10. At the same time, the deck 21 at the top of the hull 20 should be far enough above the water line so that waves are not able to wash across the deck 21. As such, the deck 21 is preferred to be at least 7 to 8 meters above the sea surface 12 and potentially higher. Conversely, the neckline 42 is preferred to be at least 4 to 8 meters below the sea surface 12 to adequately bend the ice floes to break them up into more harmless pieces. Thus, the hull 20 is preferably in the range of 5-16 meters in height from the flat of bottom to the deck 21, more preferably 8-16 meters or 11-16 meters.

[0036] It should also be noted that the legs 25 and the openings 27 through which they are connected to the hull 20 are within the perimeter of the ice deflector 45 so that the ice floes are less likely to contact the legs while the rig 10 is in its defensive ice condition configuration as shown in Figure 3 and sometimes called hull-in-water configuration. Moreover, the rig 10 does not have to handle every ice floe threat to significantly add value to oil and gas companies. If an ice worthy drilling rig 10 can extend the drilling season by as little as a month, that could be a fifty percent increase in productivity in some ice prone areas and therefore provide a very real cost saving benefit to the industry. A fifty percent longer drilling window may allow the drilling of two or three wells rather than one or two wells per year substantially reducing costs and increasing the production of oil and gas.

[0037] Referring to Figures 5A and 5B, the derrick 30 may be positioned to drill through a moon pool that is within the perimeter of the ice deflector 45 as shown in Figure 5A or may be arranged to drill over the side of the deck 21 in a cantilevered fashion as shown in Figure 5B.

[0038] In closing, it should be noted that the discussion of any reference is not an admission that it is prior art to the present invention, especially any reference that may have a publication date after the priority date of this application. At the same time, each and every claim below is hereby incorporated into this detailed description or specification as an additional embodiment of the present invention.

[0039] Although the systems and processes described herein have been described in detail, it should be understood that various changes, substitutions, and alterations can be made without departing from the spirit and scope of the invention as defined by the following claims. Those skilled in the art may be able to study the preferred embodiments and identify other ways to practice the invention that are not exactly as described herein. It is the intent of the inventors that variations and equivalents of the invention are within the scope of the claims, while the description, abstract and drawings are not to be used to limit the scope of the invention. The invention is specifically intended to be as broad as the claims below and their equivalents.

CLAIMS

1. An ice-worthy jack-up rig for drilling for hydrocarbons in potential ice conditions in offshore areas comprising:

a flotation hull having a relatively flat deck at the upper portion thereof and an ice-bending shape along the lower portion thereof and extending downwardly and inwardly around the periphery of the hull where the ice-bending shape extends from an area of the hull near the level of the deck and extends downwardly near the bottom of the hull;

an ice deflecting portion extending around the perimeter of the bottom of the hull to direct ice around the hull and not under the hull;

at least three legs that are positioned within the perimeter of the bottom of the flotation hull wherein the legs are arranged to be lifted up off the seafloor so that the rig may be towed through shallow water and also extend to the sea floor and extend further to lift the hull partially or fully out of the water; and

a jack-up device associated with each leg to both lift the leg from the sea bottom so that the ice worthy jack-up rig may float by the buoyancy of the hull and push the legs down to the seafloor and push the hull partially up and out of the water when ice floes threaten the rig and fully out of the water when ice is not present.

2. The ice worthy jack-up rig according to claim 1, further including an anchoring mechanism associated with a foot of each leg to provide additional resistance to the forces an ice floe may impose on the rig.

3. The ice worthy jack-up rig according to claim 1 or claim 2, wherein the ice bending surface is slanted upwardly and outwardly from a smaller dimension neckline to a larger dimension shoulder.

4. The ice worthy jack-up rig according to any preceding claim, wherein the ice bending surface extends vertically at least 8 to 10 or more meters.

5. The ice worthy jack-up rig according to claim 4, wherein the angle of the ice-bending surface is in the range of 30 to 60 degrees from the vertical.

6. The ice worthy jack-up rig according to any preceding claim, wherein the ice-bending surface comprises a plurality of relatively flat, sloped, segments extending around the periphery of the rig.

7. The ice worthy jack-up rig according to any preceding claim, wherein the ice-bending surface is a reinforced surface.

8. A method for drilling a well in ice prone waters, the method comprising:

providing a rig having a flotation hull having a relatively flat deck at the upper portion thereof and an ice-bending shape along the lower portion thereof where the ice-bending shape extends from an area of the hull near the level of the deck and extends downwardly near the bottom of the hull and an ice deflecting portion extending around the perimeter of the bottom of the hull to direct ice around the hull and not under the hull;

providing at least three legs that are positioned within the perimeter of the bottom of the hull;

jacking down each leg in a manner that feet on the bottom of the legs engages the sea floor and lifts the hull up and fully out of the water when ice is not threatening the rig while the rig is drilling a well on a drill site;

lowering the hull into the water into an ice defensive configuration so that the ice-bending shape extends above and below the sea surface to bend ice that comes against the rig to cause the ice to submerge under the water and

endure bending forces that break the ice where the ice flows past the rig; and

drilling a well from the rig.

9. The method according to claim 8 further including the step of anchoring the legs to the seafloor to further resist the force of ice floes.

10. The method according to claim 8 or claim 9 wherein the ice-bending surface extends from a shoulder to a neckline and the step of lowering the hull into the water more particularly comprises lowering the hull into the water so that the neckline is at least 4 meters below the sea surface and the shoulder is at least 7 meters above the sea surface.

11. The method according to any of claims 8 to 10 further including the step of raising the hull up out of the water when the threat of ice floes are reduced.

12. A method for drilling a well in ice prone waters comprising the use of a rig as claimed in any of claims 1 to 7.