An improved rig assist compensation system is provided, comprising a motion compensation unit operatively connected to a semi-submersible rig platform having a blow-out prevention (BOP) stack; a hydraulic workover (HWO) jack rotatably affixed above the BOP stack, wherein the HWO jack includes a through-rotary portion, and a stationary portion; and a hydraulic motion compensator unit, positioned between the HWO jack and the BOP stack. The motion compensator unit comprises a base frame having a plurality of base cylinders; an upper frame having a plurality of mating upper cylinders to engage the base cylinders in telescoping fashion, wherein the base frame and the upper frame are slidably connected, and are movable from an extended position and a retracted position.
FIGURE 1
(prior art)
RIG ASSIST COMPENSATION SYSTEM

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates generally to well intervention compensators, and more particularly to deep water rig assist compensation systems. It has particular application to lowering and lifting apparatuses that operate pipe and other tubular elements into and out of a well.

II. Background and Prior Art

A. Hydraulic Workover and Snubbing Background

It is not uncommon in certain fields to drill through formations wherein effective well pressure conditions in excess of 3000 pounds per square inch are encountered, or to repair wells with pressure on the surface control equipment. In order to operate tubular goods within a well in the presence of high formation pressure, it has become the practice to pack off, near the surface, the annular space between the casing and the drill pipe or other tubular goods operating within the casing and to install a check valve on the end or inside the drill pipe or other tube operating inside the casing. This check valve is installed to permit passage of fluid downward and prevent upward passage of fluid. In the process of lowering a drill pipe into the well, a continuous length is made up length by length. It may be evident that when the length of pipe in the hole with the check valve installed is such that its weight is less than that of the effective well pressure tending to lift it, the pipe must be forced down until sufficient lengths have been added to the top of the pipe to allow the force of gravity to sink it.

Moreover, when the pipe is retracted from the hole, immediately after the pressure balance point has been reached (that is, the point where the pipe has been shortened by lifting it and unjoining lengths from the top until the weight of the pipe left in the hole just balances the effective force of the well pressure tending to lift it), the well pressure tends to eject the pipe from the casing.

The forceful entry of the pipe until after the balance point is passed by adding sufficient pipe lengths to overcome the lifting force of the well pressure, is termed “snubbing in”, and the control of the movement of the pipe under the influence of well pressure in coming out, is termed “snubbing out”. The apparatus that is provided to permit control in snubbing in and snubbing out is referred to as snubbing apparatus or merely as the “snubber”. This process is also often referred to as “hydraulic workover” (HWO). It will be realized that with high well pressures, the lifting force exerted on the pipe may become tremendous and if not kept under control could easily result in damage causing great delays and even result in disaster.

To ensure control over a pipe in the above-described environment, it is conventional to employ unidirectional grippers referred to in the industry as “slips”. Such slips are similar to a chuck and are used to hold the pipe against movement in either one direction or the other. When two sets of slips are placed back-to-back, they then hold the pipe against movement in either direction. It is further conventional to employ such sets or pairs of slips at two locations: (1) on a vertical traveling table or support (herein referred to as the traveling support) and (2) on a stationary platform or support. Hence, it may be seen, that during a snubbing operation the slips on the stationary support are released while the slips on the vertical traveling support are in their gripping state. Once the stroke is complete, then the slips on the stationary support are actuated to grip the pipe and the slips on the traveling support are released to allow for repositioning of the traveling support with respect to the pipe for another stroke.

In normal operation in the absence of pressure (or when the pipe is of sufficient length that operation is below the pressure balance point), there is no need to apply downward pressure in addition to that applied by gravity to the pipe. The traveling support is suspended on the cable usually provided on a conventional drilling rig or rig used in well repair or servicing. The cable is reeled onto or off of a conventional winch drum complete with brake and clutches to enable the operator to lower or hoist the traveling support. This conventional winch with its accessories is commonly called the “draw works”. The draw works provides adequate pipe hoisting and lowering capability when well pressure is not a factor. When well pressure is a factor, external means are applied to the pipe to push the pipe into the well.

For example, one common method employed to provide downward pressure is to provide a plug in the pipe, normally in the form of a check valve, and pump drilling fluid through the pipe. Pump pressure in excess of well pressure causes pumped fluid to enter the pipe and travel downward through the check valve. This method leaves the pipe at atmospheric pressure above the check valve and at well pressure below the check valve. Hence, succeeding lengths of pipe can be screwed together and forced into the well without loss of pressure through the bore of the pipe.

In the more sophisticated rigs, hydraulic, pneumatic or electrical driving means are provided for applying both upward as well as downward force to the pipe. In some hydraulic rigs, accumulators are used to provide energy storage of the hydraulic fluid during hydraulic piston retraction. These systems are generally referred to as hydraulic workover jacks, or HWO jacks.

The main problem with conventional well intervention compensators are that use of frames and cables nearly eliminates the possibility of using the drilling structure for anything other than a support structure for the conventional HWO unit, coiled tubing, wireline, slick line, and electric line applications. Another problem with conventional well intervention compensators is that the handling of a large compensator frame must be done in a highly controlled fashion, with numerous points of hazard to equipment and personnel on the offshore structure. Working with the cable systems creates a higher level of time for rigging up, while using uncustomed methods to achieve the rig-up. Both of these processes create a working environment that is relative less safe. Another problem is that the compensator lift frame is a large and bulky system. Due to its large size, transporting on-shore often requires a permit load, and typically requires larger transporting equipment when dispatched offshore.

B. Heave Compensation Systems

When operations on marine locations are performed that are not supported by a stationary structure, it becomes necessary to compensate the effects of waves,
tides, currents, and the like. A heave compensation system provides a means of controlling forces on a drill or work string suspended from a floating drill ship, spars, tension leg platforms, and semi-submersible platforms. The objective is to eliminate wave induced vertical motion of the drill or work string, and it has been accomplished by a number of technologies developed over the years in conjunction with the design of the drilling rig. The most common type of heave compensation system involves the use of a cable arrangement which is connected at one end to the riser extending from the seabed and at the other end to machinery on the floating rig floor.

[0015] Consequently, there is a need for a compensation system in connection with hydraulic workover operations that can either work with the existing cable-type rig compensation system, or that can serve as a "stand alone" system integrated into the design of the snubbing unit. For example, in the first case, the traveling head of the HWO jack would provide compensation when needed, in addition to the existing cable-type rig compensator, for the weight and force of the drill or work string during both balanced and under-balanced operations. In the second case, the riser system extending from the seabed would be supported entirely by an improved HWO jack system which includes a motion compensation unit to provide total compensation for such operations.

SUMMARY OF THE INVENTION

[0016] Therefore, one object of the present invention is to provide a rig assist compensation system which is integrated into an improved HWO jack system having a motion compensation unit.

[0017] It is also an object of the present invention to provide a rig assist compensation system wherein the improved HWO jack system may optionally be used in conjunction with existing cable-type heave compensators.

[0018] A further object of the present invention is to provide a rig assist compensation system wherein the stroke of the improved HWO jack system may operate in conjunction with the included motion compensation unit.

[0019] Accordingly, an improved rig assist compensation system is provided, comprising a motion compensation unit operatively connected to a semi-submersible rig platform having a blow-out prevention (BOP) stack; a hydraulic workover (HWO) jack rotatably affixed above the BOP stack, wherein the HWO jack includes a through-rotary portion, and a stationary portion; and a hydraulic motion compensator unit, positioned between the HWO jack and the BOP stack. The motion compensator unit comprises a base frame having a plurality of base cylinders; an upper frame having a plurality of mating upper cylinders to engage the base cylinders in telescoping fashion, wherein the base frame and the upper frame are slidably connected, and are movable from an extended position and a retracted position.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIG. 1 is an elevation view of a prior art HWO unit having a motion compensator frame.

[0021] FIG. 2 is an elevation view of a first embodiment of the present invention depicting an improved HWO jack having a motion compensation unit, and working in conjunction with an existing cable-type rig compensation system at zero heave.

[0022] FIG. 3 is an elevation view of the embodiment of FIG. 2 at minus heave.

[0023] FIG. 4 is an elevation view of the embodiment of FIG. 2 at plus heave.

[0024] FIG. 5 is an elevation view of a second embodiment of the present invention depicting an improved HWO jack having a motion compensation unit, and working in conjunction with an existing cable-type rig compensation system at zero heave, wherein additional compensation is provided by the through-rotary elements of the HWO jack.

[0025] FIG. 6 is an elevation view of the embodiment of FIG. 5 at minus heave.

[0026] FIG. 7 is an elevation view of the embodiment of FIG. 5 at plus heave.

[0027] FIG. 8 is an elevation view of the first embodiment of the present invention at zero heave without the existing cable-type rig compensation system.

[0028] FIG. 9 is an elevation view of the embodiment of FIG. 8 at minus heave.

[0029] FIG. 10 is an elevation view of the embodiment of FIG. 8 at plus heave.

[0030] FIG. 11 is an elevation view of the second embodiment of the present invention at zero heave without the existing cable-type rig compensation system.

[0031] FIG. 12 is an elevation view of the embodiment of FIG. 11 at minus heave.

[0032] FIG. 13 is an elevation view of the embodiment of FIG. 11 at plus heave.

[0033] FIG. 14 is a detailed view of the through-rotary portion of the improved HWO jack with snubbing slips.

[0034] FIG. 15 is a detailed view of an optional detachable stationary slip window that may be used as a replacement or alternative to a lower stationary slip.

[0035] FIG. 16 is a detailed view of the motion compensation unit for the improved HWO jack.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0036] Certain features which are used in assembling or operating the invention, but which are known to those of ordinary skill in the art and not bearing upon points of novelty, such as screws, bolts, nuts, welds, and other common fasteners, may not be shown for clarity. In order to appreciate the novelty of the present invention and its improvements over prior designs, a detailed description of the existing art is provided first with reference to FIG. 1, followed by a description of various embodiments of the invention. It should be noted that due to the relative sizes of the components to be described in comparison to the rig platform, the figures are not drawn to scale for clarity purposes.

[0037] Turning now to FIG. 1, a prior art depiction of an HWO jack 1 is shown attached to a blow out preventer
(BOP) stack connected using rig slips 13 to a riser 5 extending from the seabed. Compensation for these components is provided by a motion compensator frame 2 connected to a rig block 3. Generally, the HWO jack 1 comprises a traveling head 6 having slips 7, 8 for gripping tubulars in "snubbing in" and "snubbing out" operations, respectively. The traveling head 6 is slidably engaged to a stationary platform 9 by a plurality of double-acting hydraulically operated pistons and cylinders 10 and guided within a telescoping frame 14. As in the case of traveling head 6, stationary platform 9 includes slips 11, 12 for gripping tubulars in "snubbing in" and "snubbing out" operations, respectively. When in operation, motion of the floating rig platform 24 due to wave action is compensated by motion compensator frame 2.

In contrast to the prior art of FIG. 1, FIG. 2 is an elevation view of a first embodiment of the present invention depicting an improved HWO jack 20 having a motion compensation unit 21, and working in conjunction with an existing cable-type rig compensation system 22 at zero heave. A semi-submersible rig platform 23 is shown having a deck 24, to which the HWO jack (or "snubbing jack") 20 is rotatably affixed for operation on top of the BOP stack 4. The water line 25 resides below the "moon pool" area 26 of the rig 23. The cable compensation system 22 is connected to the riser 5, passing through pulleys 27 and terminating at the rig deck 24. The HWO jack 20 includes a through-rotary portion 28, i.e. drilling platform rotary table, shown in more detail in FIG. 14, and a stationary portion 29, shown in more detail in FIG. 15. Below the stationary portion 29 of the HWO jack 20 is a hydraulic motion compensator unit 30, shown in more detail in FIG. 16.

With specific reference to FIGS. 14 and 15, FIG. 14 is a detailed view of the through-rotary portion of the improved HWO jack with snubbing slips. Likewise, FIG. 15 is a detailed view of the stationary slips for the improved HWO jack. In FIG. 14, the through-rotary portion 28 comprises a base plate 41 and top plate 42, between which are disposed double-acting hydraulic piston and cylinder arrangements 43, preferably four in number. A central telescoping tubing guide 44 is also positioned between base plate 41 and top plate 42 to assist in maintaining alignment of the components. A traveling rotary platform 45 is connected between top plate 42 and snubbing slips 46, 47 for manipulating tubulars as known in the art. The HWO jack 20 is rotatably affixed to the rig deck 24 by rotary bushings 49.

FIG. 15 is a detailed view of an optional detachable stationary slip window that may be used as a replacement or temporary to the lower stationary slip. Top and bottom plates 61, 62 are joined by typically four "window" legs 63. A stationary "snubbing" hydraulic slip 64 resides below top plate 61 for insertion of strings into the well bore. Similarly, a stationary "heaving" hydraulic slip 65 resides above bottom plate 62 for removal of strings from the well bore. Lifting and rigging pad eyes 66 are affixed to legs 63 for moving the slip window as required during operations.

With specific reference to FIG. 16, the motion compensator unit 30 comprises a base frame 31 having multiple base cylinders 32, preferably four in number, and an upper frame 33 with mating upper cylinders 34 to engage base cylinders 32 in telescoping fashion. Base frame 31 and upper frame 33 are thereby slidably connected, and are moved from an extended position and a retracted position by a double-acting hydraulic piston and cylinder 35 powered and controlled in a manner known to those in the art. Operation of these components may be active or passive, and they may involve hydraulic or pneumatic operation. By positioning the motion compensator unit 30 between the HWO jack 20 and the BOP stack 4, the desired pull tension on the riser 5 is produced and maintained. Ideally, the motion compensator unit 30 would be installed in mid-stroke to accommodate an adequate range for both plus and minus heaves of the platform 23. Thus, the motion compensator unit 30 would operate in addition to the rig compensator 22 already in place.

FIG. 3 is an elevation view of the embodiment of FIG. 2 at minus heave. Note that as a result, the moon pool area 26 is positioned lower with reference to the riser 5 and the BOP stack 4 as the platform 23 moves closer to the seabed. Conversely, FIG. 4 is an elevation view of the embodiment of FIG. 2 at plus heave, depicting the opposite effect as the platform 23 moves away from the seabed. In this embodiment, the through-rotary portion 28 of the HWO jack 20 remains stationary, and all compensation is achieved by a combination of the motion compensator unit 30 and the rig compensator 22.

FIG. 5 is an elevation view of a second embodiment of the present invention depicting an improved HWO jack having a motion compensation unit, and working in conjunction with an existing cable-type rig compensation system at zero heave, wherein additional compensation is provided by the through-rotary elements of the HWO jack. In this embodiment, the through-rotary portion 28 of the HWO jack 20 includes its own hydraulic power and control components, and further serves as a compensation system. However, the through-rotary portion 28 of the HWO jack 20 is independently controlled from both the motion compensator unit 30 and the rig compensator 22, although all such systems work cooperatively to reduce the effects of heave. When the invention is operated in this manner, the through-rotary portion 28 is also designed and controlled to maintain the depth or "weight on bit" of the work string below.

FIG. 6 is an elevation view of the embodiment of FIG. 5 at minus heave. Note that as a result, the stroke of the HWO jack 20 is extended, and the moon pool area 26 is positioned lower with reference to the riser 5 and the BOP stack 4 as the platform 23 moves closer to the seabed. Conversely, FIG. 7 is an elevation view of the embodiment of FIG. 5 at plus heave, and the stroke of the HWO jack 20 is retracted, depicting the opposite effect as the platform 23 moves away from the seabed.

FIG. 8 is an elevation view of the first embodiment of the present invention at zero heave without the existing cable-type rig compensation system. This arrangement operates identically to the embodiment as depicted in FIGS. 2-4, in the sense that the through-rotary portion 28 of the HWO jack 20 does not serve as an additional and independent compensation means. In this configuration, a rig compensator 22 would not be necessary, as the motion compensator unit 30 dispenses with the need for a separate cable compensation system. Similar to the case with FIGS. 2-4, FIGS. 9 and 10 illustrate elevation views of the embodiment of FIG. 8 at minus heave and plus heave, respectively.
Finally, FIG. 11 is an elevation view of the second embodiment of the present invention at zero heave without the existing cable-type rig compensation system. This arrangement operates identically to the embodiment as depicted in FIGS. 5-7, in the sense that the through-rotary portion 28 of the HWO jack 20 serves as an additional and independent compensation means. Once again, in this configuration, a rig compensator 22 would not be necessary, as the motion compensator unit 30 and the extension and retraction of the through-rotary portion 28 of the HWO jack 20 dispense with the need for a separate cable compensation system. Similar to the case with FIGS. 5-7, FIGS. 12 and 13 illustrate elevation views of the embodiment of FIG. 11 at minus heave and plus heave, respectively.

Although exemplary embodiments of the present invention have been shown and described, many changes, modifications, and substitutions may be made by one having ordinary skill in the art without necessarily departing from the spirit and scope of the invention.

I claim:

1. An improved rig assist compensation system, comprising:

   (a) a motion compensation unit operatively connected to a semi-submersible rig platform having a blow-out prevention (BOP) stack;

   (b) a hydraulic workover (HWO) jack rotatably affixed above said BOP stack, wherein said HWO jack includes a through-rotary portion, and a stationary portion; and

   (c) a hydraulic motion compensator unit, positioned between said HWO jack and said BOP stack, wherein said motion compensator unit comprises:

   a base frame having a plurality of base cylinders;

   an upper frame having a plurality of mating upper cylinders to engage said base cylinders in telescoping fashion, wherein said base frame and said upper frame are slidably connected, and are movable from an extended position and a retracted position.

* * * * *