

APPARATUS AND METHOD FOR MEASURING INCLINATION IN SUBSEA RUNNING, SETTING, AND TESTING TOOLS

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] This technology relates to subsea oil and gas wells. In particular, this technology relates to measurement of inclination of running, setting, and testing tools during the primary phase of jetting a subsea well.

2. Brief Description of Related Art

[0002] Typical subsea drilling operations include a drilling vessel and an arrangement of equipment to accomplish the first drilling phase of a well. Where the sea floor is sandy, the first phase of the drilling operation may include jetting. Jetting is a process wherein a jetting tool, enclosed within a casing, is placed adjacent the sea floor. Fluid is sprayed through the end of the jetting tool and directed at the sand on the sea floor. The fluid is turbulent and stirs up the sand, which mixes with the fluid and is carried up the casing away from the bottom of the casing. When the sand is thus removed, the casing is lowered into the void left behind. This process is continued until the casing reaches a predetermined depth, after which equipment related to the next phase of drilling (i.e. a high pressure housing, blow out preventer, marine riser, etc.) is connected.

[0003] It is beneficial for the equipment used in this first stage of drilling to be vertically oriented while the well is created. Such a vertical orientation allows for straight and proper connections of equipment used in subsequent phases of drilling. Accordingly, monitoring the inclination of the jetting equipment used during the first phase of drilling may be beneficial to help ensure that a vertical orientation is maintained.

SUMMARY OF THE INVENTION

[0004] Disclosed herein is a system for jetting a borehole in a sea floor. In an example, the system includes a tubular having a stem, a housing running and jet tool, and a jetting tool inserted into the tubular and having an end from which fluid is selectively discharged to excavate the borehole. An electrical inclination sensor is attached either to the stem of the tubular, or to the housing running and jet tool. The electrical inclination sensor measures vertical inclination of the jetting tool and the housing running and jet tool.

[0005] A transmitter is attached to the electrical inclination sensor that receives information related to the inclination of the jetting tool and the housing running and jet tool from the electrical inclination sensor. The transmitter then transmits either a mud pulse signal or an acoustic signal, depending on the placement of the transmitter, containing information about the inclination of the jetting tool and the housing running and jet tool.

[0006] A receiver is located at the drilling vessel and is configured to receive the mud pulse or other acoustic signal from the transmitter. If the transmitter is attached to the stem of the jetting tool, the receiver may be attached to a receptor at the top of the drill string. If the transmitter is attached to the housing and drill tool, so that it transmits acoustic signals into the sea water, the receiver may be positioned near the drilling vessel and submerged in the sea.

[0007] Also disclosed herein is a method for jetting a borehole in a sea floor. The method includes the steps of jetting a borehole by selectively discharging fluid out of a jetting tool directed at the sea floor, and providing an electrical inclination sensor that measures the inclination of the jetting tool. The method also provides monitoring the inclination of the jetting tool with the electrical inclination sensor prior to and during drilling activities, acoustically transmitting a signal containing information about the inclination of the jetting tool via a transmitter attached to the electrical inclination sensor, and receiving the signal with a receiver proximate the sea surface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The present technology will be better understood on reading the following detailed description of nonlimiting embodiments thereof, and on examining the accompanying drawings, in which:

[0009] Fig. 1A is a perspective view of a jetting assembly according to an embodiment of the present technology;

[0010] Fig. 1B is an enlarged view of the area indicated by the circle 1B in Fig. 1A;

[0011] Fig. 2 is a side view of the jetting assembly of claim 1 in operation during a primary phase of drilling a well;

[0012] Fig. 3A is a perspective view of a system for running, setting, and testing subsea jetting tools according to an embodiment of the present technology;

[0013] Fig. 3B is an enlarged side view of a portion of the jetting equipment shown in Fig. 3A, as indicated by the area 3B of Fig. 3A;

[0014] Fig. 4 is a side view of a the jetting assembly according to an embodiment of the present technology, with a known analog inclination sensor and a remotely operated vehicle;

[0015] Fig. 5A is a side view of the jetting assembly according to an embodiment of the present technology, including an electrical inclination sensor attached to the stem of the housing running and jet tool;

[0016] Fig. 5B is an enlarged side view of the electrical inclination tool attached to the stem of the housing running and jet tool, as indicated by area 5B of Fig. 5A;

[0017] Fig. 6 is a perspective view of components of a system for running, setting, and testing subsea jetting tools according to an embodiment of the present technology, including a transmitter and receiver configured to communicate via mud pulse data transmission;

[0018] Fig. 7A is a side view of components of a system for running, setting, and testing subsea jetting tools according to an embodiment of the present technology, including a transmitter and receiver configured to communicate via acoustic data transmission; and

[0019] Fig. 7B is a side view of a portion of the jetting assembly, including an electrical inclination sensor and a transmitter configured for acoustic data transmission, as indicated by area 7B of Fig. 7A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] The foregoing aspects, features, and advantages of the present technology will be further appreciated when considered with reference to the following description of preferred embodiments and accompanying drawings, wherein like reference numerals represent like elements. In describing the preferred embodiments of the technology illustrated in the appended drawings, specific terminology will be used for the sake of clarity. However, the technology is not intended to be limited to the specific terms used, and it is to be understood that each specific term includes equivalents that operate in a similar manner to accomplish a similar purpose.

[0021] Fig. 1A shows a jetting assembly 10 according to an embodiment of the present technology, including a low pressure housing 12, a casing string 14, a housing running and jet tool 16, drill pipe 18, and a jetting tool 20. The housing running and jet tool 16 has a stem 21. Jetting assembly 10 is configured to accomplish the first phase of a drilling program, by beginning drilling a wellbore into the sea floor. As shown in Fig. 1B, when the jetting assembly 10 is assembled, the end 22 of the jetting tool 20 is positioned a predetermined distance D from the bottom of the casing string 14. In one embodiment, this distance D may be about 18 inches. Before initiating jetting operations, and

during the course of jetting the first phase of the well, it is desirable for the jetting assembly 10, and in particular the drill pipe 18 and the casing 14, to be vertically oriented. Such a vertical orientation allows for the successful connection and operation of equipment during subsequent drilling phases.

[0022] Fig. 2 shows the jetting assembly 10 in practice. Once the jetting assembly 10 is positioned vertically adjacent the sea floor 24, the jetting tool 20 ejects fluid downward toward the sea floor 24. The ejection of fluid causes turbulence at the end of the casing string 14, which turbulence stirs up the sand and sediment on the sea floor 24. As the sand and sediment is stirred up, it is carried by the fluid upwardly through the casing string 14, along the path indicated by arrows A. In the embodiment shown, the sand and sediment may be discharged into the sea through the low pressure housing 12. As the sand and sediment is stirred and carried upward by the drill fluid, a void space is created immediately below the casing string 14. The casing string 14 then travels downward to fill the void space. This sequence of operation (i.e., jetting, removal of sand and sediment, and lowering of the casing string) is repeated as needed until the assembly 10 achieves a predetermined depth. The fluid may be incontaminable, to minimize or eliminate environmental hazards when the fluid is discharged in the sea along with the sand and sediment.

[0023] Referring to Fig. 3A, there is shown a system for running, setting, and testing subsea jetting tools, including equipment used to carry out subsequent phases of drilling after the first phase is completed. Specifically, Fig. 3A shows a drilling vessel 26, located at the surface of the sea, and additional subsea drilling equipment located at the sea bed 24. Although the drilling vessel 26 is shown to be a ship, it could also be a drilling platform, such as, for example, a floating platform, tension leg platform, etc. An enlarged view of some of this additional subsea drilling equipment is shown in Fig. 3B, and includes the low pressure housing 12, a high pressure housing 30 configured for insertion inside the low pressure housing 12, and a pressure management device 32, such as, for example, a blowout preventer (BOP). As shown, the subsea drilling equipment may be connected to the drilling vessel 26 by a marine riser 28.

[0024] In practice, the jetting assembly 10 may be assembled on the drilling vessel 26. To accomplish this, the housing running and jet tool 16 is inserted and locked into the low pressure housing 12. Drill pipe 18 is also attached to the housing running and jet tool 16. This may be accomplished by connecting a bottom thread of the housing running and jet tool 16 to a top thread of the drill pipe 18. Similarly, the jetting tool 20 may then be attached to the drill pipe 18 by, for example, connecting a bottom thread of the drill pipe 18 with a top thread of the jetting tool 20. The casing string 14 is also connected to the low pressure housing 12, and is configured so its bottom end

is a predetermined distance D from the bottom end 22 of the jetting tool 20, as discussed above. Once the jetting assembly 10 has been assembled, it is lowered to the sea floor. The jetting assembly 10 remains connected to the drilling vessel 26 by a drill pipe (not shown) which extends upwardly through the marine riser 28 from the jetting assembly 10 to the drilling vessel 26. The fluid to be ejected by the jetting tool 20 is delivered to the jetting tool 20 from the drilling vessel 26 via the drill pipe 18.

[0025] As discussed above, it is desirable that the jetting assembly 10 maintain a vertical orientation through the jetting phase. Accordingly, Fig. 4 shows one known method of verifying such a vertical orientation that includes an analog inclination measuring device 34 attached to the jetting assembly 10. In an example, an analog inclination measuring device 34 is of the type known as a “Bullseye” device in the industry that includes liquid in a sealed chamber, and a ball floating in the liquid. Reference lines are drawn on surfaces of the chamber, and as the equipment inclines, the liquid pushes the floating ball to a corresponding reference line. Association of the ball with a particular reference line indicates how much the device is inclined. Options exist where the analog inclination measuring device 34 is attached to or formed integrally with, the housing running and jet tool 16.

[0026] In practice, the use of such an analog inclination measuring device 34 requires that an inclination reading be taken between each iteration of jetting (i.e., between each sequence of jetting, sand and sediment removal, and lowering of the casing string). Such an inclination reading requires use of a remotely operated vehicle (ROV) 36, and can be time consuming and inefficient. This is because the ROV 36 can only read the analog inclination measuring device 34 from close proximity, as shown in Fig. 4. During the actual jetting operation, however, the ROV 36 must be positioned relatively far away from the jetting assembly 10 so as not to interfere with operations. This means that between each iteration of jetting, the ROV 36 must move into close proximity of the analog inclination measuring device 34, take the inclination reading, transmit the reading to an operator on the drilling vessel 26, and move back away from the jetting assembly 10 a safe distance.

[0027] A better way to measure the inclination of the jetting assembly 10 is through the use of an electrical inclination sensor 38, as shown in Figs. 5A and 5B. One example of such an electrical inclination sensor 38 is disclosed in U.S. Patent No. 4,937,518, which is hereby incorporated by reference herein. As shown, the electrical inclination sensor 38 is attached to the jetting assembly 10, and is configured to send an inclination signal to an operator on the drilling vessel 26 in real time. In some embodiments, the electrical inclination sensor 38 may be attached to the stem 21 of

the housing running and jet tool 16. In other embodiments, the electrical inclination sensor 38 may be attached to the low pressure housing 12 (as shown in Fig. 7).

[0028] The real time transmission of inclination data from the jetting assembly 10 to an operator on the drilling vessel 26 is advantageous because it eliminates the need to stop jetting between each jetting iteration to allow the ROV 36 to take an inclination reading. Furthermore, the real time transmission allows an operator to detect a problem with the inclination immediately when the problem occurs, rather than waiting for the next break between jetting iterations. Thus, the jetting process is more efficient, and potential problems can be identified and remedied more rapidly.

[0029] Signal transmission from the electrical inclination sensor 38 to the operator on the drilling vessel 26 can be accomplished in at least two different ways. For example, the data signal from the electrical inclination sensor 38 can be sent via mud pulse transmission (shown in Fig. 6) or acoustic data transmission (shown in Fig. 7). In each case, the data signal is transmitted from the electrical inclination sensor 38 by a transmitter 40, and received by a receiver 42.

[0030] In the case of mud pulse transmission, shown in Fig. 6, the electrical inclination sensor 38 may be attached to the stem 21 of the housing running and jet tool 16. The transmitter 40 may also be attached to the stem 21 of the housing running and jet tool 16, and may be connected to the electrical inclination sensor 38 by a wire (not shown). Coupled with the drill pipe 18, proximate the drilling vessel 26, is a receptor stem 44. The receptor stem 44 may be attached to the drill pipe 18 by engaging a top thread of the drill pipe 18 with a corresponding bottom thread of the receptor stem 44. A receiver 42 is attached to the receptor stem 44 and in communication with a display 46 that is viewable by an operator.

[0031] In practice, the electrical inclination sensor 38 determines the inclination of the stem 21 of the housing running and jet tool 16, which corresponds to the inclination of the entire drill assembly 10. The inclination sensor 38 then communicates the inclination data to the transmitter 40. Next, the transmitter 40 transmits an inclination data signal upward in a pulse through the mud surrounding the stem 21 and the drill pipe 18 to the receptor stem 44. At the receptor stem 44, the receiver 42 receives the signal, and communicates the inclination data to the display 46. In certain embodiments, the inclination data is generated constantly by the electrical inclination sensor 38 and transmitted in real time to the receiver 42. Thus, the operator receives continuous real time data about the inclination of the drill assembly 10 throughout the primary jetting process.

[0032] In an example of acoustic data transmission, as shown in Figs. 7A and 7B, the electrical inclination sensor 38 is attached to an outer face of the low pressure housing member 12. Likewise,

the transmitter 40 is attached to the outer surface of the low pressure housing member 12, and is connected to the electrical inclination sensor 38 by a wire (not shown). Receiver 42 is positioned near the drilling vessel 26 (shown as a floating platform in Fig. 7), and is connected to a display 46 (shown in Fig. 6) that is viewable by an operator.

[0033] In an example of operation, the electrical inclination sensor 38 senses an inclination of the low pressure housing 12, which corresponds to the inclination of the entire drill assembly 10. The inclination sensor 38 then communicates the inclination data to the transmitter 40, which transmits an inclination data signal into the surrounding sea water that is received by receiver 42. Based on the received signal, the receiver 42 communicates the inclination data to the display 46. In certain embodiments, the inclination data is generated constantly by the electrical inclination sensor 38 and transmitted in real time to the receiver 42. Thus, the operator receives continuous real time data about the inclination of the drill assembly 10 throughout the primary jetting process. In this embodiment, the receiver 42 is submerged in the sea water proximate the vessel so that it can better intercept the acoustic signals transmitted by the transmitter 40.

[0034] In certain embodiments, the receiver 42 can communicate with an analysis device or system, such as a computer, processor, network, software, analytics engine, etc. Such communication may be by means of a wire, or wireless transmission signals. The analysis device or system may be adapted to react to certain data received from the receiver 42 by, for example, sounding an alarm, sending a message, or sending control signals to automatically or semi-automatically control the equipment. In addition, the analysis device or system could be located near the receiver 42 or remote from the receiver 42, such as, for example, at a distant location.

[0035] While the technology has been shown or described in only some of its forms, it should be apparent to those skilled in the art that it is not so limited, but is susceptible to various changes without departing from the scope of the invention. Furthermore, it is to be understood that the above disclosed embodiments are merely illustrative of the principles and applications of the present invention. Accordingly, numerous modifications may be made to the illustrative embodiments and other arrangements may be devised without departing from the spirit and scope of the present invention as defined by the appended claims.

What is claimed is:

1. A system for jetting a borehole in a seafloor (24), the system comprising:
 - a tubular (16);
 - a jetting tool (20) inserted into the tubular (12) and having an end from which fluid is selectively discharged to excavate the borehole;
 - an electrical inclination sensor (38) attached to the stem (21) of the tubular (16);
 - a transmitter (40) in communication with the electrical inclination sensor (38); and
 - a receiver (42) proximate the sea surface and in communication with the transmitter (40) through the fluid in a drill pipe (18), so that when the jetting tool (20) is excavating the borehole, an inclination of the tubular (16) is sensed by the inclination sensor (38), which inclination is communicated from the transmitter (40) to the receiver (42).
2. The system of claim 1, further comprising a display (46) in communication with the receiver (42) that is accessible to an operator, and shows the information transmitted to the receiver (42).
3. The system of claim 1, wherein the transmitter (40) transmits, and the receiver (42) receives, information about the inclination of the tubular (16) continuously in real time.
4. The system of claim 1, wherein communication between the receiver (42) and the transmitter (40) comprises acoustic pulses that propagate through the drill pipe (18).
5. A system for jetting a borehole in a seafloor (24), the system comprising:
 - running and setting tools, including at least a housing running and jet tool (16) operatively connected to a drilling vessel (26), and a jetting tool (20) having an end from which fluid is selectively discharged to excavate the borehole;
 - an electrical inclination sensor (38) attached to the housing running and jet tool (16), and capable of measuring the relative vertical inclination of the housing running and jet tool (16);
 - a transmitter (40) attached to the electrical inclination sensor (38) that receives information related to the inclination of the housing running and jet tool (16) from the electrical inclination

sensor (38), and that transmits an acoustic signal containing information about the inclination of the housing running and jet tool (16) into the sea; and

a receiver (42) located proximate the drilling vessel (26) and at least partially submerged in the sea, the receiver (42) configured to receive the acoustic signal from the transmitter (40).

6. The system of claim 5, further comprising a display (46) in communication with the receiver (42), and accessible to an operator, that shows the information transmitted to the receiver (42) in the acoustic signal.

7. The system of claim 5, wherein the transmitter (40) transmits, and the receiver (42) receives, information about the inclination of the housing running and jet tool (16) continuously in real time.

8. A method for jetting a borehole in a seafloor (24), the method comprising:

jetting a borehole by selectively discharging fluid out of a jetting tool (16) directed at the sea floor (24);

providing an electrical inclination sensor (38) that measures the inclination of the jetting tool (16);

monitoring the inclination of the jetting tool (16) with the electrical inclination sensor (38) prior to and during jetting activities; and

acoustically transmitting, to a receiver (42) proximate the sea surface, a signal containing information about the inclination of the jetting tool (16) via a transmitter (40) attached to the electrical inclination sensor (38).

9. The method of claim 8, further comprising the step of displaying the information about the inclination of the jetting tool (16) on a display screen (46) in communication with the receiver (42).

10. The method of claim 8, wherein the step of monitoring the inclination of the jetting tool (16) is carried out continuously in real time during the landing and setting of subsea wellhead consumables on the sea floor (24).

11. The method of claim 8, wherein the jetting tool (16) is deployed on a fluid filled tubular string (18), and wherein the step of acoustically transmitting the signal comprises directing pulses through the fluid in the string (18).
12. The method of claim 8, wherein the step of acoustically transmitting the signal comprises directing pulses through sea water.
13. The method of claim 8, further comprising the step of receiving the signal by the receiver (42).