A high energy tubular shear is connectable within a drilling system and includes a body forming a bore through which a tubular is disposed, a cross-bore intersecting the bore, opposing cutters moveably positioned in the cross-bore on opposite sides of the bore, and the each cutter in hydraulic communication with a respective hydraulic intensifier.
**FIG. 4A**

1. **INITIATE SAFING SEQUENCE IN RESPONSE TO MONITORING LIMIT STATE SENSOR 84 PACKAGE**
2. **VENTING PRESSURE FROM CSP 28 AND WELL 18 THROUGH VENT SYSTEM 64**
3. **CLOSE CHoke LINE 44 AND KILL LINE 46**
4. **PRESSURIZE WELLHEAD CONNECTOR LOCK 120 CIRCUIT**
5. **DIVERT FLUID FLOW FROM THE WELL THROUGH THE CSP VENT SYSTEM 64**
6. **SECURE THE TUBULAR 38 IN THE LOWER CSP 34 IN RESPONSE TO ACTUATING LOWER SLIPS 60**
7. **SECURE THE TUBULAR 38 IN THE UPPER CSP 32 IN RESPONSE TO ACTUATING THE UPPER SLIPS 48**
8. **SHEAR THE TUBULAR 38 BETWEEN THE UPPER SLIPS 48 AND THE LOWER SLIPS 60**
9. **DISCONNECT THE UPPER CSP 32 FROM THE LOWER CSP 34 IN RESPONSE TO ACTUATING THE CSP CONNECTOR 72**

**FIG. 4B**
FIG. 4B

FIG. 4A

SEPARATE THE UPPER CSP 32 AND RISER 30
FROM THE LOWER CSP 34 IN RESPONSE TO
ACTUATING EJECTOR DEVICE 74

ACTUATING BLIND RAM 56 TO SEAL FLOW
THROUGH THE BORE 40 OF LOWER CSP 34

INJECT METHANOL 76 INTO LOWER CSP 34
TO PREVENT HYDRATE FORMATION

CLOSE VENT SYSTEM 64

PERFORM A FORMATION STABILITY TEST
HIGH ENERGY TUBULAR SHEAR

SUMMARY

[0001] According to one or more embodiments, a high energy tubular shear is connectable within a drilling system and includes a body forming a bore through which a tubular is disposed, a cross-bore intersecting the bore, opposing cutters moveably positioned in the cross-bore on opposite sides of the bore, and the each cutter in hydraulic communication with a respective hydraulic intensifier. Each cutter may be hydraulically connected to a respective two or more hydraulic intensifier. According to at least one embodiment, each cutter is disposed on a ram having a piton and a retraction chamber is formed in the body between the piston and the cutter. According to one or more embodiments, a dual-mode chamber disposed between a high pressure end of the hydraulic intensifier and the piston of the cutter. The cutters may be positioned between laterally spaced apart opposing backing plates that are located in the cross-bore and extend across the bore.

[0002] A subsea well system according to one or more embodiments includes a safiny assembly interconnecting a lower safiny assembly to an upper safiny assembly, the lower safiny assembly connected to a blowout preventer stack on a subsea well and the upper safiny assembly connected to a marine riser; the lower safiny assembly has lower slips to engage a tubular suspended in a bore formed through the lower and the upper safiny assemblies; the upper safiny assembly has upper slips operable to engage the tubular; and a high energy tubular shear positioned between the upper slips and the lower slips, the high energy tubular shear operable to shear the tubular, wherein the high energy tubular shear includes a body forming the bore through which the tubular is disposed, a cross-bore intersecting the bore opposing cutters moveably positioned in the cross-bore on opposite sides of the bore; and the each cutter in hydraulic communication with a respective hydraulic intensifier.

[0003] The foregoing has outlined some features and technical advantages in order that the detailed description of the high energy tubular shear that follows may be better understood. Additional features and advantages of the high energy tubular shear will be described hereinafter which form the subject of the claims of the invention. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in limiting the scope of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] The disclosure is best understood from the following detailed description when read with the accompanying figures. It is emphasized that, in accordance with standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of various features may be arbitrarily increased or reduced for clarity of discussion.

[0005] FIGS. 1 and 2 illustrate a subsea safety system according to an embodiment incorporating the high energy tubular shear.

[0006] FIG. 3 illustrates a high energy tubular shear installed in subsea well casing assembly according to one or more embodiments.

[0007] FIG. 4A-4B is a flow chart of a subsea well safiny sequence according to one or more embodiments.

[0008] FIG. 5 illustrates a high energy tubular shear in a retracted position in accordance to one or more embodiments.

[0009] FIG. 6 illustrates the high energy tubular shear in an extended position in accordance to one or more embodiments.

[0010] FIG. 7 is a schematic diagram of a high energy tubular shear system in accordance to one or more embodiments.

[0011] FIG. 8 is a schematic illustration of a pipe disposed between opposing cutters and backing plates of a high energy tubular shear in accordance to one or more embodiments.

DETAILED DESCRIPTION

[0012] It is to be understood that the following disclosure provides many different embodiments, or examples, for implementing different features of various embodiments. Specific examples of components and arrangements are described below to simplify the disclosure. These are, of course, merely examples and are not intended to be limiting. In addition, the disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed. Moreover, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed interposing the first and second features, such that the first and second features may not be in direct contact.

[0013] In this disclosure, “hydraulically coupled” or “hydraulically connected” and similar terms, may be used to describe bodies that are connected in such a way that fluid pressure may be transmitted between and among the connected items. The term “in fluid communication” is used to describe bodies that are connected in such a way that fluid can flow between and among the connected items. It is noted that hydraulically coupled may include certain arrangements where fluid may not flow between the items, but the fluid pressure may nonetheless be transmitted.

[0014] FIG. 1 is a schematic illustration of a subsea well safiny system, generally denoted by the numeral 10, being utilized in a subsea well drilling system 12. In the depicted embodiment drilling system 12 includes a BOP 14 which is landed on a subsea wellhead 16 of a well 18 (i.e., wellbore) penetrating seafloor 20. BOP stack 14 conventionally includes a lower marine riser package (“LMRP”) 22 and blowout preventers (“BOP”) 24. The depicted BOP stack 14 also includes subsea test valves (“SSTV”) 26. As will be understood by those skilled in the art with benefit of this disclosure, BOP stack 14 is not limited to the devices depicted.

[0015] Subsea well safiny system 10 comprises safiny package, or assembly, referred to herein as a catastrophic safiny package (“CSP”) 28 that is landed on BOP system 14 and operationally connects a riser 30 extending from platform 31 (e.g., vessel, rig, ship, etc.) to BOP stack 14 and thus well 18. CSP 28 comprises an upper CSP 32 and a lower CSP 34 that are adapted to separate from one another in response to initiation of a safiny sequence thereby disconnecting riser 30 from the BOP stack 14 and well 18, for example as illustrated in FIG. 2. The safiny sequence is initiated in response to parameters indicating the occurrence of a failure in well 18 with the potential of leading to a blowout of the well. According to one or more embodiments, subsea well safiny system
In this embodiment, vent system 64 comprise vent valves (e.g., ball valves) 66a, choke valves 66b, and one or more connection mandrels 68. Valves 66b can be utilized to control fluid flow through connection mandrels 68. For example, a recovery riser 126 is depicted connected to one of mandrels 68 for flowing effluent from the well and/or circulating a kill fluid (e.g., drilling mud) into the well as further described below.

In the depicted embodiment, lower CPS 34 further comprises a deflector device 70 (e.g., impingement device, shutter ram) disposed above vent system 64 and below lower slips 60, high energy shear 58, and blind rams 56. Lower CPS 34 includes a plurality of hydraulic accumulators 50 that are arranged and connected in one or more lower hydraulic pods 62 for operations of various devices of CPS 28. As will be further described below, CPS 28, in particular lower CPS 34, may include methanol, or other chemical, source 76 operationally connected for injecting into lower CPS 34, for example to prevent hydrate formation.

Upper CPS 32 and lower CPS 34 are detachably connected to one another by a connector 72. An ejector device 74 (e.g., ejector bollards) are operationally connected between upper CPS 32 and lower CPS 34 to separate upper CPS 32 and riser 30 from lower CPS 34 and BOP stack 14 after connector 72 has been actuated to the unlocked position. CPS 28 also includes a plurality of sensors 84 which can sense various parameters, such as and without limitation, temperature, pressure, strain (tensile, compression, torque), vibration, and fluid flow rate. Sensors 84 further includes, without limitation, erosion sensors, position sensors, and accelerometers and the like. Sensors 84 can be in communication with one or more control and monitoring systems, for example as further described below, forming a limit state sensor package.

CPS 28 has a control system 78 which may be located subsea, for example at CPS 28 or at a remote location such as at the surface. Control system 78 may comprise one or more controllers which are located at different locations. For example, in at least one embodiment, control system 78 comprises an upper controller 80 (e.g., upper command and control data bus) and a lower controller 82 (e.g., lower command and controller bus). Control system 78 may be connected via conductors (e.g., wire, cable, optic fibers, hydraulic lines) and/or wirelessly (e.g., acoustic transmission) to various subsea devices and to surface (i.e., drilling platform 31) control systems. Each of upper and lower controllers 80, 82 may comprise a collection of real-time computer circuitry, field programmable gate arrays (FPGA), I/O modules, power circuitry, power storage circuitry, software, and communications circuitry. One or both of upper and lower controller 80, 82 may comprise control valves.

According to at least one embodiment, one of the controllers, for example lower controller 82, serves as the primary controller and provides command and control sequencing to various subsystems of safing package 28 and/or communicates commands from a regulatory authority for example located at the surface. Upper controller 80 is described herein as operationally connected with a plurality of sensors 84 positioned throughout CPS 28 and may include sensors connected to other portions of the drilling system, including along riser 30, at wellhead 16, and in well 18. Upper controller 80, using data communicated from sensors 84, continuously monitors limit state conditions of drilling system 12. If a defined limit state is exceeded an activation signal (e.g., alarm) can be transmitted to the surface and/or lower
controller 82. A safing sequence may be initiated automatically by control system 78 and/or manually in response to the activation signal.

[0026] With reference to FIGS. 4A and 4B, a safing sequence 86 according to one or more embodiments of subssea well safing system 10 is disclosed. In sequence step 88, the safing sequence is initiated in response to monitoring the limit state sensor 84 package by upper controller 80. In sequence step 90, pressure is vented from CSP 28 by opening a valve 66A in vent system 64. In sequence step 92, the choke and kill lines are closed. In sequence step 94, the wellhead 16 connector lock is pressurized to prevent accidental ejection of BOP stack 14 from wellhead 16. In sequence step 96, fluid flow from the well is diverted, e.g., partially diverted, to the open vents to prevent erosion of CSP elements such as the slips 48, 60. For example, fluid flow may be diverted by operating a deflection device 70 to a closed position. In sequence step 98, tubular 38 is secured in lower CSP 34 by closing lower slips 60. In sequence step 100, tubular 38 is secured in upper CSP 32 by closing upper slips 48. In sequence step 102, tubular 38 is sheared in lower CSP 34 by activating high energy shear 58. In sequence step 104, upper CSP 32 and lower CSP 34 are disconnected from one another by operating CSP connector 72 to a disconnected position, see, e.g., FIG. 3. In sequence step 106, riser 30 and upper CSP 32 are separated (e.g., ejected) from lower CSP 34 and BOP stack 14 by activating ejection device 74 (i.e., ejection bollards), see, e.g., FIG. 3. In sequence step 108, blind mains 56 are closed to shut-off fluid flow from BOP stack 14 through bore 40 and escaping to the environment. In sequence step 110, treating hydrate formation in lower CSP 34 by injecting methanol. In sequence step 112, closing the vents 66A opened in vent system 64 in sequence step 90. In sequence step 114, a formation stability test is performed.

[0027] Sequence step 102 according to one or more embodiments of subssea well safing system 10 is now described. After tubular 38 is engaged and secured respectively in upper CSP 32 (i.e., by slips 48) and lower CSP 34 (i.e., slips 60), lower controller 82 actuates high energy shear 58 thereby shearing tubular 38 between upper slips 48 and lower slips 60. According to one or more embodiments, high energy shear 58 can apply a force of 12 million pounds-force or more.

[0028] FIGS. 5 and 6 illustrate a high energy shear 58 in accordance to one or more embodiments in isolation. FIG. 7 is a schematic diagram of a hydraulic circuit of a high energy shear 58 utilized in a well system 12. FIG. 8 illustrates a tubular 38 in the process of being severed by high energy shear 58. High energy shear 58 and an example of operation are now described with reference to FIGS. 1-8.

[0029] High energy shear 58 includes a body 1010 forming a bore 40 through which a tubular 38 FIGS. 1-3) is disposed for example during wellbore drilling, completion, and testing. A cross-bore 1012 interconnecting bore 40 is formed by body 1010. Cutters 1014 (e.g., blades) are moveably positioned in the opposing branches of cross-bore 1012 such that cutters 1014 are opposing one another on opposite sides of bore 40. For example, a left cutter 1014 is disposed in the left branch or side of cross-bore 1012 and right cutter 1014 is disposed in the right branch or side of cross-bore 1012.

[0030] Cutters 1014 can be positioned between opposing backing plates 1015 (see, e.g., FIG. 8) to take the cutting force (e.g., 12 million pounds) generated when cutting a tubular 38 with high energy shear 58. For example, with reference in particular to FIG. 8, opposing backing plates 1015 are spaced laterally apart and are positioned in cross-bore 1012 and extend across bore 40. According to some embodiments, cutters 1014 extend laterally the width between opposing backing plates 1015.

[0031] Each cutter 1014 is mounted on a ram 1016 (i.e., rod) carrying a piston 1018. Piston 1018 is spaced a distance away from cutter 1014 such that a retraction chamber 1020 is formed in cross-bore 1012. Each retraction chamber 1020 is in selective hydraulic communication through a respective fill port 1022 with a hydraulic system represented by hydraulic accumulator 50. With reference to FIG. 7, hydraulic communication is provided through a retraction valve 1024 and power valve 1042 to retract cutters 1014 from the extended or shearing position depicted in FIG. 6 and to the retracted position of FIG. 5.

[0032] Each side of cross-bore 1012 is in hydraulic communication with a respective hydraulic intensifier 1026. In the depicted embodiment, two hydraulic intensifiers 1026 are in hydraulic communication with each side of cross-bore 1012. As will be understood by those skilled in the art with benefit of this disclosure, only one or both intensifiers 1026 of a respective pair of intensifiers may be activated to motivate the respective cutter 1014. Hydraulic intensifier 1026 has a low pressure piston 1028 and a high pressure piston 1030. Low pressure piston 1028 is in fluid communication with hydraulic source 50 via shear line 1032 and shear control valve 1034. A relief line 1036 is in hydraulic communication with intensifier 1026 between pistons 1028, 1030 to relieve back pressure.

[0033] A chamber 1038, also referred to as a dual mode chamber 1038, is located on the opposite side of cutter piston 1018 from retraction chamber 1020 and between cutter piston 1018 and high pressure piston 1030 of the respective intensifier 1026. Dual mode chamber 1038 is in hydraulic communication with system hydraulic pressure (e.g., hydraulic accumulator 50) through a valve 1040. Valve 1040 is closed, isolating dual mode chamber 1038 from the system hydraulic pressure during shear operations. Valve 1040 is open during fill operations and when cutters 1014 are being retracted and hydraulic fluid pressure is being applied to retraction chamber 1020. According to embodiments, valve 1040 may have a remote operated vehicle interface to operate valve 1040 manually from ROV 124 (FIG. 2).

[0034] In operation, system hydraulic pressure and fluid volume may be applied and supplied for example from hydraulic accumulator 50 through valve 1040 into dual mode chamber 1038 to fill the chamber 1038 and extend cutters 1014 from the retracted position (FIG. 5) into contact (FIG. 8) with tubular 38. Valve 1040 can be then closed and dual mode chamber is changed to cutting pressure. Application of hydraulic pressure via intensifiers 1026 urges opposing cutters 1014 to the fully extended position as shown for example in FIG. 6. In the instance that tubular 38 is thick pipe or a tool joint is positioned between the cutters, cutters 1014 act to first nick and weaken tubular 38. The continued movement cutters 1014 toward one another crushes and severs tubular 38. Upon cutting of tubular 38, cutters 1014 come into contact with one another as illustrated for example in FIG. 6.

[0035] The foregoing outlines features of several embodiments so that those skilled in the art may better understand the aspects of the disclosure. Those skilled in the art should appreciate that they may readily use the disclosure as a basis for designing or modifying other processes and structures for
carrying out the same purposes and/or achieving the same
advantages of the embodiments introduced herein. Those
skilled in the art should also realize that such equivalent
constructions do not depart from the spirit and scope of the
disclosure, and that they may make various changes, substi-
tutions and alterations herein without departing from the
spirit and scope of the disclosure. The scope of the invention
should be determined only by the language of the claims
that follow. The term "comprising" within the claims is intended
to mean "including at least" such that the recited listing of
elements in a claim are an open group. The terms "a," "an"
and other singular terms are intended to include the plural
forms thereof unless specifically excluded.

What is claimed is:

1. A subsea well system, comprising:
a safing assembly connector interconnecting a lower safing
assembly to an upper safing assembly, the lower safing
assembly connected to a blowout preventer stack on a
subsea well and the upper safing assembly connected to
a marine riser;
the lower safing assembly comprising lower slips to engage
tubulars suspended in a bore formed through the lower
and the upper safing assemblies;
the upper safing assembly comprising upper slips operable
to engage the tubular; and
a high energy tubular shear positioned between the upper
slips and the lower slips, the high energy tubular shear
comprising:
a body forming the bore through which the tubular is
disposed;
a cross-bore intersecting the bore;
apposing cutters moveably positioned in the cross-bore on
opposite sides of the bore; and
the each cutter in hydraulic communication with a respec-
tive hydraulic intensifier.

2. The system of claim 1, wherein the each cutter is in
hydraulic communication with a respective two hydraulic
intensifiers.

3. The system of claim 1, comprising:
the each cutter disposed on a ram having a piston; and
a retraction chamber is formed in the body between the
piston and the cutter.

4. The system of claim 1, further comprising:
the each cutter disposed on a ram having a piston;
a retraction chamber formed in the body between the piston
and the cutter; and
a chamber disposed between a high pressure end of the
intensifier and the piston of the respective cutter.

5. The system of claim 4, wherein the each cutter is in
hydraulic communication with a respective two hydraulic
intensifiers.

6. The system of claim 1, further comprising laterally
spaced apart opposing backer plates located in the cross-
bore and extending across the bore, wherein the opposing
cutters are positioned between the opposing backer plates.

7. The system of claim 6, further comprising:
the each cutter disposed on a ram having a piston;
a retraction chamber formed in the body between the piston
and the cutter; and
a chamber disposed between a high pressure end of the
intensifier and the piston of the respective cutter.

8. The system of claim 6, wherein the each cutter is in
hydraulic communication with a respective two hydraulic
intensifiers.

9. The system of claim 8, further comprising:
the each cutter disposed on a ram having a piston;
a retraction chamber formed in the body between the piston
and the cutter; and
a chamber disposed between a high pressure end of the
intensifier and the piston of the respective cutter.

10. A tubular shear connectable within drilling system,
comprising:
a body forming a bore through which a tubular is disposed;
a cross-bore intersecting the bore;
apposing cutters moveably positioned in the cross-bore on
opposite sides of the bore; and
the each cutter in hydraulic communication with a respec-
tive hydraulic intensifier.

11. The device of claim 10, wherein the each cutter is in
hydraulic communication with a respective two hydraulic
intensifiers.

12. The device of claim 10, comprising:
the each cutter disposed on a ram having a piston; and
a retraction chamber is formed in the body between the
piston and the cutter.

13. The device of claim 10, further comprising:
the each cutter disposed on a ram having a piston;
a retraction chamber formed in the body between the piston
and the cutter; and
a chamber disposed between a high pressure end of the
intensifier and the piston of the respective cutter.

14. The device of claim 13, wherein the each cutter is in
hydraulic communication with a respective two hydraulic
intensifiers.

15. The device of claim 13, further comprising laterally
spaced apart opposing backer plates located in the cross-
bore and extending across the bore, wherein the opposing
cutters are positioned between the opposing backer plates.

16. The device of claim 15, further comprising:
the each cutter disposed on a ram having a piston;
a retraction chamber formed in the body between the piston
and the cutter; and
a chamber disposed between a high pressure end of the
intensifier and the piston of the respective cutter.

17. A subsea well safing sequence, comprising:
utilizing a safing assembly installed between a blowout
preventer stack of a subsea well and a marine riser, the
safing assembly comprising a lower safing assembly
connected to the blowout preventer stack and an upper
safing assembly connected to the marine riser forming a
bore between the riser and the blowout preventer stack;
securing a tubular suspended in the bore at a position in the
lower safing assembly;
securing the tubular at a position in the upper safing assem-
bly;
utilizing a high energy shear having a tubular extending
through a bore into a wellbore, the high energy shear
comprising:
a body forming the bore through which the tubular is
disposed;
a cross-bore intersecting the bore;
apposing cutters moveably positioned in the cross-bore on
opposite sides of the bore; and
the each cutter in hydraulic communication with a respec-
tive hydraulic intensifier;
applying a hydraulic pressure to the respective hydraulic
intensifiers;
moving the cutters toward each other in response to the application of hydraulic pressure to the respective hydraulic intensifiers; and shearing the tubular in response to moving the cutters toward each other.

18. The method of claim 17, wherein the high energy shear further comprises:
   the each cutter disposed on a ram having a piston;
   a retraction chamber formed in the body between the piston and the cutter; and
   a dual-mode chamber disposed between a high pressure end of the hydraulic intensifier and the piston of the respective cutter.

19. The method of claim 17, wherein the high energy shear further comprises laterally spaced apart opposing backing plates located in the cross-bore and extending across the bore, wherein the opposing cutter are positioned between the opposing backing plates.

20. The method of claim 17, further comprising moving the cutters from a retracted position into contact with the tubular before applying the hydraulic pressure to the respective hydraulic intensifiers.

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