

REPLACEABLE WEAR PLATES FOR USE WITH BLIND SHEAR RAMS

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] This technology relates generally to well drilling. In particular, this technology relates to a shear ram assembly for a blowout preventer (“BOP”) that has wear plates designed to adjust the relative position of ram blocks so that blades of the ram blocks can better shear ductile items, such as wireline, coiled tubings, etc.

2. Brief Description of Related Art

[0002] Offshore drilling rigs typically employ a riser to connect the subsea wellhead with the drilling rig. A BOP is located at a lower end of the riser. Land rigs also use BOPs. A BOP is a large assembly having many features for closing around a drill pipe and/or casing in the event that high pressure in the wellbore begins pushing the drilling mud upward. Those features include an annular assembly that seals around the pipe, regardless of the diameter. In addition, the BOP has pipe shear ram assemblies that will shear a drill pipe string or a production tubing string in the event of an emergency.

[0003] Pipe shear ram assemblies typically have two rams, each of which has a blade mounted to it. Pistons move the rams toward each other to shear pipe and other items extending through the BOP. Generally, one blade is located at a higher elevation than the other, and the higher blade slides over the lower blade when the shear rams close. This difference in elevation creates a gap between the blades.

[0004] One problem with known shear ram assemblies is that the blades may not shear everything in the well bore. For example, because there is a gap between the blades, items that are ductile or flexible may simply bend between the blades, rather than cut. Thus, even after the ram blocks are closed and the blades have deployed, ductile items like wiring or flexible tubing may still be intact.

SUMMARY OF THE INVENTION

[0005] Disclosed herein is a pipe shear ram assembly for use in a BOP that in one example includes upper and lower ram blocks having blades. The ram blocks are designed to be positioned on opposite sides of a well bore so that the pipe string, and other more ductile items, such as wiring, pass between the blades of the ram blocks. In the event of an emergency, the ram blocks close by moving toward one another so that the blades pass over one another. As the blades pass over one another, they shear the pipe string and other items in the wellbore, and then seal the wellbore. Generally, as the blades of the upper and lower ram blocks pass over one another, there is a vertical gap between the blades.

[0006] In an example embodiment, the pipe shear ram assembly disclosed herein includes a pair of pipe guide arms that are mounted to the upper ram block and are positioned to enter corresponding recesses in the lower ram block as the ram blocks close. In this example, the pipe shear arms are located in an outboard position relative to the blades and have a wedge-shaped inboard profile. One purpose of the pipe guide arms is to direct piping or other items located on the edges of the wellbore into the path of the blades to be cut.

[0007] Wear plates may be attached to the upper surfaces of the pipe guide arms. The wear plates are positioned so that their top surfaces are higher than the tops of the recesses on the lower ram block. As the ram blocks close, therefore, and the pipe guide arms, along with the

wear plates, enter the recesses, the lower ram block is forced to rise so that the recesses can accept the wear plates. As the lower ram block rises, so does the blade attached to the lower ram block. Thus, the gap between the blades of the upper and lower ram blades is reduced. The edges of either the recesses or the wear plates may be chamfered to allow entry of the wear plates into the recesses.

BRIEF DESCRIPTION OF THE DRAWINGS

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

[0009] Figure 1 is a perspective view of the ram blocks of a shear ram assembly in accordance with this disclosure;

[0010] Figure 1A is a perspective view of the ram blocks of Fig. 1, with the ram blocks substantially closed around pipe and ductile items;

[0011] Figure 2 is a side view of the ram blocks of Fig. 1;

[0012] Figure 3 is a bottom perspective view of the ram blocks of Fig. 1;

[0013] Figure 4 is a front view of the upper ram block of Fig. 1;

[0014] Figure 5 is a top view of the upper ram block of Fig. 1; and

[0015] Figure 6 is a perspective view of the ram blocks of Fig. 1 installed within a subsea BOP assembly.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0016] The foregoing aspects, features, and advantages of the present invention 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 invention illustrated in the appended drawings, specific terminology will be used for the sake of clarity. However, the invention 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.

[0017] Referring to Fig. 1, shear rams 10 are shown removed from the housing or bonnet (not shown) in which they are located. Shear rams 10 are part of a ram BOP assembly that is part of a stack assembly. In the case of offshore drilling, the stack assembly is located at the lower end of a riser extending downward from a drilling vessel. The lower end of the BOP stack assembly will normally also contain pipe rams, variable bore rams, and a quick disconnect mechanism for disconnecting from the riser in an emergency. When actuated, shear rams 10 will close the through bore and also shear pipe and other items in the well, such as, for example, drill pipe, tubing, casing, or wiring.

[0018] In the example of Fig. 1, shear rams 10 include a generally planar upper ram block 12 having a lateral surface that defines a face or forward end 14. A semicircular groove 16 is located on the upper side of upper ram block 12 for receiving a portion of an elastomeric seal. An upper shearing blade 18 mounts to forward end 14, by any appropriate means, such as, for example, by fasteners 74. Upper blade 18 has a forward face 20 with an upper edge 22 and a lower edge 24. For purposes of this disclosure, the term forward, with reference to the ram blocks and associated components, shall mean in a lateral direction from face 20 and away from end 14. In the example of Fig. 1, the lower edge 24 extends farther forward from forward end 18 than upper edge 22, resulting in face 20 inclining relative to forward end 14. Face 20 is also generally concave or converging, resulting in the center of face 20 between its outboard ends 26

being recessed relative to the more forward portions of face 20 at outboard ends 26. A variety of different shapes for upper blade 18 may be employed.

[0019] Pipe guide arms 28 are elongate members shown located on the outboard sides of upper ram block forward end 14 and projecting generally forward away from end 14. In one embodiment, the pipe guide arms 28 are similar to those disclosed in U.S. Patent Appln. No. 13/339,519, which is hereby incorporated herein by reference. Each arm 28 can be formed integrally with upper ram block 12, or can be otherwise attached, such as by welding or fasteners. Each arm 28 has a vertically oriented inboard side 30 extending forward from a base 32 of each arm 28. Base 32 is where arm 28 joins forward end 14. Each arm 28 also has a wedge surface 34 that extends from a junction with a forward end of inboard side 30 to a tip 38, and an upper surface 36. The wedge surface 34 depends laterally inward with distance away from the tip 38. As shown in Fig. 2, upper surface 36 is spaced at a lower elevation on upper ram block forward end 14 than upper blade lower edge 24. Upper surface 36 is not located directly under upper blade 18 in this example because inboard side 30 of each arm 28 is approximately the same outboard distance as one of the upper blade outboard ends 26, as shown, e.g., in Fig. 5. Also, Figs. 2 and 5 illustrate that tip 38 extends forwardly more than upper blade 18 from forward end 14. The junction of inboard side 30 with wedge surface 34 is approximately in vertical alignment with the junction of upper shear blade upper edge 22 and outboard end 26. One purpose of the arms 28 is to guide a pipe (not shown) and other, more ductile items, in an inboard direction toward the blades. A wear plate 52 is optionally attached to the top surface of each arm 28, as discussed in greater detail below.

[0020] Referring again to Fig. 1, a substantially planar lower ram block 40 is illustrated in horizontal alignment with upper ram block 12. Lower ram block 40 has a forward end 42 that is

parallel to forward end 14 of upper ram block 12. A top seal groove 44 in the upper side of lower ram block 40 receives an elastomeric seal and aligns with seal groove 16 to form a continuous seal when ram blocks 12, 40 are in abutment with each other. The seal is not necessarily circular. On its upper surface, lower ram block 40 has a sheared pipe end recess 46 for receiving the lower end of well pipe and ductile items after shearing. Sheared pipe end recess 46 has a curved rear wall portion 48 that blends with two straight side wall portions 50. Other shapes are feasible.

[0021] A lower blade 54 is attached to forward end 42 of lower ram block 40. Lower blade 54 is at a lower elevation than upper blade 18, as illustrated in Fig. 2. Lower blade 54 slides under upper blade 18 when shearing. An upper edge 56 of lower blade 54 is at a slightly lower elevation than lower edge 24 of upper blade 18. Lower blade 54 has a lower edge 58 that is closer to lower block forward end 42 than the upper edge 56. A face 60 extends between lower edge 58 and upper edge 56 and is thus inclined relative to forward end 42. As illustrated in Fig. 2, in this example, the inclination of lower blade face 60 is the same as the inclination of upper blade face 20. Lower blade face 60 also recesses or converges to a central area that is closer to lower block forward end 42 than the outboard ends 62 of lower blade 54, as shown in Fig. 1. The length of lower blade 54 from one outboard end 62 to the other is the same as the length of upper blade 18 from one outboard end 26 to the other.

[0022] Referring to Fig. 3, which shows the bottom of shear rams 10, a recess 64 is located on lower shear block 40 along each outboard side outward and rearward from lower blade outboard ends 62. Each recess 64 has a space or clearance provided along an outboard side to receive one of the arms 28 when ram blocks 12, 40 are closed. Each recess 64 is defined by a downward-facing upper side wall 66 and an inboard sidewall 68, sidewalls 66 and 68 being flat and

perpendicular in this example. Each recess 64 is aligned with one of the arms 28 to receive the arm when in the closed, or sheared position. Each recess 64 has a greater longitudinal length than the length of each arm 28. Also, upper side wall 66 has a greater width than that of each arm 28, and inboard side wall 68 has a greater height than the height of each arm 28. Recess 64 need not be a closed cavity, and in the example shown has no outboard side wall or bottom side wall.

[0023] Referring to Figs. 1 and 2, the wear plates 52 may be attached to the arms 28 in any appropriate manner, such as, for example, by welding, adhesive, or mechanical fasteners. In an alternative embodiment, the wear plates 52 may be formed integral with the arms 28. Each wear plate 52 has a thickness sufficient that the top 70 of each wear plate 52 is slightly higher than the upper side wall 66 of the recesses 64 when the ram blocks 12, 40 are open. Thus, when the ram blocks 12, 40 close, the wear plate 52 comes into contact with the upper side wall 66 of the recess 64 and forces the lower ram block 40 to raise. As the lower ram block 40 raises, the lower blade 54 raises relative to the upper blade 18, so that the vertical gap between the blades 18, 54 is reduced. A forward edge 72 of the recess 64 is chamfered (as shown in Figs. 2 and 3) to enable the wear plate 52 to slide into recess 64 as the ram blocks 12, 40 close. Alternatively, the forward edge of the wear plate may be chamfered for the same purpose. In yet another embodiment, the arms 28 may be positioned so that the upper surface 36 of the arms 28 themselves contact the upper side wall 66 of the recess 64, thereby forcing the ram block 40 to raise. In such an embodiment, wear plates 52 may not be necessary.

[0024] Figure 1A shows the upper and lower ram blocks 12, 40 in a substantially closed position around pipe 100 and ductile items 102, such as, for example, flexible tubing or wiring. Arms 28, including wear plates 52, are shown partially engaged with recess 64. As can be seen, upper and

lower blades 18, 54 have substantially passed over each other, shearing both the pipe 100 and the ductile items 102.

[0025] One advantage to the use of wear plates 52 to narrow the gap between the upper and lower blades 18, 54 is that, as shown in Fig. 1A, the rams 12, 40 are able to better shear ductile items. For example, in embodiments that do not include the wear plates 52, the vertical offset between the upper end 56 of the lower blade 54 and the lower end 24 of the upper blade 20 may be great enough that ductile items will not sever, but will merely bend, or flex, in the gap between the blades as the blades close. However, with the wear plates 52 in place, such as shown in Fig. 1A, the gap between the blades is substantially decreased so that even ductile items will be severed, having no room to bend. In one example embodiment, the vertical distance between the upper end 56 of the lower blade 54 and the lower end 24 of the upper blade 20 when the wear plates 52 are not in place is about 0.020 inch. Conversely, in embodiments with the wear plates 52, the vertical offset between the blades is reduced to a range of less than about 0.020 inch, and in the range of about 0.003 inch or less to about 0.008 inch.

[0026] Figure 4 is a front view of the upper ram 12 according to an embodiment of the present technology. In particular, Fig. 4 shows wear plates 52 attached to the upper surface 36 of each arm 28. Figure 5 similarly shows a top view of the upper ram 12 having wear plates 52 attached to the arms 28. Figures 4 and 5 also show the position of the arms 28 relative to the blade 18 of the upper ram 12. For example, Figs. 4 and 5 show that the wear plates 52 are positioned lateral to the upper ram blade 18 so that they do not interfere with the path of the blade 18 as the rams 12, 40 close. Although the wear plates 52 are shown to be rectangular in shape, they may alternatively be a different shape, as long as the top 70 of each wear plate 52 is configured to

contact the upper side wall 66 of the recess 64 and raise the lower ram block 40 relative to the upper ram block 12, as described above.

[0027] Referring to Fig. 6, shear rams 10 are shown installed in a typical subsea BOP assembly. The BOP assembly has a BOP stack 76 that includes a frame 78 with a wellhead connector 80 at the lower end for connecting to a subsea wellhead assembly (not shown). Shear rams 10 are normally located above pipe rams, which in this example include pipe rams 82, 84, and 86. Each pipe ram 82, 84, and 86 has rams with semi-cylindrical recesses on the mating faces for closing around a different size range of pipe. When closed, shear rams 10 will seal off the bore and if pipe and/or other items are present, will shear the pipe and other items.

[0028] A lower marine riser package (LMRP) 88 connects to the upper end of BOP stack 76. An annular BOP 90 may be located at the lower end of LMRP 88. Annular BOP 90 will close around any size of pipe and seal the annulus between the pipe and the side wall of the bore. Annular BOP 90 will also seal fully even if a pipe is not present. A flex joint 92 is located at the upper end of LMRP 88 to allow flexing of a lower end of a riser string 94 connected to flex joint 92. Choke and kill lines 96 extend from below annular blowout preventer 90 to alongside riser 94 for pumping fluid into the well. In the event of an emergency, LMRP 88 and riser 94 can be detached from BOP stack 76. Redundant control pods 98 mount LMRP 88 and contain hydraulic and electrical circuitry for controlling movement of the various rams 10, 82, 84, 86, the annular BOP 90, and other equipment. Control pods 98 are retrievable from LMRP 88 and are connected to an umbilical (not shown) leading to the drilling vessel at the surface.

[0029] 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 technology. Furthermore, it is to be understood that the

above disclosed embodiments are merely illustrative of the principles and applications of the present technology. 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 technology as defined by the appended claims.

What is claimed is:

1. A shear ram assembly for shearing a pipe and ductile items, comprising:

first and second ram blocks positioned adjacent the pipe and ductile items, and on opposite sides thereof, the first and second ram blocks arranged to close around the pipe and ductile items;

first and second blades attached respectively to the first and second ram blocks and positioned so that as the first and second ram blocks close around the pipe and the ductile items, the blades pass over one another and shear the pipe and the ductile items;

at least one recess in the second ram block;

at least one arm attached to the first ram block that inserts into the at least one recess when the first and second ram blocks close; and

at least one plate positioned on the at least one arm, so that when the arm inserts in to the at least one recess, the wear plate slides against a surface of the recess and orients the blades at a maximum distance apart.

2. The shear ram assembly of claim 1, wherein the blades are separated by a distance of about 0.003 inch to about 0.008 inch when closed.

3. The shear ram assembly of claim 1, wherein the wear plates are attached to the arms by a means selected from the group consisting of welding, adhering, and fastening with mechanical fasteners.

4. The shear ram assembly of claim 1, wherein a distance from a lower surface of the first blade to an upper surface of the wear plate exceeds a distance from a lower facing surface of the recess to an upper surface of the second blade by a designated amount.

5. The shear ram assembly of claim 1, wherein the edges of the recesses are chamfered to allow the wear plates to enter the recesses as the upper and lower ram blocks close.
6. The shear ram assembly of claim 1, wherein the edges of the wear plates are chamfered to allow the wear plates to enter the recesses as the upper and lower ram blocks close.
7. The shear ram assembly of claim 1, wherein the blade of the upper ram block is attached to a forward end of the upper ram block, and has a face, an upper edge, and a lower edge, and wherein the lower edge extends farther forward from the forward end than the upper edge, so that the face is inclined relative to the forward end of the upper ram block.
8. The shear ram assembly of claim 7, wherein the blade of the upper ram block has outboard ends that extend farther forward from the forward end than a central portion of the blade, so that the face of the blade has a generally concave configuration.
9. The shear ram assembly of claim 1, wherein the arms are attached to the upper ram block by means selected from the group consisting of welding, adhering, and mechanical fasteners.
10. The shear ram assembly of claim 1, wherein the arms are integral with the upper ram block.
11. A shear ram assembly for shearing a pipe and ductile items, comprising:
 - first and second ram blocks, each having a blade, and the second ram block defining a recess positioned laterally with respect to the blades, the first and second ram blocks positioned on opposite sides of the pipe and the ductile items, and such that one slides over the other when the first and second ram blocks are moved forward to a closed position, thereby shearing the pipe and the ductile items;
 - a guide arm protruding from the first ram block toward the second ram block and positioned to enter the recess when the first and second ram blocks close, and

a wear plate attached to an upper surface of each guide arm that selectively engages an upper surface of the recess to raise the second ram block upward relative to the first ram block so that any gap between the blades is reduced.

12. The shear ram assembly of claim 11, wherein the gap between the blades is about 0.003 inch to about 0.008 inch when closed.

13. The shear ram assembly of claim 11, wherein the wear plates are attached to the arms by a means selected from the group consisting of welding, adhering, and fastening with mechanical fasteners.

14. The shear ram assembly of claim 11, wherein the wear plates are integral with the arms.

15. The shear ram assembly of claim 11, wherein the edges of the recesses are chamfered to allow the wear plates to enter the recesses as the upper and lower ram blocks close.

16. The shear ram assembly of claim 11, wherein the edges of the wear plates are chamfered to allow the wear plates to enter the recesses as the upper and lower ram blocks close.

17. The shear ram assembly of claim 11, wherein the arms are attached to the upper ram block by means selected from the group consisting of welding, adhering, and mechanical fasteners.

18. The shear ram assembly of claim 11, wherein the arms are integral with the upper ram block.

19. A subsea BOP assembly, comprising:

a BOP stack having a frame with a wellhead connector at a lower end for connecting to a subsea wellhead assembly; and

at least one shear ram attached to the frame for shearing pipe and ductile items extending through the BOP assembly and into the wellhead assembly, the at least one shear ram comprising:

first and second ram blocks positioned adjacent the pipe and ductile items, and on opposite sides thereof, the first and second ram blocks arranged to close around the pipe and ductile items;

first and second blades attached respectively to the first and second ram blocks and positioned so that as the first and second ram blocks close around the pipe and the ductile items, the blades pass over one another and shear the pipe and the ductile items;

at least one recess in the second ram block;

at least one arm attached to the first ram block that inserts into the at least one recess when the first and second ram blocks close; and

at least one plate positioned on the at least one arm, so that when the arm inserts in to the at least one recess, the wear plate slides against a surface of the recess and orients the blades at a maximum distance apart.