ASSEMBLY AND METHOD TO SECURE TUBING STRING TO BLOWOUT PREVENTER

ABSTRACT

A flange assembly and method for securing the downhole tubing string and packer to a blowout preventer is disclosed. The application is particularly useful for high pressure fluid applications downhole such as hydraulic fracturing.
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TECHNICAL FIELD

[0001] This invention relates to oil field operations and in particular, down hole hydraulic fracturing or oftentimes referred to as fracking.

BACKGROUND ART

[0002] Fracking is used to increase production from underground hydrocarbon bearing zones. With the recent development of horizontal drilling, wellbores can now penetrate horizontally within a hydrocarbon bearing zone. Fracking, in simplest terms, is a procedure where fluid is pumped into the wellbore at a rate sufficient to increase pressure down hole to exceed the pressure gradient of the targeted strata. The rock cracks and the fracture fluid continues further into the rock, extending the crack. Typically, a proppant is included with the injected fluid such as grains of sand, ceramic, or other particulars which prevent the fractures from closing when injection is terminated. The strata attempts to return to its original condition but the injected particles prevent complete closure and thus provide pathways for hydrocarbon within the strata to migrate to the wellbore.

[0003] In preparation of a down hole fracking operation, a string of high pressure tubing capable of withstanding high pressures, typically at least 7,000 psi, is lowered into a well directly above the strata to be hydraulically fractured by pumping fluid through the tubing string. The lower portion of the tubing string is anchored in position using a packer. Depending on the packer used, it is set in neutral, tension or compression. For example, if the packer is set in compression, the tubing string is rotated causing the seals of the packer to engage the adjacent casing wall and thereafter the tubing string is lowered so that weight is applied to the packer and the seals firmly engage the casing wall. This requires the tubing string to be lowered possibly several feet at the surface and the actual length required is dependent upon how deep the packer is positioned.

[0004] Because of the high pressures associated with fracking, a blow-out-preventer (BOP) is located at the top of the well, typically bolted to the casing flange which is located at the surface end of the casing. The BOP seals the annular region between the casing and the tubing to prevent gasses or fluids from escaping the well from this annular region.

[0005] A typical fracking operation will involve multiple diesel trucks powering positive displacement pumps. The discharge from these pumps typically connect at a manifold and exit the manifold via a single line connected to the tubing at the top of the BOP.

[0006] Once the packer is set, typical procedure is to apply a backpressure in the annular region between casing and tubing so it is against the topside of the packer. This back-pressure serves as further insurance against packer failure. However, if the downhole packer fails for any reason during the fracking operation, the high down hole pressure can act upon the bottom side of the packer and cause the packer and tubing string to be violently displaced upward out of the well before surface pumps can be shut down. Any sudden and unexpected movement of the tubing string upward can cause a serious safety problem not only for the topside equipment but also for nearby personnel.

SUMMARY OF INVENTION

[0007] My invention provides an added level of protection for on-site service personnel during a fracking operation.

[0008] The invention is a method and the supportive equipment used for securing the tubing string to the BOP so in the event of a packer failure, the tubing string cannot violently displace out of the hole before the fracking pumps can be shut down.

[0009] The invention provides that the tubing string is secured to the BOP to prevent sudden vertical movement of the tubing string and comprises: a) a threaded flange which is secured to the BOP; and, b) a mandrel threadably secured to the threaded flange and which operatively connects to the down hole tubing string and the surface pumps.

[0010] The appearance of the threaded flange can be generally described as a modified weld neck flange. The threaded flange comprises a main body having a plurality of bolt holes passing through the main body and arranged circumferentially and spaced for alignment with corresponding holes on the top flange of a BOP. Preferably, the bottom surface of the threaded flange has an annular groove for receiving a ring gasket which will be disposed between the flange groove and a corresponding groove found on the top flange of the BOP.

[0011] Extending outward from the top surface of the main body of the threaded flange is a neck portion integral with the main body. The neck portion may be either cylindrical or tapered.

[0012] The threaded flange further comprises a central aperture having a first inside diameter passing through the main body and a second inside diameter passing through the neck portion. The first inside diameter is larger than the second inside diameter. The neck portion further comprises a set of female or internal threads for connection to a mandrel which is described below. The central aperture is sufficiently wide to accommodate tubing collars to pass through.

[0013] A mandrel is provided having a first end and a second end with a set of female threads at each end. The set of female threads located at the first end are for operatively connecting to a down hole tubing string and the set of female threads located at the second end are for operatively connecting to surface pumps. The mandrel further comprises a set of male or external threads located at the second end for connection to the set of female threads located within the threaded flange. The mandrel is sized to be slidable receivable within the central aperture of the main body, by inserting the second end of the mandrel into the aperture of the main body so that the male threads of the mandrel can threadably engage the female threads of the neck portion. The outside diameter of the mandrel is therefore larger than the outside diameter of tubing collars used for the tubing string particularly proximal to the BOP.

[0014] Preferably, at least one annular groove is provided in the outside wall of the mandrel for positioning of an O-ring which provides a seal to the inner wall of the threaded flange and permits all types of packers to be utilized down hole, including tension, compression or neutral set packers.

[0015] Also preferably, the outside diameter of the mandrel is substantially uniform from the first end to the second end and having a pre-determined diameter. The crest of the male threads is equivalent to the outside diameter of the mandrel.

[0016] Thus, the mandrel is operably connected on one side to the tubing string below and on the other side operably connected to the fracking pumps. The male set of threads on
the mandrel is threadably connected to the threaded flange which is bolted to the BOP after the packer is set.

By securing the tubing string to the BOP, the seals of the BOP are not subjected to failure as a result of a sudden movement by the tubing string. This eliminates any chance of gasses or fluids escaping the well as a result of BOP failure during high pressure fracking operations; thus protecting the health of the nearby personnel as well as the surrounding environment.

The method of use is as follows and is considered an improvement in flowline assembly for delivering fracturing fluid from surface pumps to the wellbore. In combination with a hydraulic fracturing operation for a well having a hydrocarbon bearing zone and casing string extending up to a surface casing flange, a blowout preventer connected to the casing flange and a tubing string and packer positioned at a predetermined depth within the casing string for the delivery of fluid from surface pumps connected to the tubing string at high pressure, the method for securing the tubing string to the blowout preventer comprising the steps of:

providing the flange and mandrel as described above; operatively connecting the first end of the mandrel to the down hole tubing string; positioning the threaded flange upon the mandrel where the lower surface of the main body of the threaded flange is facing the blowout preventer;

setting the packer at the predetermined depth;

rotating the threaded flange to engage the male threads of said mandrel;

aligning the bolt holes on the threaded flange to the bolt holes on the blowout preventer;

securing the threaded flange to the blowout preventer; and,

operatively connecting the second end of the mandrel to the surface pumps.

A tubing string having a downhole packer is provided for setting the packer at a predetermined depth. The top of the tubing string is operably connected to the mandrel either by direct threaded connection or indirectly using tubing extensions well known in the art. Above the mandrel is typically a short length of tubing for operably connecting to the discharge from the pump trucks or manifold. However, there can be any number of configurations for the flowline from the pumps to the second end of the mandrel. What is to be appreciated is that the mandrel, at the second end, is operatively connected to the pump discharge line and will be threadably connected to the threaded flange once the packer is set. This configuration allows for the tubing string to travel vertically up or down to set either a tension or compression packer and subsequently have the threaded flange rotated to engage the mandrel and finally be bolted to the top flange of the BOP. With the flange resting on top of the mandrel before the packer is set, securement to the BOP is quick; requiring only that threaded flange be rotated into engagement with the mandrel and then bolted to the BOP. This can be accomplished by a single worker and require approximately 20 minutes.

Before the packer is set, the threaded flange does not threadably engage the mandrel although tubing extends not only below but above the threaded flange. Since the inside diameter across the neck portion is sufficiently large to allow tubing collars to pass, this allows the tubing string to be not only raised but lowered as well.

After the packer is set, the male threaded portion of the mandrel should be located above the top flange of the adjacent BOP at a height to permit threadable engagement with the threaded flange by rotating the threaded flange about the mandrel and alignment of the bolt holes with corresponding bolt holes on the BOP. Bolts are then used to secure the threaded flange to the BOP.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded perspective view of the flange assembly connected to a blowout preventer.

FIG. 2 is a side view of the mandrel and connections upstream and downstream.

FIG. 3 is a side view indicating the positioning of threaded flange above the mandrel.

FIG. 4 is a cross-sectional view of the flange assembly and connections upstream and downstream.

FIG. 5 is a side view of threaded flange resting upon the mandrel.

FIG. 6 illustrates the rotation of threaded flange to connect to the mandrel.

FIG. 7 is a cross-sectional view of the final attachment of the flange assembly to the blow out preventer.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The figures are provided for illustration purposes and are not necessarily drawn to scale.

FIG. 1 illustrates an exploded view of my flange assembly. The assembly comprises a threaded flange 12, a mandrel 14, and threaded connections 16 and 18 for operable connections to the surface pumps designated by P and the tubing string TS respectively. In a preferred embodiment, flange assembly 12 can function up to a maximum pressure of at least 8,500 psi.

As can best be viewed looking at both FIG. 1 and FIG. 6, threaded flange 12 comprises a main body 20 having a plurality of bolt holes H passing through the main body and arranged circumferentially and spaced for alignment with corresponding holes H' located on the top flange of a blowout preventer BOP. Preferably, the bottom surface of the threaded flange has an annular groove G for receiving an API ring gasket R/46 R which will be disposed between annular groove G and a corresponding groove G' found on the top flange of the BOP. Threaded flange 12 is rated API Series 6-1500 flange which is bolted down with 12 1 1/2 inch bolts 40 and nuts 42 to the top of the BOP.

Extending outward from the top surface of main body 20 is a neck 22 integral with the main body.

As shown in FIG. 4, threaded flange 12 further comprises a central aperture A having a first inside diameter passing through main body 20 and a second inside diameter passing through neck portion 22. The first inside diameter is larger than the second inside diameter. Neck portion 22 further comprises a set of female square threads 24 for connection to mandrel 14 which is described below. The central aperture is sufficiently wide to accommodate the outside diameter of tubing collars to pass through.

Mandrel 14 comprises a first end and a second end with a set of 8 round N-80 female threads at each end and an outside diameter extending from the first end to the second end. The set of female threads located at the first end are for operatively connecting to a down hole tubing string and the set of female threads 30 located at the second end are for operatively connecting to surface pumps. Mandrel 14 further
comprises a set of male square threads 34 located at the second end for connection to the set of female threads 24 located within threaded flange 12. The crest of male threads 34 is equivalent to the outside diameter. A pair of annular grooves 36 are present in the outer wall of mandrel 14 for placement of respective O-rings 38 which permits use of the mandrel with all types of packers to be utilized down hole, including tension-compression or neutral set packers. Mandrel 14 is sized to be slidably receivable within the central aperture, by inserting the second end of mandrel 14 into the aperture of main body 20 so that male threads 34 can threadably engage female threads 24 as shown in FIG. 4.

[0041] Having described the individual parts comprising my flange assembly, the method for assembly will be discussed.

[0042] Hydraulic fracturing of a well is a procedure well known. Generally, my invention is an improvement over the current flowline configuration for delivering fracking fluid from surface pumps to the wellbore because it prevents upward movement of a tubing string in the event of a packer failure. For a hydraulic fracturing operation of a hydrocarbon bearing zone and casing string extending up to a surface casing flange, a blowout preventer connected to the casing flange and a tubing string and packer positioned at a predetermined depth within the casing string for the delivery of fluid from surface pumps connected to the tubing string at high pressure, the method for securing the tubing string to the blowout preventer will now be explained.

[0043] Because the desired depth for setting a packer may not position the top collar of the tubing string at the optimum position for setting my flange assembly 10 to the BOP, an extension 16 can be used for operably connecting my flange assembly to the down hole tubing string. Extension 16 can comprise one or more tubular parts threaded to one another for connection to the down hole tubing string as illustrated in FIG. 2. As is well known to those having skill in the oilfield services industry, the top collar of the tubing string is held in position using slips (not shown) above the BOP. When the packer is down hole at or near its intended depth, mandrel 14 is operably attached to the tubing string. Extension 16, mandrel 14 and extension 18 are threadably connected in series to the top of the tubing string as illustrated generally in FIG. 3 along with an O-ring R set upon the top surface of the BOP. In a most preferred embodiment, the proximal portion of extension 16 to mandrel 14 is spot welded.

[0044] Threaded flange 12 is then placed over extension 18 and lowered represented by motion L in FIG. 3 until it rests upon the upper edge of male threads 34 of mandrel 14 as shown in FIG. 5 and FIG. 6. The packer is set at a predetermined depth and final movement of the tubing string is made; the direction of which depends upon the type of packer utilized down hole. The final position of the tubing string has the lower surface of mandrel 14 on substantially the same plane as the top surface flange of the surrounding BOP. Next, threaded flange 12 is rotated as represented by X in FIG. 6 into threadable engagement with male threads 34. Rotation continues until the bottom surface of threaded flange 12 contacts the top flange surface of the BOP and bolt holes 11 align with respective holes on the BOP. Threaded flange 12 is thereafter secured to the BOP using bolts 40 and nuts 42 as illustrated in FIG. 7. After flange assembly 10 is secured to the BOP, extension 18 is operably connected to the surface pumping equipment (not shown).

1. A flange assembly for securing a tubing string to a blowout preventer comprising:
   a threaded flange comprising:
   a main body having a lower surface for engagement with the upper flange of a blowout preventer, a plurality of bolt holes passing through the main body and arranged circumferentially and spaced for alignment with corresponding holes on a blowout preventer;
   a neck portion integral with and extending outward from the main body;
   a central aperture having a first inside diameter passing through the main body and a second inside diameter passing through said neck portion, said first inside diameter being larger than said second inside diameter; said neck portion further having a set of female threads; and,
   a mandrel comprising:
   a first end and a second end, an aperture passing through the mandrel, a set of female threads at said first end for operatively connecting to a down hole tubing string and a set of female threads at said second end for operatively connecting to surface pumps, and a set of male threads located at said second end; said mandrel slidably receivable within the central aperture of the main body of said threaded flange where the female threads of said neck portion can threadably engage the male threads of said mandrel.

2. The flange assembly of claim 1 where said mandrel further comprises at least one annular groove.

3. The flange assembly of claim 2 where an O-ring is positioned within each respective at least one annular groove.

4. The flange assembly of claim 1 where said mandrel further comprises a pre-determined outside diameter from said first end to said second end and where the crest of said male threads is equivalent to said pre-determined outside diameter.

5. In combination with a hydraulic fracturing operation for a well having a hydrocarbon bearing zone and casing string extending up to a surface casing flange, a blowout preventer connected to the casing flange and a tubing string and packer positioned at a pre-determined depth within the casing string for the delivery of fluid from surface pumps connected to the tubing string at high pressure, the method for securing the tubing string to the blowout preventer comprising the steps of:
   providing a threaded flange comprising:
   a main body having a lower surface for engagement with the upper flange of a blowout preventer, a plurality of holes passing through the main body and arranged circumferentially and spaced for alignment with corresponding holes on a blowout preventer;
   a neck integral with and extending outward from the main body;
   a central aperture having a first inside diameter passing through the main body and a second inside diameter passing through said neck, said first inside diameter being larger than said second inside diameter; said neck further having a set of female threads; and,
   a mandrel comprising:
   a first end and a second end, an aperture passing through the mandrel, a set of female threads at said first end for operatively connecting to a downhole tubing string and a set of female threads at said second end for operatively connecting to surface pumps, and a set of male threads located at said second end; said mandrel...
slidably receivable within the central aperture of the main body of said threaded flange where the female threads of said neck threadably engage the male threads of said mandrel; operatively connecting the first end of said mandrel to the downhole tubing string; positioning the threaded flange upon said mandrel where the lower surface of said main body is facing the blowout preventer; setting the packer at the pre-determined depth; rotating the threaded flange to engage the male threads of said mandrel; aligning said plurality of holes on the threaded flange to bolt holes on a blowout preventer; securing said threaded flange to said blowout preventer; and, operatively connecting the second end of said mandrel to the surface pumps.

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