32

2093500

METHOD FOR CONTROLLING SUBSURFACE BLOWOUT

Some hydrocarbon production fields have boreholes which penetrate to various different depths, so that production from two or more different levels or geological formations may simultaneously occur. Some of these wells may be dual completed, whereupon production from two different zones are maintained separated from one another but are produced concurrently from the same wellbore. In this same oil field, there may be other boreholes which extend to only one of the multiple production levels.

Any time people, including knowledgeable oil field engineers, undertake abnormal intercourse with mother nature, many unexpected and sometimes devastating results can occur. For example, in the dual completed well having an extremely high pressure lower formation, the lower packer has been known to fail, whereupon high pressure hydrocarbons from the lower payzone rush uphole and commence entering the upper payzone. This sudden release of high pressure hydrocarbons can shock the upper packer with sufficient force to cause the packer to fail. The upper packer loses control of the well, and under extreme conditions erosion of the upper perforated zone commences cavitating the formations.

Accordingly, the above castrophe continues snow balling

until it is impossible to shut-in the well using conventional methods. Drilling mud cannot be pumped down the borehole in order to kill the well because of the damaged area surrounding the upper formation. Therefore, valuable hydrocarbons from the lower zone are lost into the upper zone.

Many high pressure wells extend through thousands of feet of salt formation. It is possible for the salt formation to shift laterally with sufficient shear force to sever the casing and production tubing, whereupon the high pressure fluid is uncontrollably released into the salt formation.

Earthquakes and other disturbances brought about by abnormal geological phenomena can have similar devastating effects and cause below surface blowout of oil wells.

A method and apparatus by which a subsurface well blowout, such as described above, can be brought under control is the subject of the present invention.

The present invention provides a method of recompleting a formation having a wellbore extending thereto, wherein the wellbore is damaged and the formation is inaccessible therethrough, which method comprises the steps of:

(1) forming a borehole which is arranged in spaced relationship to the wellbore; and, drilling the lower marginal end of the borehole within shooting range (as hereinbefore defined) of the wellbore;

(2) orienting a plurality of shaped charges of a perforating gun to fire in the same direction;

(3) running the gun of step (2) downhole into the borehole at a location adjacent to the perforated casing of the wellbore; orienting the gun respective to the wellbore to position the shaped charges to fire radially away from the gun and form tunnels towards the perforated casing of the wellbore;

(4) pumping killing fluid down through the borehole, through the tunnels, and into the lower marginal end of the wellbore, thereby isolating the formation from the upper wellbore.

The invention includes a method bringing under control a wellbore having a high pressure lower formation which is uncontrollably flowing uphole, which method comprises the steps of:

(1) forming a borehole into the ground which is spaced from the wellbore and slanting the lower end of the borehole to place the lower marginal end of the borehole adjacent to a marginal length of the wellbore at a location where the wellbore penetrates the lower formation;

(2) running a perforating gun downhole within the borehole until the gun is located in close proximity to the wellbore and at an elevation which is in close proximity of said lower formation;

(3) orienting a multiplicity of charges for the gun to fire in like direction so that the charges penetrate from said borehole towards said wellbore;

(4) detonating the gun, thereby communicating the borehole with the wellbore;

(5) pumping killing fluid down the borehole and into the wellbore, thereby isolating the lower formation and preventing flow uphole therefrom.

Preferrred methods of bringing a well having a subsurface blowout under control, wherein a high pressure lower payzone has erupted into an upper formation or zone will now be described. A second borehole is formed in spaced relationship to the blown-out wellbore. The lower marginal end of the new borehole is slanted towards the lower marginal end of the damaged wellbore so that the lower end of the new borehole is brought within shooting range of the casing of the lower high presssure zone. A perforating gun having a plurality of enormous shaped charges may be run downhole within the new borehole until the perforating gun is positioned adjacent the old casing in proximity of the lower high pressure zone. The gun is oriented to cause all of the shaped charges thereof to be directed radially away from the new hole and towards the casing preferably near the lower zone of the damaged wellbore. The perforating gun is fired, thereby communicating the lower marginal end of the new borehole with the lower marginal end of the damaged wellbore.

A killing fluid, preferably cement is pumped downhole

through the new borehole and forced into the lower perforated marginal end of the old wellbore, and back up the wellbore, until flow from the well is killed.

After the well has been brought under control, another slanted lower marginal end of the borehole can be formed through the lower payzone and the new slanted portion of the borehole completed, thereby regaining production in a safe manner which does not disturb the cement job.

The invention will be illustrated by the following detailed description of a preferred embodiment, with reference being made to the accompanying drawings, in which:-

Figure 1 is a schematical representation of wellbores penetrating the earth;

Figure 2 is a cross-sectional view of wellbores formed into the ground, with some steps of the present invention being disclosed therewith;

Figure 3 is a fragmentary representation of part of the Figure 2 disclosure which illustrates some of the features of the present invention;

Figure 4 is similar to Figure 3 and shows additional steps of the present invention; and,

Figure 5 is a cross-sectional view taken along line 5-5 of Figure 3.

In Figure 1 or the drawings, there is shown prior art spaced apart wellbores 10 and 12. The wellbore 10 is a dual completed well while the wellbore 12 extends downhole to only one production formation.

The wellbore 10 extends below the surface 14 of the ground, through an upper payzone 16, and through a lower high pressure payzone 18. A wellhead 20 is provided with the usual Christmas tree which is attached to the upper terminal end of a casing 21. The Christmas tree includes outlets 22, 24, and 26, respectively, connected to production tubing 28, production tubing 30, and upper casing annular area 31, respectively.

Packer 32 is a dual packer and isolates a central annulus 34 from the upper annulus 31. A lower annulus 36 underlies the lower packer 38. The casing is perforated at 40 so that hydrocarbons from the lower formation can flow through the perforations, into the lower annulus, into the inlet end 42 of tubing 30, and uphole to the outlet 24. Inlet 44 of tubing 28 likewise receives produced fluid which flows from formation 16, through the perforations 46, into annulus 34, into the inlet 44 of tubing 28, and to the Christmas tree where the production from the upper zone exits through outflow pipe 22.

The wellbore 12 includes a packer 132 which separates the casing annulus into upper annulus 131 and lower annulus 134. Production from formation 16 occurs through perforations 146, into the inlet end 144 of the production tubing 128, up the tubing, and to the Christmas tree where the flow exits at 122.

In Figure 2, it will be noted that a malfunction has occurred to wellbore 10, as indicated by the arrow at numeral 48, which was caused by tubing 30 becoming separated from packer 38

and accordingly, a tremendous surge of hydrocarbons from the lower high pressure formation rushed uphole and impacted against the dual packer 32. The force of the impact unseated the packer which was subsequently forced uphole along with thousands of feet of the tubing string and pieces of formation 16 and 18. An enormous flow of hydrocarbons continue to leave the lower formation and enter the upper formation, and therefore a considerable amount of production is lost from the lower high pressure reservoir until the wellbore 10 can be brought under control.

In accordance with the present invention, a new borehole 52 has been formed down through the formation 16, where the borehole is slanted at 53 and continues down towards the lower formation. The borehole is cased and provided with a suitable wellhead at 54 by which the well can subsquently be controlled when it becomes necessary to do so. The lower marginal end 56 of the new borehole is placed in close proximity to the lower perforated zone of the wellbore casing. Drilling rig 58 preferably remains on location while carrying out the present invention. Drill pipe or production tubing 60 is connected to a large casing gun 62. All of the shaped charges 64 of the casing gun have been oriented in the same direction. A Sperry Sun orienting apparatus 66 is included in the tool string so that the shaped charges can be aligned radially away from the new borehole 52 and directed towards the lower marginal end of the damaged wellbore 10.

In Figure 3, the shaped charges have been detonated, thereby forming tunnels 68 which communicate annulus 36 of the damaged wellbore with the annulus 69 of the new borehole. A releasable coupling 70, made in accordance with Patent Nos. 3,966,236 and 4,066,282, is interposed between the tubing 60 and the jet gun.

39

As seen in Figure 4, cement 72 has been forced down the tubing string 60, and squeezed through the tunnels 68 into the annulus 36 of the perforated casing of damaged wellbore 10. The cement is pumped into the wellbore 10 until the production is killed and no flow occurs from formation 18, uphole towards formation 16.

Numeral 74 indicates a cement truck, such as a Halliburton rig. The numeral 76 indicates a new slanted hole which has been deviated away from the second wellbore and first borehole. The new slant hole can subsequently be perforated at 78 using techniques set forth in Patent No. 3,706,344 so that the newly formed borehole can replace the old damaged wellbore, thereby taking advantage of the existing facilities.

In Figures 3 and 5, it will be noted that the Sperry Rand orienting apparatus has been used to install a key 80 in the lower end of the new cased borehole 52, hence it is not necessary to include the apparatus 66 in Figure 3. The lower end of the gun housing is provided with a notch 82 made complementary respective to key 80, so that the gun can be manipulated by string 60 until the notch and key are brought into registry with one another, whereupon all of the shaped charges are directed radially away from the new hole and towards the lower marginal end of the damaged wellbore.

The key 80 can be installed further uphole if desired so that the gun perforates an area of casing 10 which is located above the old perforated zone. The new perforations, in this instance, must penetrate the old casing of wellbore 10, unless the Halliburton truck can develop sufficient pressure differential to tunnel across the intervening strata to the old perforations.

In Figure 3, a bar 60 is circulated downhole to detonate gun firing head 85 in accordance with Patent No. 3,706,344.

The shaped charges are 300 grams placed on 9 inch spacings along 100 feet of gun housing. The usual charge of prior art guns is 30 grams, so it is evident that an extremely large amount of energy will be released when the gun is actuated.

OPERATION

In operation, after all efforts for killing the wellbore 10 by conventional means has failed, the drilling rig 58 is moved onto location and a borehole 52 formed into the ground. The new borehole preferably is spudded in several hundred feet from the wellbore 10 to lessen the danger of fire and explosions. A whipstock is employed to slant the lower portion 53 of the borehole so that the lowermost marginal end 56 arrives as close as possible to the lower marginal end of the old casing 21.

A large casing gun 62 is mated with a Sperry Sun orienting apparatus 66 and the entire package run downhole on either the drill string or any suitable tubing. All of the extremely large 300 gram shaped charges 64 are oriented radially away from borehole 52 and towards wellbore 10. The gun is detonated thereby forming passageways 68 which communicate the new borehole with the old wellbore.

Alternatively, it is advantageous to have previously provided the gun housing and lower borehole with the illustrated coacting slot 80 and key 82, so that when the slot and key are brought into registry, the gun charges are properly oriented towards the old hole.

It is advantageous to communicate the two boreholes at the old perforated zone so that killing fluid, such as heavy drilling mud or cement, is pumped exteriorly of the old perforations. In many instances, it is advantageous to locate the perforating guns uphole of the perforated zone of the old casing so that the new perforations make entry above the payzone, and therefore cement can be pumped into

the old casing at a location uphole of the original perforations.

In some instances where the borehole is placed several feet from the wellbore, the jet charge may tunnel to the casing but fail to penetrate the casing wall. In this instance, it is possible to circulate sufficient cement through the tunnels 68 and through the old perforations and into the cased wellbore. It is preferable, however, to place the lower marginal end of the new borehole close enough to the perforated casing of the wellbore to enable penetration to occur. The term "shooting distance" is intended to include all of the above relationships of the gun and old wellbore.

Another advantage derived from the present concept is that the gun can be positioned downhole at a location where entry is made above the payzone, and the cement is pumped simultaneously with actuation of the perforating gun. This technique forces cement to flow through the tunnels concurrently with their formation, thereby enhancing communication between the two adjacent boreholes, and increasing the volume of cement conveyed into the damaged borehole per unit of time. Accordingly, the cement flows into the old wellbore and rapidly accumulates at a rate which enhances the action of killing the well and thereby permanently seals off the high pressure formation from the upper strata.

CLAIMS:

1. A method of recompleting a formation having a wellbore extending thereto, wherein the wellbore is damaged and the formation is inaccessible therethrough, which method comprises the steps of:

(1) forming a borehole which is arranged in spaced relationship to the wellbore; and, drilling the lower marginal end of the borehole within shooting range (as hereinbefore defined) of the wellbore;

(2) orienting a plurality of shaped charges of a perforating gun to fire in the same direction;

(3) running the gun of step (2) downhole into the borehole at a location adjacent to the perforated casing of the wellbore; orienting the gun respective to the wellbore to position the shaped charges to fire radially away from the gun and form tunnels towards the perforated casing of the wellbore;

(4) pumping killing fluid down through the borehole, through the tunnels, and into the lower marginal end of the wellbore, thereby isolating the formation from the upper wellbore.

2. A method as claimed in Claim 1 wherein the killing fluid is cement.

* C L M S *

43

3. A method as claimed in Claim 1 or Claim 2 wherein the gun is run into the borehole on a tubing string, the killing fluid is pumped down the tubing string, and said gun is released from said tubing string by a releasable coupling means.

4. A method as claimed in any one of Claims 1 to 3 wherein the tunnels are formed to extend to the old perforations of the wellbore, so that the killing fluid is forced to flow from the borehole, through the tunnels, and into the wellbore at a rate which accumulates sufficient killing fluid to shut-in the wellbore from the formation.

5. A method as claimed in any one of Claims 1 to 3 wherein the tunnels are formed to extend from the borehole to new formed perforations in the wellbore at a location which is above the old perforations.

6. A method as claimed in Claim 5 wherein the killing fluid is pumped down the cased borehole simultaneously with the firing of the gun, with the killing fluid being maintained at a pressure which forces a flow path to be formed from the borehole into the perforated zone of the wellbore.

* C L M S *

7. A method as claimed in any preceding claim wherein the lower end of the borehole is slanted to cause the borehole to be placed in shooting distance of the wellbore, and the killing fluid is left at the bottom of the borehole and wellbore.

8. A method as claimed in any preceding claim wherein the borehole is provided with a second slanted marginal lower end which penetrates the lower formation at a location spaced from the first recited lower end of the borehole and wellbore, so that production from the borehole can be carried out up through the second slanted marginal lower end after the recompleting operation has been completed.

9. A method bringing under control a wellbore having a high pressure lower formation which is uncontrollably flowing uphole, which method comprises the steps of:

(1) forming a borehole into the ground which is spaced from the wellbore and slanting the lower end of the borehole to place the lower marginal end of the borehole adjacent to a marginal length of the wellbore at a location where the wellbore penetrates the lower formation;

(2) running a perforating gun downhole within the borehole until the gun is located in close proximity to the wellbore and at an elevation which is in close proximity of said lower formation;

(3) orienting a multiplicity of charges for the gun to fire in like direction so that the charges penetrate from said borehole towards said wellbore;

(4) detonating the gun, thereby communicating the borehole with the wellbore;

(5) pumping killing fluid down the borehole and into the wellbore, thereby isolating the lower formation and preventing flow uphole therefrom.

10. A method as claimed in Claim 8 comprising recompleting the lower formation by a method as claimed in any preceding claim.

11. A method of closing a damaged wellbore substantially as hereinbefore described with reference to and as illustrated in the accompanying drawing.