METHOD FOR CONTROLLING SAND IN WELLS

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The present invention is directed to a method and apparatus for controlling sand in wells. More particularly, the invention is directed to the gravel packing of wells. In its more specific aspects, the invention is directed to a method and apparatus for use in wells in which a tubing string is arranged.

Serial No. 445,244, filed July 23, 1954, Patent No. 2,725,107 for the same inventors is a divisional application of this application.

The present invention may be described briefly as involving a method for gravel packing a well having a casing traversing a producing formation and having a tubing string arranged in the casing terminating in an open end at a point above the bottom of the casing. The invention contemplates perforating the casing at a point below the open end of the tubing string corresponding to the producing formation and then washing from the casing sand which has been produced from the formation through the perforations with the formation fluid and as a result of which a cavity is formed.

A screen and liner is lowered through the open end of the tubing string and arranged in the casing adjacent the perforation. Gravel as a suspension in a fluid is then flowed downwardly through the tubing string and deposited in the casing below the tubing string. The gravel is then squeezed through the perforations around the casing while maintaining the screen and liner free of gravel to form a pack around the casing and in the casing around the screen and liner. A path of flow is established from the formation through the pack and into the screen and liner and thence into the tubing string.

The apparatus which accomplishes gravel packing through a tubing string involves a screen and liner which comprises an elongated perforated section having a closed end. A cap slidably engages and fits into an open end of the elongated member, the cap being provided with at least a lateral opening communicating with the interior of the cap. The opening has a surface defining an acute angle with the longitudinal axis of the cap and has a spaced apart surface defining a right angle with the longitudinal axis of the cap. A cylindrical sleeve embraces at least a portion of the cap, and an insert member having surfaces corresponding with the surfaces of the opening in the cap is arranged in the opening to provide a space between the acute angle surface of the opening and the acute angle surface of the insert member. The insert member has an extension member which extends along the cylindrical sleeve and is attached to the cap by a cylindrical sleeve and to the cap.

A frangible means, which may be a shear pin, releases the cap from the elongated section when weight is set down on the cap to rupture the frangible means and engage the acute angle surfaces between the opening and the insert member so that the insert member is forced from the opening and the cap is released.

In gravel packing wells, it is customary to refer to the material employed to pack wells as gravel. It is understood that this finely divided particulate material, and the term "gravel," embraces the material commonly employed in gravel packing oil and water wells. The invention will be further illustrated by reference to the drawing in which

Figs. 1a to 1e represent a step-wise procedure in gravel packing a well;

Fig. 2 is a view in partial section of the improved screen and liner;

Fig. 3 is a front elevation of the insert member of Fig. 2 apart from the apparatus of Fig. 2; and

Fig. 4 is a view taken at right angles to Fig. 3.

Referring now to the drawing, numeral 11 designates a casing in a borehole in an earth formation which extends into and traverses a producing formation 12 from which oil is to be produced. It is to be understood that the casing 11 is suitably anchored in the well by cementing, as is conventional procedure. Arranged in the casing 11 is a tubing string 13 provided with a plurality of slotted openings 14 adjacent its lower end. The lower end 15 is flared, and immediately above the lower end 15 is an offset section 16, the purpose of which will be described further.

In Fig. 1a illustrating our invention, a gun perforator 17 is lowered through the tubing string 13 on a wire line 18a and fired through the casing 11, as shown by the arrows, to form perforations 18 and to penetrate the formation 12. The perforating gun 17 is of the type of the so-called "small" tubing gun perforator, that is, a gun perforator which may be lowered through a tubing string such as 14 while the tubing remains in the casing. The gun perforator 17, after firing to form the perforations 18, may be withdrawn to the earth's surface through the tubing 14 by electric cable 17a, or, in some instances, firing of the gun may destroy the gun perforator 17 and require only retrieving of the cable 17a. In any event, in Fig. 1a, the well is cased with a casing 11 and the tubing string 13 arranged therein, and thereafter the perforations 18 are formed.

After the formation 12 has been perforated, fluid is produced therefrom along with sand which flows through perforations 18 into the casing 11. This sand has to be removed. As a result of the sand being produced, a cavity such as 24 may be formed in formation 12.

When it is desired to wash sand out of the casing 11 which has been produced from the formation 12, in accordance with our invention, an extension member 19 is lowered into the tubing string 13 on a wire line 20. This extension member 19 is suitably provided with a sealing means, such as a deformable or flexible cup 19a, which engages with the interior walls of the tubing string 13 to seal the extension member 19 therein and to form a passageway from above the slots 14 to the bottom of the casing 11. The extension member 19 is provided with centering means or centralizers 21, which may expand into the offset 16 to hold the extension member 19 in the tubing string 13. Thereafter the wire line 20, which has been attached to the extension member 19 by suitable well-known engaging means 22, is released therefrom and the wire line 20 and the engaging means 22 withdrawn from the hole.

A suitable fluid, such as salt or fresh water and the like, may then be pumped down through the tubing string 13 and out the open end 23 thereof and following the flow indicated by the arrows washes the sand which has entered the casing 11 through the perforations 18 from the formation 12. The sand is washed up the annulus 25 between the tubing string 13 and the casing 11. The sand produced from the formation 12 thus causes the formation 12 to expand the cavity 24. This series of operations is illustrated in Fig. 1b.

After the cavity 24 has been formed, as has been
described, the extension member 19 is retrieved by suitable retrieving means on a wire line, not shown, and a screen and liner 26 is lowered through the tubing 13 on wire line stabbing as shown in Fig. 1c, to the bottom of the casing 11. The screen and liner 26 is provided with centralizers or centering means 27 which are designed to engage with the interior walls of the casing 11. The wire line 20 connected to a cap 28 of the screen and liner 26 by engaging means 29 is released and withdrawn from the casing 11, leaving the extension member 19 and liner in the tubing and casing, as shown in Fig. 1d.

Gravel or finely divided particulate material as a suitable suspension is then flowed downwardly through the tubing string 13 and outwardly through the slots 14 and around screen and liner 26. A bridging head squeeze, in which pressure is exerted on the tubing 13 and the annulus 25, is then placed on the gravel deposited in the casing, and the gravel is forced out through the perforations 18 to fill the cavity 24 as shown. The cap 28 closes the upper end of screen and liner 26 and prevents gravel from entering into the screen and liner 26; the lower end 28a of screen and liner 26 is closed. Thus a pack generally indicated by numeral 24a is formed around the screen and liner 26 and around the casing 11.

In accordance with our invention, the cap 28 is then released from the screen and liner 26 by bearing the downward pressure on the cap 28 to rupture a shear pin or shear pins 30 which hold the cap 28 to the elongated perforated section 26a of the screen and liner 26. The wire line 20 is then lowered into the tubing string 13 and the engaging means 29 latched to the fishing neck 31. With the breaking of shear pins 30 by weight imposed on the cap, the cap moves downwardly, as will be described, to release the cap 28 from the elongated screen section 26a. The cap 28 is then withdrawn from the hole, as shown in Fig. 1c, leaving the screen and liner 26 with a gravel pack 24a surrounding it and the casing 11. Production is then had from the formation 12 through the pack 24a, flow being through the perforations 18, thence into the screen and liner 26 and upwardly through the tubing 13.

Referring now to Fig. 2, it will be seen that the elongated section 26a has a cap member 28 which fits into the open upper end 40 in sliding engagement therewith. The cap 28 is provided with a plurality of openings 41. The openings 41 have a surface 42 which defines an acute angle with the longitudinal axis 43 of the cap 28. The cap 28 also has a shoulder 45 which defines a right angle with the axis 43. Arranged in the opening 41 is an insert member 45 which has a surface 46 which corresponds with the surface 42 and a surface 47 which corresponds with the surface 44. The insert member has an extension member 48 which is arranged in a recess 49 of sleeve 50 which embraces the lower portion of the cap 28. The extension member 49 and the sleeve 50 are connected to the cap 28 through a shear pin or frangible means 30.

The surface 42 and the surface 46 provide a space 51 when the cap is in engagement with the upper end 40 of the screen section 26a. The upper end 40 of the screen section 26a has a recess 52 which receives a shoulder 53 of the insert member 45. To release the cap 28 from the screen section 26a, weight is placed on the cap 28 by setting down weights on a wire line which may be connected thereto which causes the shear pins 30 to shear, which then allows the cap 28 by virtue of the weight thereon to slide downwardly through the sleeve 50. Shoulders 50a engages with the upper end of sleeve 50 and surface 42 is forced against the surface 46 which, by virtue of their weight, causes the insert member to pop out of the opening 41. The cap 28 is then free and may be retrieved from the tubing 13 by the wire line 20, as has been described.

The invention is quite useful in gravel packing wells through a tubing string because the present invention eliminates the need for a drilling rig in gravel packing. This is advantageous since, when sand production is encountered, the perforated screen with a liner and cement at present either to hold the drilling rig on the well until production is obtained or to move the drilling rig off and to move a workover rig on if the well sands up. With our invention only employing a small gun perforator, an extension member and the improved screen and liner, the screen is possible to seal the well by means of a tubing string and eliminate the need for a rig.

The nature and objects of the present invention having been completely described and illustrated, what we wish to claim as new and useful and to secure by Letters Patent is:

1. A method for gravel packing a well having a casing traversing a producing formation and having a tubing string arranged in said casing terminating in an open end at a point above the bottom of said casing which comprises perforating said casing at a point below the open end of said tubing string creating a perforation or a pack in said formation, flowing fluid from said formation to wash out a cavity in said formation, lowering a screen and liner having closed upper and lower ends through the open end of said tubing string, arranging said screen and liner in said casing adjacent the perforated or pack in said formation in the tubing, flowing gravel downwardly through said tubing string and depositing said gravel in said casing, squeezing said gravel through said perforations into the ends of said cavity while maintaining said screen and liner closed and free of gravel to form a pack in said cavity and around said screen and liner, opening the upper end of said screen and liner, and thereby establishing a path of flow from said formation through said pack and into said screen and liner and tubing string.

2. A method for gravel packing a well having a casing traversing a producing formation and having a tubing string arranged in said casing terminating in an open end at a point above the bottom of said casing, which comprises lowering a gun perforator through said tubing string into said casing to a point in said producing formation, firing said gun to form perforations in said casing, washing out a cavity in said producing formation through said perforations, lowering a screen and liner having closed upper and lower ends through the open end of said tubing string and arranging said screen and liner in said casing adjacent the perforations with its upper end in the tubing, firing a gun to form gravel packing in said formation and depositing gravel into said casing, squeezing said gravel through said perforations into said cavity while maintaining the ends of said screen and liner closed and free of gravel to form a pack in said cavity and around said screen and liner, opening the upper end of said screen and liner, and thereby establishing a path of flow from said formation through said pack and into said screen and liner and tubing string.

3. A method for gravel packing a well having a casing traversing a producing formation and having a tubing string arranged in said casing terminating in an open end at a point above the bottom of said casing which comprises lowering a gun perforator through said tubing string to a point below the open end of the tubing string, firing said gun to perforate said casing in said producing formation, flowing fluid from said producing formation to wash out a cavity in said producing formation, lowering a screen and liner having closed upper and lower ends through said tubing string and arranging said screen and liner in said casing adjacent the perforations with its upper end in the tubing, flowing gravel downwardly through said tubing string and depositing gravel into said casing, squeezing said gravel through said perforations into said cavity while maintaining the ends of said screen and liner closed and free of gravel to form a pack in said cavity and around said screen and liner, opening the upper end of said screen and liner, and thereby establishing a path of flow from said formation through said pack and into said screen and liner and tubing string.
said screen and liner, and thereby establishing a path of flow from said formation through said pack and into said screen and liner and tubing string.

4. A method for gravel packing a well having a casing traversing a producing formation and having a tubing string arranged in said casing terminating in an open end at a point above the bottom of said casing which comprises perforating said casing at a point below the open end of said tubing string corresponding to said producing formation, lowering a screen and liner having closed upper and lower ends through the open end of said tubing string, arranging said screen and liner in said casing adjacent the perforations with its upper end in the tubing, flowing gravel downwardly through said tubing string and depositing said gravel in said casing, squeezing said gravel through said perforations while maintaining the ends of said screen and liner closed and free of gravel to form a pack around said casing and around said screen and liner, opening the upper end of said screen and liner, and thereby establishing a path of flow from said formation through said pack and into said screen and liner and tubing string.

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