METHOD AND APPARATUS FOR PLACING A FILTER BODY IN A WELL

Filed March 20, 1939

Fig. 1.

Fig. 2.

Fig. 3.

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METHOD AND APPARATUS FOR PLACING A FILTER BODY IN A WELL

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Application March 20, 1939, Serial No. 262,836

12 Claims.

(Cl. 160—21)

This invention relates to a method and apparatus for placing filter bodies in a well adjacent the producing zone, and relates more particularly to a method and apparatus for forming a filter pack adjacent the producing zone and around the outer surface of the perforated pipe in a well, such as a deep oil well.

In the completion stages of an oil well it is conventional practice to set a section of perforated pipe or liner adjacent the producing formation in the well and a gravel filter pack is often placed around the perforated pipe to reduce the quantity of sand which tends to migrate towards the well and into the pipe and to increase the effective permeability of the surrounding producing formation.

In placing the gravel filter pack it has been customary to introduce the gravel into the well either through the annular space between the casing and the perforated pipe or to introduce it through suitable tubing extending to the bottom of the perforated section of pipe. Introduction of the gravel in the manner first mentioned is fraught with numerous mechanical difficulties such as for example the frequent bridging of the introduced material resulting in freezing of the pipe in the casing and the resultant stoppage of flow of the gravel material into the well cavity, or if a perforated liner is employed the necessity of special and complicated suspending and anchoring means. In the second mentioned method of introduction of the gravel through tubing at the bottom of the well, which is the most practical mechanically, difficulty is usually encountered in lifting the heavy accumulated pack upward during introduction into the cavity surrounding the perforated pipe. A complete filling and proper distribution of the gravel pack is thus often impossible.

It is the object of this invention to obviate the above enumerated difficulties.

This invention resides broadly in a method and apparatus for introducing a filter pack material through tubing or pipe and raising and properly distributing a filter pack material in the well cavity surrounding the perforated pipe.

Other objects and features of novelty will be evident hereafter.

In the accompanying drawing which illustrates a preferred embodiment of the invention, Figure 1 is a cross-sectional elevation of the apparatus of the invention in operating position within a perforated liner in a well at the producing zone showing a portion of the pack material in place.

Figure 2 illustrates in cross-section one type of filter pack material employed. Figure 3 is a cross-section taken at 3—3 in Figure 1.

Referring to the drawing, 10 is a well casing set and cemented at 11 in formation 12 overlying the producing sands 13. A perforated liner 15 is suspended from the lower portion of the casing 10 by means of a conventional type of packing liner hanger 16 having slips 17 attached to a cage ring 18 by means of reins 19, a slideable cone 20 and a deformable packer 21. A hook 22 on the cage ring 18, when in engagement with pin 23 in the hanger body 24, serves to hold the slip down off the cone surfaces and in a restricted position so that they do not engage the inner surfaces of the casing 18. The said perforated liner 15 makes connection with and is suspended from the lower end of the hanger body 24 through threaded coupling 25. At the lower end of the perforated liner is a casing shoe 26 similar in construction to “Baker whirler float shoe” having an outer metal body portion 27 and an inner metal central ported valve chamber 28 bonded together with an intermediate cement filler 29. A ball valve 31 serves to prevent back flow of fluid into and through the shoe.

A drill pipe or other suitable pipe or tubing 36 is suspended from the surface by means not shown and extends through the liner hanger to a keyed slip joint 37 having an outer tubular section 38 and inner tubular section 39 keyed at 40 against relative rotation. The inner tubular portion 39 of the slip joint is provided with a packer 41 in the slide limiting head 42. The casing shoe valve chamber 28 is provided with left hand threads at 45 to which the inner telescoping section 39 of the slip joint 37 makes connection through the sub joint 46.

An umbrella-shaped packer 48 similar in construction to a Gubersau type “A" swab, inverted, is attached by means of suitable threads at 50 to the lower end of the outer tubular portion of the slip joint 37 and makes fluid tight contact with the inner surface of the perforated liner 15.

While in the preferred embodiment and for purposes of illustration the method and apparatus of the invention described as utilizing a perforated liner as shown at 15, a perforated pipe or casing extending into the producing formation and suspended from the top of the well and provided with suitable means for packing off in the annular space between the perforated casing and the surrounding casing 10 or adjacent
formation, may be similarly employed without departing from the invention.

The operation of the invention is as follows: After the well has been drilled to the producing formation and the casing 10 is set and cemented in place as shown at 11, an under reamer is run into the well and the producing zone in the formation drilled out as shown at 12, to form a cylindrical cavity of extended diameter substantially greater than the perforated liner to be suspended therein. A string of tubing or preferably the drill pipe, carrying the perforated liner 15 and packer liner hanger 16 together with the slip joint 31 and associated packing devices attached at the lower end is next lowered down the well casing and when the liner 15 has reached the proper position adjacent the producing zone as illustrated in Figure 1, the suspending drill pipe is given a short left hand turn. The left hand turn of the drill pipe 36 is communicated to the hanger body 24 through the keyed slip joint 31, connecting sub 38, diving float shoe 27, perforated liner 15 and through the screwed collar 25. Pin 23 is thus caused to be released from the cage ring hook 22, allowing the slip 17 to be forced by cage spring 14 upward along the slotted surfaces of the cone 20 and into contact with the inner surface of the casing 10. Upon subsequent further lowering of the drill pipe the weight of the liner is taken upon the slips 11 which wedge between the cone and the inner surface of the casing 10 and this weight is transmitted from the hanger body 24 through packer collar 21 and thence through the cone 20 and slips 17 to the casing walls into which said slips firmly set. The weight of the liner causes the packer 21, thus put under longitudinal compression to swell and tightly pack off the annular space between the hanger body 24 and the casing 10. At this point in the operation, the packer 48 is at the top position of the slip joint adjacent the head 42, and also adjacent the top of the underreamed cavity in the producing zone. While the packer is in this uppermost position, circulation of drilling mud or other suitable fluid containing granulated or globular filter pack material is commenced, the said mixture flowing down the drill pipe through the slip joint 31 and upward radially outward from the shoe 27 into the lower position of the underrreamed cavity surrounding the perforated liner 15. The return circulation of the fluid introduced into the underreamed cavity is effected by way of the annular space between the casing 10 and the drill pipe 36, but the return fluid can escape from the underreamed cavity into the annular space only by way of those liner perforations which are above the packer 48. The fluid is thus initially forced to rise from the point of introduction near the bottom of the underreamed cavity to the point of escape near the top of said cavity, and the filter pack material is thus carried upward with the fluid, and being larger in size than the perforation openings in the liner, accumulate at the top of the underreamed cavity as shown at 30 in Figure 1. As the circulation is continued the pack accumulates and builds from the top downward until the entire cavity is filled. As the filling process progresses the packer 48 may be progressively lowered in order to confine the fluid escaping through the region through and adjacent the lower boundary of the accumulating pack material. The subsequent introduction pack material is thus forced to rise with the upward flowing fluid and join the accumulation of pack material previously introduced. After the placing of the filter pack around the perforated liner has been completed the next step is the removal from the well of the drill pipe 36 together with the slip joint 37, tubes 38 and 39 and sub joint 45. This is accomplished by rotating the drill pipe 36 in a right hand direction a sufficient number of times to unscrew the left hand threaded joint 45 at the lower end of the drill pipe 36. The assembly can then be withdrawn from the liner and the well leaving it ready for the insertion of the oil tubing and for subsequent production.

The material comprising the filter pack 30 is preferably composed of material having a specific gravity equal or slightly less than the fluid with which it is introduced and circulated into place in the producing zone of the well. The filter pack material may however, on occasion have a specific gravity slightly greater than the fluid with which it is introduced. In this case the oil and fluid circulated may be increased to a value where the upward velocity of the fluid in the underreamed annular space surrounding the perforated pipe in the well is greater than the downward sinking velocity of said pack material's elements therein. The pack material will thus be carried to the top of the filter pack as described hereinbefore. In some cases where the diameter or cross-sectional area of the underreamed cavity is not too great and relatively high upward velocities of the circulating fluid can thus be maintained therein, even gravel or sand can be successfully circulated into place in this manner.

The filter pack material should be carefully selected as to size and shape so that the permeability to flow of the produced liquid from the producing zone will be a maximum value while at the same time effectively preventing the flow of sand from the surrounding formation to the well casing. Suitable packing material formed into spherical shapes ranging from 1/8 to 1/2 inch in diameter have been found effective in this connection and the spheres when composed of relatively heavy material are preferably formed hollow as illustrated in Figure 2 with a sufficient displacement to have effective specific gravities slightly less than the fluid with which they are introduced in the underreamed cavity. Shells, spheres, however, must be sufficient to withstand such external fluid pressures as are encountered in deep wells which may range from 500 to 7000 pounds per square inch.

Materials which may be utilized in fabricating the packing spheres should have high mechanical strength and freedom from corrosion. Examples of such suitable materials are Bakelite, duprene, beryllium alloy, magnesium alloy, aluminum alloy, glass and fluid circulated may be increased to a value where the upward velocity of the fluid in the case of materials is the undershot operation, preparatory to placing the filter pack, and to subsequently circulate the pack material into place in the same oil, whereby freedom of the placed filter pack and the penetrated surface of the producing formation from mud may be assured. However the conventional drilling may be so employed with the advantage that the greater possible weight of such a fluid contributes.
to the desirable buoyancy of the filter pack material. Thus the heavier the circulating fluid employed the heavier the filter pack material can be. When employing oil the effective specific gravity of the filter pack elements should be slightly less than approximately 0.8 which is approximately the density of oil. When mud is used the effective specific gravity of the filter pack elements should be preferably 1.0 although if sufficiently high velocity of circulating fluid are employed the specific gravity may render some circumstances be as high as 2.7 for glass, quartz, gravel and the like substances.

The foregoing is illustrative of the preferred method and apparatus and the invention is not to be limited thereby but may include any method and apparatus which accomplishes the same within the scope of the claims.

We claim:

1. A method comprising introducing liquid containing filter bodies at the lower end of the perforated liner into the annular space surrounding said liner, allowing the thus introduced liquid to rise from the lower end of said liner and to escape from the said annular space by passing inwardly through the perforations in said liner and controlling the region of escape of said liquid gravity of the filter pack element, whereby the filter bodies retained outside of said liner may be properly and uniformly distributed throughout the length of said annular space.

2. A method according to claim 1 in which the escape of said liquid into said perforated liner is controlled so that it is initially restricted to the upper region of the said annular space.

3. A method according to claim 1 in which the escape of said liquid into said perforated liner is controlled so that it is initially restricted to the upper region of the perforations and progressively downwardly throughout the length of the said liner as the upper portions of the said annular space becomes filled with filter bodies.

4. A method according to claim 1 in which the upward rise of introduced liquid is at a rate sufficient to carry the filter bodies upward in the annular space surrounding the perforated liner whereby the filter pack is initially formed in the upper portion thereof.

5. Apparatus for placing filter bodies at the lower end of the perforated liner in the annular space surrounding said liner comprising a string of tubing reaching into the lower end of said liner and adapted to discharge fluid into said annular space at the lower end of said liner, means to withdraw fluid from said annular space through said perforated liner and means to restrict the portion of said perforated liner through which fluid may pass from said annular space into said liner.

6. Apparatus for placing filter bodies at the lower end of the perforated liner in the annular space surrounding said liner comprising a string of tubing reaching into the lower end of said liner and adapted to discharge fluid into said annular space at the lower end of said liner, means to withdraw fluid from said annular space through said perforated liner, a packer in said liner making a fluid tight seal between said liner and said string of tubing and means to move said packer axially through said liner whereby the region of flow of liquid from the annular space and through the perforations into the liner may be varied.

7. Apparatus for placing filter bodies adjacent the producing zone at the lower end of a well comprising in combination a perforated liner, a string of tubing attached to and making fluid connection with the lower end of said liner, a slip joint in said string of tubing in said liner forming thereby upper and lower sections of said tubing longitudinally movable with respect to one another, a packer attached to the upper movable section of said tubing adjacent said slip joint and forming a movable fluid tight seal in the annular space between said tubing and said liner.

8. Apparatus according to claim 7 with a liner hanger and packer at the upper end of said perforated liner making contact with a well casing and means to actuate said hanger and packer.

9. A method according to claim 1 in which the said introduced liquid contains filter bodies having effective specific gravities not greater than the said liquid.

10. Apparatus according to claim 7 with a packer adjacent the upper end of the said perforated liner forming a liquid seal around the outside of said liner.

11. In combination with a well a filter pack adjacent the producing zone comprising hollow rigid bodies.

12. In combination with a well, a filter pack adjacent the producing zone comprising rigid hollow spheres.

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