METHOD FOR SEALING LEAKS IN PRODUCTION PACKERS


Filed Dec. 16, 1965, Ser. No. 514,264
8 Claims. (Cl. 166—14)

ABSTRACT OF THE DISCLOSURE

A method for repairing leaks in a production packer wherein a low density sealant fluid containing particles of an insoluble polymer is forced through the tubing string between two piston-like members until the lowermost member emerges from the lower end of the tubing and at least part of the sealant is displaced into the wellbore beneath the packer.

The present invention relates to oil and gas wells and is particularly concerned with an improved method for repairing leaks in the tubing strings and production packers used in such wells.

The tubing strings and production packers used in oil and gas wells often develop leaks due to corrosion, sand blasting and excessive pressure. Such leaks are generally repaired by killing the well, withdrawing the tubing string and packer assembly, replacing the faulty components, and then reinstalling the apparatus in the wellbore. This procedure interrupts production for prolonged periods, requires the use of expensive workover equipment which may not be readily available at the well site, and sometimes results in damage to the producing formation by the fluids used to kill the well. These disadvantages are particularly pronounced in deep well and in offshore areas.

The present invention provides an improved method for sealing leaks in the tubing strings and production packers in oil and gas wells. This method involves the injection of a rubber ball or similar piston-like member and a sealant fluid containing graded plastic particles having a specific gravity less than that of water into the tubing string at the surface, the use of a second piston-like member and a later-injected fluid to force the sealant fluid through the tubing into the space beneath the production packer, and the subsequent removal of the second piston-like member and excess fluid from the tubing string. This provides a simple and inexpensive way of establishing a reliable seal on the high pressure side of a production packer, permits the concomitant sealing of any leaks in the tubing string, and does not preclude the subsequent removal of both the tubing and packer if desired.

The nature and objects of the invention can best be understood by referring to the following detailed description and the accompanying drawings, in which:

FIGURE 1 is a schematic sectional view of a well showing the injection of a sealant fluid through the tubing; and
FIGURE 2 is a schematic view of the same well following the plugging of a leak around the production packer.

The well shown in FIGURE 1 of the drawing contains a string of casing 11 which has been cemented in place in the wellbore and perforated in the usual manner. The cement is indicated by reference numeral 12. Tubing string 13 extends downwardly through the casing from the earth's surface to a point adjacent perforations 14 in producing zone 15. A production packer 16 of conventional design is mounted on the tubing string above the producing zone to provide a seal between the tubing and the inner wall of the casing. Pressure measurements made at the surface have indicated that a leak exists in the tubing or production packer and that fluids are escaping from the well into the annulus above the packer. The methods generally used to detect such leaks do not indicate their precise location and hence both the tubing and the packer may be defective.

The leak in the apparatus of FIGURE 1 is repaired by first preparing a sealant fluid containing graded particles of a high molecular weight polymer which is substantially insoluble in both oil and water. Suitable polymers include butadiene-styrene copolymers, butadiene-acrylonitrile copolymers, polychloroprene, isobutylene-diolefins copolymers, polyethylene, polypropylene, polystyrene, cellulose acetate, polystyrene, nylon and the like. It will be understood that not all of these materials are equally effective for purposes of the invention. It is preferred to employ plastics and resins which have specific gravities less than that of water, although slightly heavier materials can also be used. The use of polypropylene has been found to be particularly effective.

The plastic solids utilized in accordance with the invention are employed in the form of graded granular particles between about 10 and about 400 Tyler mesh size. It is preferred to employ granules between about 10 and about 40 mesh in size in a concentration of about 10 to 30 percent, granules between about 40 and about 200 mesh in a concentration of about 30 to 50 percent, and granules between about 200 and about 400 mesh in size in a concentration of about 50 percent. The sealant fluid is prepared by suspending the graded polymer particles in crude oil, in diesel fuel, heating oil, lubricating oil or a similar petroleum fraction, or in a water-in-oil emulsion in a concentration between about one-half and about three pounds per gallon, preferably between about one and about two pounds per gallon. The specific gravity of the total slurry including the suspended particles should be less than that of the water or brine in the well and hence the amount of plastic particles per volume of fluid will depend in part upon the specific gravities of the materials used. Polypropylene particles having a specific gravity of about 0.9 give satisfactory results when suspended in SAE 20 to 30 refined oils and can also be used in most crude oils. In some cases, however, the addition of small amounts of a suspending agent such as blown asphalt, low molecular weight polyisobutylene, aluminum stearate or colloidal silica to the oil will improve the suspending properties and result in fluids which can be suspended for indefinite periods without settling of the particles. The addition of silica flour or similar oil-insoluble colloidal solids also improves the sealing ability of the fluid and is therefore particularly effective. Such materials may be used in concentrations between about 0.01 and about 3 percent by weight.

The sealant fluid is employed for repairing leaks in the tubing and production packer in the well of FIGURE 1 by first venting the annulus between casing 11 and
3 tubing 13 at the earth's surface in order to create a differential pressure between the annulus and the interior of the tubing. Assuming that the well is an oil well, rather than a gas well, gas is bled from tubing string 13 at the surface until the string is filled with a column of liquid. A rubber ball or similar piston-like member 16 of sufficient size to plug the tubing and prevent the flow of fluids past it is then inserted into the tubing string through a lubricator or similar device at the earth's surface. The injection method will depend upon the manner in which the well is completed at the surface and hence is not necessarily restricted to inserting the ball or similar member through a lubricator. A volume of sealant fluid slightly greater than the volume of the annular space between the tubing and casing which extends from the bottom of production packer 16 to the bottom of tubing string 13 is pumped into the tubing string at the surface. The column of sealant fluid thus injected into the well is indicated by reference numeral 19 in FIGURE 1. A second rubber ball or similar piston-like member 20 is then inserted into the tubing immediately above the column of sealant fluid. Water, oil or other fluid is pumped into the tubing behind this second ball or similar member in a quantity sufficient to force the second ball to a point just above the bottom of tubing string 13 as shown in FIGURE 2 of the drawing. As the column of sealant fluid between the two balls moves down the tubing, the sealant will tend to escape into any leaks in the tubing and flow into the annulus. The plastic particles suspended in the fluid are carried into the openings and effectively seal them. Wedging of the particles in place and gradual swelling in the presence of oil tend to improve the tightness of the seal. The time required for complete sealing can be determined by pressure and flow drawdown measurements for the tubing-casing annulus.

After pumping the column of sealant fluid through the tubing until the second ball 20 rests a short distance above the lower end of tubing string 13 as indicated in FIGURE 2, the tubing string is closed off at the surface. The first ball 18 has at this point dropped into the bottom of the well below the tubing and is left there. The sealant fluid which has emerged from the tubing, being lighter than the water or brine present, rises in the annular space surrounding the tubing below production packer 16. If the packer contains a leak, the sealant fluid escapes through it until the plastic particles bridge the opening. As the particles accumulate beneath the tubing string below the packer as indicated by reference numeral 21 in FIGURE 2, the pressure differential across the leak increases so that the bridged particles are deformed and wedged tightly in place to form an effective seal. Since the particles are deposited on the high pressure side of the packer, they cannot be readily dislodged. If no leak exists in the packer, the sealant fluid remains in the annulus beneath it. Because of the limited volume of sealant fluid employed and the low density, there is little danger of the fluid entering the perforations 14 and damaging the producing formation.

After the leak has been stopped, the tubing string 13 is opened at the surface and the well is allowed to flow. The entry of fluids from the reservoir forces ball 20 to move upwardly through the tubing, swabbing the sealant fluid from the tubing string. The ball 20 is removed from the flow line when it reaches the production choke or other restrictions at the surface. Sealant fluid not consumed can be withdrawn into the original container for reuse at a later date. The well may then be returned to normal production.

The procedure employed in sealing leaks in dry gas wells similar to that described above for wells normally containing salt water beneath the production packer but requires that brine or a similar fluid having a specific gravity greater than that of the sealant fluid be injected into the well in an amount sufficient to fill the gas space below the packer. The fluid employed for this purpose should be one which is compatible with and will not damage the producing formation. As the gas initially present below the packer escapes through the leak, the injected fluid will rise into the space below the packer so that the sealant fluid will then displace it by gravity. A ball or similar piston-like member should precede the brine or other fluid so that gas does not rise through this fluid as it traverses the tubing. The annulus is then vented, ball 18, sealant fluid 19 and ball 20 are injected into the tubing string, and fluid is then injected behind the second ball to force it downwardly to a point adjacent the end of the tubing. The sealant fluid rises into the space beneath the production packer and leaks off through the leak until the particles accumulate in sufficient quantities to provide an effective plug.

The invention is not restricted to the particular well arrangement shown in FIGURES 1 and 2 of the drawing and may be employed in wells containing multiple tubing strings, crossovers, landing nipples and the like. The balls utilized can generally be pumped through landing nipples and other restrictions having diameters slightly less than that of the tubing string without difficulty. In cases where the formation pressure is insufficient to force the balls back through such restrictions, the well can be swabbed to permit their recovery. An alternate procedure is to pump in additional fluid so that the balls are forced through the end of the tubing and drop into the bottom of the well below the producing zone. The sealant fluid can then be recovered, if necessary, by swabbing the tubing string.

What is claimed is:
1. A method for sealing a leak in a production packer within a well containing a string of tubing extending downwardly through said packer and open at its lower end which comprises:
   (a) injecting a first piston-like member into said string of tubing at the earth's surface;
   (b) injecting an oil-containing sealant fluid having graded particles of an oil- and water-insoluble high molecular weight polymer between about 10 mesh and about 400 mesh in size suspended therein into said string of tubing behind said first piston-like member, said sealant fluid including the suspended particles having a specific gravity less than that of the water in said well and the volume of sealant fluid injected being slightly in excess of the volume of the annular space between the bottom of said production packer and the top of the tubing string;
   (c) injecting a second piston-like member into said string of tubing above said sealant fluid;
   (d) pumping fluid into said string of tubing behind said second piston-like member until said first piston-like member has emerged from the lower end of the tubing, said second member having been displaced downwardly in said string of tubing to a point near the bottom of the tubing, and at least part of said sealant fluid has been displaced into the wellbore beneath said packer; and,
   (e) thereafter backflowing said well.
2. A method as defined by claim 1 wherein said sealant fluid contains a suspension of polypropylene particles.
3. A method as defined by claim 1 wherein said sealant fluid contains a suspension of polypropylene particles.
4. A method as defined by claim wherein said sealant fluid contains a suspension of polypropylene particles.
5. A method as defined by claim wherein said sealant fluid contains a suspension of polypropylene particles.
6. A method as defined by claim wherein said sealant fluid contains a suspension of polypropylene particles.
7. A method as defined by claim wherein said sealant fluid contains colloidal silica.
8. A method as defined by claim 1 wherein said polymer particles include particles between about 10 and about 40 mesh in size in a concentration between about 10 to 30 percent, particles between about 40 and about 200 mesh in size in a concentration between about 30 to 50 percent, and particles between about 200 and about 400 mesh in size in a concentration between about 30 to 50 percent.

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