Water Flood Pumping In The South Ward Field

By R. E. TURRENTINE
Texas Pacific Coal and Oil Co.
Monahans, Texas

Introduction

Among the peculiarities of producing an oil well which is involved in a secondary recovery project by water flooding, it is probably outstanding that the performance history of such a well can be expected to be in exact reverse order of that expected from a normal primary producing well. At the outset of a water flood project, the normal producing well is a marginal producer or "stripper," possibly making only one or two barrels daily. As the injection begins to yield results, old production equipment, such as the central power and gas lift equipment, is retired in favor of an individual pumping unit capable of handling the increasing volume and load. This volume and load continue to increase throughout the life of the water flood producer, even though the percentage of oil eventually begins to decrease as water production starts. Finally, as the high lifting cost per barrel of oil becomes prohibitive due to the small amount of oil being produced, the rods and pump are removed and the well is allowed to flow for the remainder of the project. Thus, the life of a primary producing well has been traced, but in reverse order.

Following this general peculiarity, there are many other specific problems, some of which are not necessarily peculiar to water flooding, but which have been particularly pertinent to the projects with which the writer has been associated. This discussion will cover some of those problems, specifically and generally, as related to water flooding.

Design and Installation of Pumping Equipment

In dealing with oil wells where benefits are being anticipated as a result of offsetting or near-by water injection, the first problem encountered is that of providing adequate pumping installations. In some cases, the equipment already being used may be satisfactory for further use, but in a large majority of the wells being produced in the South Ward Field projects, it has been necessary to replace at least part of the old equipment. As the old equipment generally consisted of central power arrangement, or possibly gas lift installations, it was readily apparent that the high volume production anticipated could not be handled with existing equipment. The pumping wells generally were equipped with small bore, low volume, insert type bottom hole pumps, and old rods and tubing.

It may be argued that this is not necessarily the first problem to be encountered. However, since the return on a large investment must come from the producing wells, it is generally considered advisable to recondition these wells at the earliest possible time. In this way, some production benefits may be realized simply by installing more efficient equipment, and when flood results begin to appear, there will be no delay for changing out equipment, and maximum production may be realized from the outset. An early replacement may be further justified by the consideration that most of the pumping equipment has a high salvage value.

As the choice of equipment must be made long before the peak demand is reached, it is important that a wise initial selection be made in order to prevent additional expense at a later date, possibly after peak oil production has been passed. Such secondary replacements are sometimes necessary in order to maintain maximum oil production, but it is not desirable to install larger pumping equipment merely to handle an additional volume of water without increased oil production unless absolutely necessary.

Several factors must be used in attempting to predict the amount of fluid which eventually will be produced from each well, which in turn, may be employed in determining the size and type of equipment to be used. Experiences of other operators in the same field or area is generally the first consideration to be made, whereever possible. Free exchange of information in the South Ward Field has been an outstanding characteristic of operators in that area. In cases where old wells are to be used as producers, past production history may sometimes be applied as a yardstick in predicting water flood production. Some operators have agreed upon one-third of the well's initial production as a rule-of-thumb figure in predicting water flood production. This may vary rather widely, of course, and is subject to such factors as fracturing and extremely high or low injection pressures. Of course, new wells are eliminated from this consideration. As the water injection has generally commenced prior to the preparation of the producing wells, the injection rates may furnish a guide as to the fluid production to be expected. Core data or other well information may also be applied. Generally, all factors must be used together in order to provide intelligent reasoning.

The above factors must then be tied in with equipment on hand and future requirements after water flooding. The latter determination is usually in the hands of higher management, but the other matters are generally more closely associated with the field personnel. Close coordination between engineering and production personnel is beileved to be of utmost importance in realizing maximum oil production from a water flood project. Best results generally are obtained when all concerned have agreed on a particular method, piece of equipment, et cetera.

After the sizes of the equipment which will best fit the needs of the project have been determined, the next problem is that of which type to use. Wherever possible, maximum flexibility is a primary consideration, particularly with the pumping units. As pumping conditions are constantly changing, units may have to be balanced at frequent intervals, in addition to changing the length of stroke and pumping speed often. Pumping units equipped with adjustable counterbalances are ideal for water flood production applications. In setting the pumping units, the temporary type installations have gained increasing popularity over the concrete foundation settings. Instead of making concrete foundations, wide-base units or units with fabricated steel sub-bases are set on timbers, which are lying on a caliche or dirt grade. The wide bases provide additional bearing and stability. These installations have proved satisfactory on unit sizes up to 160,000 in. - lb. peak torque. Unit replacement on such a setting is a very simple matter and can be done in a very short time.

In selecting the bottom hole pumps to be used, insert type pumps are generally given first call if at all practicable due to the ease of changing pumps. Tubing pumps are used very extensively to handle larger volumes of fluid and generally give longer runs because of heavier construction. Some special pump applications may be made where conditions warrant them, such as three-tube pumps for excessive sand conditions. A few applications of dual plunger pumps have been made in cases where it was not feasible to install a larger tubing size at the time.

Tubing pumps and conventional insert pump arrangements constitute the greatest percentage of bottom-hole pumps in operation in the South Ward Field. Valve arrangements and the other variable characteristics of the pumps vary rather widely among operators. Carbide balls and seats have been used extensively and are believed to be a justifiable expense in obtaining longer runs with the pumps, regardless of type. Traveling barrel insert pumps have proved successful under mild sand conditions, with either metal or ring type plungers. As corrosion has not been a problem, special metals have not been necessary.

Operations and Pumping Methods

It has become an established fact in other areas as well as the South Ward Field that water flood producing wells require the greatest amount of care during the first few months of operation after flood results begin to appear. The wells are often very difficult to pump due to the increased amount of gas which, along with a two to three degree increase in the A.P.I. gravity of the oil is generally among the first indications that a well is beginning to be affected by offsetting injection. Thus, the oil is lighter than normal as a result of the additional gas in solution with the oil, and the wells may have a tendency to gas lock and flow off in heads at irregular intervals. Production may be very erratic, continually changing, and a great deal of attention is required of each well in order to obtain the maximum production possible. Frequent repacking of stuffing boxes may be necessary during the early months as a result of these flowing off conditions. These problems are usually greatly lessened as production increases to the point where the well can be pumped continuously around the clock.

As the Yates section in the South Ward area is a sand pay, sanding up of pumping equipment may be a somewhat greater problem during the increasing production period, particularly on wells that increase very rapidly. This is apparently caused by the incoming fluid bank and sharp pressure increase in the reservoir causing the sand particles to be loosened and carried with the fluid. It may be necessary to "bump bottom" occasionally to keep a pump from becoming sanded up. This may also be done to break a gas lock in the pump.

Continuous twenty-four hour pumping of water flood producers is desirable as soon as possible for a number of related reasons. It has become almost a universal practice in water flooding to keep producing wells "pumped off," or rather to maintain a fluid pound at all times. In cases where old wells are used as producers, the oil casing is often set high, leaving unsaturated, depleted gas sands open which become theif zones if exposed to fluid. In order to be assured that no fluid will enter these sands, it is necessary to have the fluid level clearly established at a lower depth at all times. This is done by setting the pump lower than the thief zone and maintaining a fluid pound at all times.

By keeping the producers pounding fluid at all times, maximum oil production is thus assured, small increases may be readily handled, and large increases may be detected more easily by the well's failure to pound fluid. Maintaining a low fluid level in the bore hole prevents a back pressure on the sand and allows the oil to enter at a maximum rate. Also, in the case of wells which produce water, these pumping conditions do not permit a high column of water to stand in the hole which might cause serious and permanent damage to the pay sand. There may be exceptions to some of the above mentioned factors when it would be necessary or desirable to maintain a back pressure or fluid on the sand face to prevent scale deposition, caving, et cetra.

Leaving the depleted gas sands open by keeping the wells pumped down furnishes another guide in checking the well's performance. Although called "depleted" gas zones, these sands generally release a small amount of free gas that can be seen when vented through small size line pipe. When gas is seen to be escaping out the vent in normal fashion, this generally provides a good indication that the well is pumped down properly. This guide can be used only when the gas being produced is in such small quantities that it cannot be gathered and sold.

It would be unwise to use any of the well operational performances as sole factors in judging a well's pumping action. A well may pound fluid as a result of the pump starving for fluid. Gas may break out of oil and escape through a vent with the hole nearly full of fluid. Fluid may flow out the bleeder at the well head, due to unbalanced fluid conditions, indicating production even though the rods may be unscrewed. Therefore, all factors must be used together in checking a well's performance and though one particular condition may not be exactly right at a given time, a later check may find all conditions satisfactory. These factors, along with other common pumping characteristics should be checked frequently, possibly several times daily, at each well and used in conjunction with frequent well tests in maintaining the wells at maximum production. Proper pumping speed, stroke length, and well balance can be maintained in this way to provide an efficient operation.

Mechanical Problems

As a result of operating water flood producing wells with a fluid pound, sucker rod breakage occurs as probably the most common problem. In reducing this problem to minimum proportions, the first step should be the assurance that the wells are not being "over pumped;" that is, running at too great a speed or too long pumping stroke. As the use of old sucker rods is a major cause of rod breakage, the installation of new sucker rods usually will eliminate a large percentage of breaks. Of course, the rods must be of the proper size and quality for the particular job being done. In some cases, as wells exceed anticipated production, it may become necessary to install larger rods. Corrosion inhibitors have been used with only mild success in eliminating rod breaks in the South Ward area.

As mentioned at the beginning of this paper, a wise selection made at the outset of a project may result in considerable savings in additional equipment as well as production. Such an item as the installation of new rods should be considered very important.

Gas locking in the early stages of water flood production may be mentioned briefly as its existence as a problem usually is very brief. It may be necessary to prevent the wells from pumping completely down to eliminate this problem. Proper gas anchor design, double valving pumps, or spacing valves very close together in pumps are other possible solutions. This problem generally resolves itself as fluid production increases.

Sand is another problem which usually becomes less serious as the wells produce increased fluid volumes, particularly after water production starts. However, some wells are plagued by serious sand conditions even with water oil ratios of 2.5 to 1 and daily volumes in the neighborhood of 300 barrels. Properly cleaned out wells are the first solution. Casing liners, tho not always desirable, may become a necessity in some instances. High quality pumping equipment usually is a necessity where abrasiveness, due to troublesome and hard balls and seats are definitely justifiable under such circumstances. Specially designed pumps may be necessary in the wells where sand conditions are most severe.

A so-called "floating sand" may be responsible for a great deal of trouble rather than caving as commonly considered. This type sand is very abrasive and may also form with paraffin to plug lines and settling tanks.

Water and Scale

As a water flood project progresses, the water that must be handled presents a variety of problems. The first problems are those of treating emulsions and disposing of the water. Settling tanks, heaters, free-water separators, and other types of equipment must be applied as conditions warrant. In the South Ward area, where climatic conditions are very favorable to the treating of oil; that is, warm the year around, a minimum of treating equipment is required. Most operators use only a water oil separating tank or gunbarrel. A moderate chemical treating program usually takes care of the emulsion problem very economically.

Three general means of water disposal usually are considered: evaporation pits, disposal wells, and re-cycling for injection. Although the hot, dry, and windy climate is ideal for evaporation, the produced volumes generally have reached such proportions that other means are necessary and disposal wells have become the most popular solution.

Increasing water production creates the need for periodic checking of pumping unit balance as an economic measure, particularly when power is being purchased. As the unit load is continually changing, considerable savings may be realized by these checks.

One of the most serious problems encountered in the operation of water flood producing wells is that of scale, and gypsum in particular. As gyp seems to adhere to no particular pattern in forming and is relatively insoluble in most commercial chemicals, the importance of obtaining a solution to the problem cannot be stressed too much.

Gyp, usually crystalline in form but which sometimes forms a solid white scale, has been known to form a solid ring between tubing and open hole with no scale inside the tubing. Conversely, it has completely plugged the inside of tubing without forming at all on the outside. The most serious effects are those of restricting production and sticking tubing and rods.

Remedial methods at this time include a variety of chemicals, most of which are relatively unknown quantities. Most of these are inhibitors, with few claiming to actually dissolve the solid gyp crystals.

Gyp is the only serious form of scale found in the producing systems in the South Ward Field. The Field has seen a small amount of iron sulfide scale but this is easily removed and causes no serious plugging. There has been little or no serious corrosion in the producing wells.

Flowing Wells

A limited number of producing

wells are being flowed into the tanks in the South Ward Field at the present time. These wells are those which became uneconomical to pump due to excessive lifting cost and produce only a few barrels daily, generally less than five barrels.

Conclusion

In order to realize maximum results from water flood producing wells, it is very important that wise decisions be made before the operation is started. As each problem encountered is so closely related to the ones preceding it, the importance of a good start must be doubly emphasized. As the lives of these projects are relatively short, the problems must be solved quickly or have marked adverse effect on the overall success of the projects.

Although all of the problems discussed here have not been strictly operational, it is felt that the points covered are important to field personnel as well as management. Excellent field supervision and close coordination between field personnel and management are very important to the success of a water flood operation. Therefore, on such items as pumping equipment and methods to be used in such an operation, it is believed that experience of field personnel should be considered in making various decisions.