Selection and Operation of Rod Pumps

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The formula for arriving at the cost of operating an oil well is probably the most controversial subject among oil-men. This formula will often differ because of available help in keeping the records, lease agreements, or amount of overhead which is charged back against each well.

We do not intend to enter into this discussion. However, experience has shown that the initial cost of equipment should not be the final point of decision when selecting the pump. Of primary consideration is the cost of operations per day and included in this cost must be pulling charges, etc.

A good example of our contention is valve failure. The prices of balls and seats will vary from $2.00 to $50.00 for a given size because of the difference in the costs of the materials. However, the cost of pulling the well to get the pump so that the valves can be replaced may cost from $50.00 to $250.00. In analyzing costs, many oil-men have found that 15 percent of the operating cost of a pumping lease is spent on repair parts for equipment and that the other 85 percent is for labor. Our primary consideration, therefore, should be to reduce the 85 percent labor cost by proper selection of equipment. Initial cost, therefore, is not the important factor if the proper installation will give more economical overall operation.

In order to properly select the specific pump for the specific well, the operator must know the amount of oil that the well will produce as well as the specific problems found in the well.

In many wells these factors are established through experience with the well. In new installations, where these factors are not known, they can be found by obtaining the productivity index of the well and by closely observing the fluid produced from the well as well as the equipment which has been operating in the fluid in the well. There is no one design of pump or type of metal that is a cure-all for all oil well problems.

Many pump designs and combinations of metals have been developed to meet the various problems (or conditions) found in an oil well. In presenting our thoughts on "The Proper Selection of an Oil Well Pump" we will, therefore, first classify the problem found in the well and then present our suggestions as to the proper design and combination of metals to be used in building the pump to meet the specific conditions of the well.

Normal Conditions

By wells under "Normal Conditions" we mean wells which do not present severe or abnormal conditions—wells in which the oil is clean, non corrosive, of medium gravity or viscosity, and of shallow to moderate depth.

A. Metals

Under normal conditions any metal can be used. Soft cast iron liners and a steel plunger can be used. However, in many areas the most widely used, under normal conditions, are hard cast iron for liners, and steel which is chrome plated, for plungers. (The difference in price is very little.) However, the longer wearing hard cast iron and chrome plungers (in comparison to soft cast iron and steel plungers) pay for themselves many times over by greatly reducing the number of pulling jobs. Many operators wish to standardize on one or two types of pumps. The soft cast iron and steel plungers have very limited application. The hard cast iron and chrome plungers can be used, not only in wells with normal conditions, but can also be used in some problem wells.

B. Design

Under normal conditions we have no design problem. Therefore, any design can be used. The most popular design is the bottom-lock traveling plunger type pump. The rod insert pump is always used where the required volume can be obtained. The T. L. E. pump is used only where the rod insert cannot produce the volume desired.

Sand, Abrasion, and Gyp

A. Classification of Wells

Wells which present sand problems are usually divided into two general classifications:

1. Wells in which the formation will suddenly heave large amounts of sand into the well, thus plugging up the valves and plunger of the pump.
2. Wells in which the fluid carries constant amounts of sand and can be pumped, but in which that sand wears the moving parts by abrasion rapidly.

In either case, when pump action stops, the sand in the tubing will settle back in the annulus between the pump and the tubing, seizing the pump so that it cannot be pulled. The well must then be pulled "wet" (in other words, a stripping job) which will greatly increase the cost of operation.

Under the first classification, that of heaving wells, where economy will permit, the best answer is to repair the well's casing or liner, if they are damaged. Under any sand condition, it is important that when the sand and fluid have once entered the tubing and pump, that sufficient fluid velocities be maintained to carry the sand up the tubing and out of the well.

B. Metals

In abrasive wells (sand wells), parts exposed to abrasion (especially the piston, cylinder, and valves) should be made of the hard alloy steels. In most cases, the best answer to the metal problem in the abrasive well is stainless steel hardened to approximately 60 degrees Rockwell C scale. In severe cases a ring of tungsten carbide has been fitted on the end of the plunger and ground to plunger size. This will prevent the sand's cutting the lead edges of the plunger when it is fitted to liners with a close clearance (usually .0005). Whenever a plunger is fitted tight it must be made fairly short or it will seize on the "high spots" in the barrel (parallelism).

There are two important factors which must be considered when building the pump to handle sand.

1. Wells in which the viscosity of the oil is not considered a problem to plunger travel.
2. Wells in which the oil is heavy and the viscosity of the oil does interfere with plunger travel.

C. Pump Design

Design is a most important factor when dealing with sand.

1. In sand problem wells, where the viscosity of the oil is not a problem, the pump should be built so that:

a. The plunger has a close fit to the liners (usually .00005) 1/2 thousands. This keeps the sand from getting between the plunger and the liners where it will cause excessive wear and, in many instances, cause the plunger to gall and seize.

b. The plunger should have a square shoulder (pin end). It is A. P. I. practice to taper box end chrome plungers on the ends in order to allow for the swelling of the plunger when a fitting (pull rod, adapter, or pull tube) is screwed into it.

c. The plunger should stroke out both ends of the liners or cylinder into collars. Where sand or gyp exists in the well they have a tendency to accumulate on the liners just above the normal travel of the plunger. This accumulation will grow in size inside of the liner until it is sufficiently built up to seize the plunger when the plunger over-strokes. By stroking the end of the plunger out of the liners into the nipple on each stroke, sand and gyp are prevented from accumulating in the liners.

2. In sand problem wells, in which the heavy viscous oil does interfere with plunger travel, (in wells where the oil is less than 16 degrees A. P. I.) experience has shown that plunger travel is the major problem in pump design. The heavy viscous oil will usually carry the sand in suspension and, in most cases, where the pump is built with a loose fit plunger (.008 in several instances) the sand particles will slip past the plunger rather than sticking or galling it.

The pump design for sand in the heavy viscous oil is the same as with light oil, except the plunger is fitted very loose. This looseness will depend upon depth and viscosity of the well.

3. In sand wells the sand will often settle back into the annulus between the pump jacket and the tubing, seizing the pump so that it cannot be unseated or pulled. It is then necessary to pull the rods and tubing wet, causing a stripping job. There are three answers in design of the rod type pump to this problem.

A. Top-Lock Pump

(1) Advantages

In a top-lock pump, the pump is seated in the tubing at the top of the pump, which seals off the annulus between the pump and the tubing. Therefore, sand cannot get into this annulus to seize or stick the pump. The amount of sand which can settle on the seating ring is limited because the fluid discharge from the pump keeps it washed free.

(2) Disadvantages

(a) The top lock pump is limited as to depth because of the pressure differential between the inside and outside of the barrel. This pressure differential may expand or even break the barrel thus allowing the liners to come out of alignment. The weight of the column of fluid, when excessive or when the pump is pounding for fluid, may strip the collar threads on the jackets.

(b) When a well is pumping intermittently, or while it is shut down for repairs, sand can settle back on the top of the plunger and traveling valve. In all traveling-plunger pumps special equipment can be obtained which, in some cases, will minimize this objection.

B. Traveling Barrel

(1) Advantages

(a) In a traveling-barrel pump (sometimes called an up-side-down-pump) the pull tube and plunger are anchored to the tubing, and the barrel or jacket reciprocates or moves up and down with the rods. By moving the barrel up and down, the fluid in the annulus between the pump and the tubing is agitated or kept in motion, which has a tendency to keep the sand in motion and washed out of the annulus between the tubing and pump.

(b) Where the well is pumped intermittently, or the well is shut down for repairs, the sand is prevented from re-entering the pump by the top or traveling valve, which is in the top cage. As soon as the pumping motion stops, the ball in the top cage seats itself, thus sealing the inside of the pump off from the fluid, sand, etc., from above.

(c) In the traveling-barrel pump, the pressure is equalized between the inside and outside of the pump.

(d) In the traveling-barrel pump, both the traveling and standing valve cages are of the open type.

(2) Disadvantages

(a) There are wells where the sand may gradually settle in the annulus between the pump and the tubing. When enough sand has accumulated, it will prevent the full travel of the barrel on the down-stroke.

(b) In deep wells the pull tube has a tendency to buckle because of the static pressure.

(c) In the traveling-barrel pump, the standing valve is the small valve and the traveling valve is the large valve. This is a big disadvantage when the well has large volume or heavy viscous oil. It is also a big disadvantage when the well has very much gas to pump. The entrance or trapping valve should be the largest valve in the pump. The pressure drop across a small valve is greater than the pressure drop across a larger valve. This greater pressure drop will increase the chances of gas coming out of solution in the pump, thus gas-locking the pump.

(d) In crooked or slanted holes the traveling-barrel type pump is not as good as the plunger traveling type pump, as the barrel does not have unrestricted travel.

(e) The high position of the standing valve in the traveling barrel pump is a disadvantage in the wells with a low fluid level.

C. The Bottom-Lock and Top-Support (Seal) Pump

This pump is a combination of both bottom-lock and top-lock. It is anchored on the bottom and sealed off at the top. This pump has most of the advantages of both the top and bottom-lock pumps, without their disadvantages.

(1) Advantages

(a) Sand cannot enter the annulus between the pump and the tubing.

(b) Pressure is equalized between the inside and outside of the barrel, therefore, depth is not a pump problem.

(c) The standing valve is the large valve, therefore, there is a minimum of pressure drop across its face.

(d) In crooked holes, it is the best type reciprocal pump because it is of the plunger travel type.

(2) Disadvantages

(a) The initial cost is slightly higher.

(b) As with all traveling plunger pumps, in wells which are pumped intermittently or shut down for repair, the sand can settle on top of the traveling valve unless equipped with sand valve or preventer.

Production Suggestions For Sandy Wells

The following techniques have proven successful in sandy wells:

A. Hold Back Pressure on the Formation

1. Tube the well high. Experiment lowering tubing gradually until the optimum position has been found.

2. Use the proper diameter of the plunger in the pump. Use the smallest plunger possible to obtain the desired production.

3. Apply back pressure on the fluid column. Carry casing pressure on well, using pressure regulator. This will help prevent heaving by the well.

4. Depress the fluid level slowly over a period of several days after the pump has been started.

B. Long, Slow Stroke

Many oil men believe that the opening and closing of the standing valve causes pulsations on the formation which tend to dislodge sand particles. By slowing this pulsation down, considerable sand is eliminated.

C. Fluid Velocities

When sand has once entered the pump and tubing, sufficient fluid velocities should be maintained to carry the sand to the surface and out of the well. In severe cases, hollow rods (commonly known as macaroni) are successfully used to maintain the desired fluid velocity.

D. Gas Anchor

If possible, a gas anchor should not be used in a sandy well. However, if a gas anchor must be used, it should be designed so that sand cannot accumulate in the bottom of the gas anchor. Also, it should be made so that the fluid velocity in the gas anchor is less than the fluid velocity in the tubing. When the fluid velocity of the gas anchor is greater than the fluid velocity of the tubing, sand will go through the gas anchor and pump but will settle in the tubing above the pump because of the lesser fluid velocity.

E. Sand Trap

Where the well has floating or powder type sand which settles in spite of top-lock, traveling-barrel, etc., the time between pulling and bailing jobs can often be lengthened by the use of a sand trap.

Pumps For Gaseous Areas

One of the most important factors in obtaining pump efficiency is the prevention of gas from entering the pump. The complete elimination is in most cases impossible. However, by proper selection, installation, and operation of equipment, this problem can be minimized.

A. When selecting a pump to handle gas, design is the most important factor. When free gas enters the pump, it will either partially or totally "gas-lock" the pump. A pump becomes "gas-locked" when free gas gets into the unswept area between the valves where it will expand and contract with each stroke, thus interfering with valve operation.

When a pump is partially "gas-locked" its efficiency is very poor because most of the stroke is spent compressing the free gas in the pump. When a pump is completely "gas-locked" no fluid is being pumped, as the standing valve is held closed by the gas in the pump and there is not sufficient compression of the gas inside the pump to open the traveling valve.

B. Design of Pumps For Gaseous Areas

1. In order to prevent gas-locking, the pump must be built and operated so that there is a minimum of unswept area, and so that the traveling valve—on the downstroke—will have a minimum clearance with the standing valve.

2. Use the largest standing valve possible so that there will be a minimum pressure drop across the face of the valve.

3. Any metal can be used for gas if the gas is not corrosive.

C. Production Suggestions For Wells In Gaseous Areas

1. Proper Placing of The Pump in The Well

There are wells in many areas in which the gas is at the top of the zone. Considerable gas is eliminated from the pump by placing the pump below the gas section of the zone.

2. Restriction

a. Maintain sufficient clearance in the annulus between the tubing and casing for free passage of gas.

b. If a tubing catcher is used, be sure that it has sufficient passage areas.

c. If possible, stay out of the liner. Tubing collars often set up a turbulence because of the restricted area inside of the liner.

3. Gas Anchor

Use an efficient gas-oil separator. Several good articles have been written about gas anchors and their designs.

4. Long Stroke

It is important that the pump have a high compression ratio. The longest stroke possible, combined with proper spacing, obtains the highest compression ratio possible in the pump.

5. Casing Pressure

Maintain a minimum casing pressure.

Corrosion

The word corrosion covers a multitude of well conditions. The name or classification of corrosion often differs with the change of locality. Most corrosive conditions are usually classified as corrosion caused by Hydrogen Sulfide (H2S), Electrolytic or Galvanic corrosion, Carbon Dioxide corrosion, Inhibited corrosion, Brine corrosion.

There have been several good documented articles written on methods to control corrosion. These articles deal with protective coatings, chemical inhibitors, neutralizers, and alloy metals. In building the pump for corrosion, we find that metal is the all important factor, rather than design. In discussing the corrosion problem, from the point of view of choosing a pump, we have had considerable success by treating corrosion under three general classifications.

A. Hydrogen Sulfide

The recommended metals to use with hydrogen sulfide are nickel alloys (nickel stainless steel) and hard cast iron. Do not use chrome alloy metals with hydrogen sulfide.

B. Brine Corrosion

By brine corrosion we mean corrosion from all causes other than hydrogen sulfide.

The recommended metals for these conditions are chrome alloy (chrome stainless steel).

C. *Inhibited Corrosion*

By inhibited corrosion we mean corrosive wells in which inhibitors or chemicals have been added to the fluids to control corrosion. The metal recommended will depend entirely upon the success of the inhibitor. Where the inhibitor has been successful, a pump made with liners and a plunger of hard cast iron is in most cases, successful.

Conclusions

The conslusions to be drawn from this paper are:

I. Pumps designed to answer the specific problems involved we feel warrant a careful consideration of the various factors involved before any attempt is made to select any given pumping equipment for any particular service.

II. There are methods available to determine the optimum rod pump installation for any well.

III. That present day pumping problems can no longer be treated in an elementary manner.

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