Application of Insert Rod Pumps In Gaseous Wells

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Despite the special pumps, bottom hole separators and other devices that have been developed throughout the years, the application of subsurface pumping equipment in gaseous wells is a problem which continues to plague all operators.

The purpose of this paper is to discuss some further developments in the older methods, to survey some new developments, and to consolidate some of the information that has been made available at various times.

There are available several types of the gas anchors available. And there is a suggested application for each type.

First, is the natural gas anchor which is formed by the casing or open hole below the casing perforations or producing zone. In this type, the pump is seated in the tubing that extends below the producing zone, and, thereby, takes advantage of the gas breakout at the point at which the formation fluids enters the well. This is the cheapest of all anchors and performs very well when the gas/oil ratio is low or moderate and when a closely spaced stationary barrel pump is used. However, one can hardly consider this as a gaseous well.

Second is the "poor boy" anchor which is very close to the natural gas anchor because the pump intake is below the inlet to the tubing and the casing perforations. In this type anchor a mud anchor consisting of one or more joints of tubing sealed on the bottom is run below the perforated tubing nipple, while placed immediately above the perforated nipple, is the seating nipple. Further, a stationary barrel bottom hold down pump with a "mosquito bill" or a top hold down pump with or without a "mosquito bill" or gas anchor is run. This anchor provides the pump for dead oil within the tubing and generally provides cleaner oil to the pump. The pump gas anchor should extend at least six ft below the tubing perforations but should not be longer than 25 ft. Greater length and small ID gas anchors create additional gas break out at the pump and circumvents the separation achieved with the gas anchors on the tubing. However, in the "poor boy" gas anchors care should be taken to see that the volume of dead oil available per pump stroke is greater than the pump capacity; otherwise, "live" fluid will be drawn in, and gas break out in the pump will occur.

This is perhaps the most widely used of all the gas anchors and when proper pump application is made usually is adequate for the moderate GOR wells. This application will be discussed later in this paper.

One will note that in both these anchors the fluid inlet to the pump as well as the inlet to the anchor are below the casing fluid inlet. In some cases, it is desired to keep the formation covered with oil at all times. And in such cases the tubing inlet is placed on bottom, below the casing perforations, and will allow the oil water interface to form at the tubing inlet. Meanwhile, the pump inlet is placed at some point above the casing perforations and thereby keep the formation covered with oil. The formation is protected at the expense of gas locking on the pump, but one has working against him both the break out because of the fluid falling and the pressure drop because of the fluid rise in the tubing, and this break out and pressure drop, coupled with a traveling barrel pump, should succeed in complete failure to pump. However, this is a rare occurrence and it is mentioned only to illustrate how poor application can result in complete failure to produce the well.

Next, one should consider the equipment that may be found to be necessary to use in those wells where in the GOR rises as the reservoirs are depleted or as a start is made with a high GOR. In these wells, one often finds it necessary to go to a more elaborate gas separation system than the "poor boy" or natural.

For these, one can consider the use of the Marsh or "Mother Hubbard" gas anchors, both of which should be installed below the casing perforations and with the perforated tubing nipple at the top of the anchor and immediately below the seating nipple. Both anchors operate on the proven principle that if the down flow of the gas/oil mixture is less than the gas bubble rise rate, additional separation, beyond the breakout because of pressure drop, will occur. In these anchors an oversize pump is created which permits the slow fall; and they are also provided with built in pump gas anchors which place the pump intake very near the bottom of the anchors where the greatest amount of "dead" oil will be found. In this way a maximum amount of natural separation will be achieved at a mimimum cost.

However often times, particularly in wells completed with open hole, it is impossible to get the anchor below the perforations. In these cases better separation can sometimes be secured by raising the anchor above the fluid entry area; thus reducing the agitation at the point of entry and permits better separation at the tubing entry point.

Furthermore, there are other cases — particularly, where the GOR's are exceptionally high or in small diameter casing which will not permit the installation of oversize anchors — when it is necessary to resort to a forced flow anchor. In this type anchor a port is placed below a packer, but, rather than opening directly into the tubing, it opens into a skirt surrounding the tubing above the packer. The admitted fluid/gas mixture is then forced to flow at some height above the packer where it is discharged into the annulus. At this point the pressure has been decreased, and the gas breaks out and flows to the surface. The separated fluid then falls down to the packer where ports introduce it directly into the tubing and pump inlet. In a forced flow separator, agitation of the mixture is encouraged by the use of several tubing subs inside the skirt, and the couplings necessary with these subs change the volume of the skirt and, therefore, increase the turbulence and gas break out. However, sometimes, small diameter pipe clamped to the tubing string is used in place of a skirt to conduct the flow above the pump, and the pressure drop in the small tubing increases the separation and seves the same purpose as does the agitation in the larger skirt.

There has been considerable work done lately on the use of baffles as a gas/oil bottom hole separator. In this type of separation several cup shaped rings are welded to a perforated tubing nipple with the perforations placed at the base of each baffle. Since the gas/oil mixture is turbulent within the well bore, the baffles tend to increase this turbulence, and it is believed that an actual rolling motion takes place. The cup shaped baffles tend to deflect the gas upward and trap the separated oil as it tries to fall, and the oil then caught is carried downward inside the tubing to the pump intake. Additional separation occurs when the fluid falls inside the gas anchor or mud anchor. For the best results, this type anchor, as well as the forced flow anchor, needs to be placed above the casing perforations. Now, since poor application at this point will destroy any advantage that one may have gained by good down hole separation, one must consider the selection of the proper pump to handle the well production.

Even the best separation cannot achieve the release of all gas, and some always remains to be handled by the pump; therefore, one should consider using the largest possible bore pump consistent with good production practices. This size is recommended to offset the loss in efficiency because of the volume taken up by the gas which inevitably breaks out within the pump. One must not, however, size the pump far beyond the wells ability to produce. The excess pump capacity will be filled with gas and is conducive to total gas lock; therefore, wherever possible, one should avoid the use of traveling barrel pumps, for traveling barrel pumps require the use of small standing valves as well as a small diameter pull tube, both of which cause pressure drops within the pump and cause considerable gas break out. Further, a gas anchor will be required since a top hold down cannot be used. The combined length of the anchor and the pull tube make an inlet tube usually longer than the 25 ft maximum recommended for gas anchor.

There is only one traveling barrel pump which can be successfully used in a gaseous well, and that is the familiar three tube pump. This pump, with its large clearances, permits so much fluid to slip back into the compression chamber that it is virtually impossible to gas lock it. True, it is extremely inefficient; but, in gaseous wells where sand or trash is also a problem, this pump can do the job. However, it is recommended only in extreme cases.

Quite often high GOR wells make slugs or heads of relative dry gas, but usually, the gas in wells of this type is easily separated and because this separation sometimes occurs at the formation face. The separated or free gas frequently must pass through the pump, and wells of this type usually have a low fluid gradient which reduces the pressure required to open the traveling valve. It is, therefore, possible to reach a compression factor high enough to open the traveling valve even though virtually all gas is being compressed. The released gas further lowers the gradient to where it is possible to flow the well for a period.

To encourage this flow, restrictions, within the pump, should be held to a minimum. For this reason, a stationary barrel pump with closely spaced single valves used in conjunction with an adequate gas anchor is recommended.

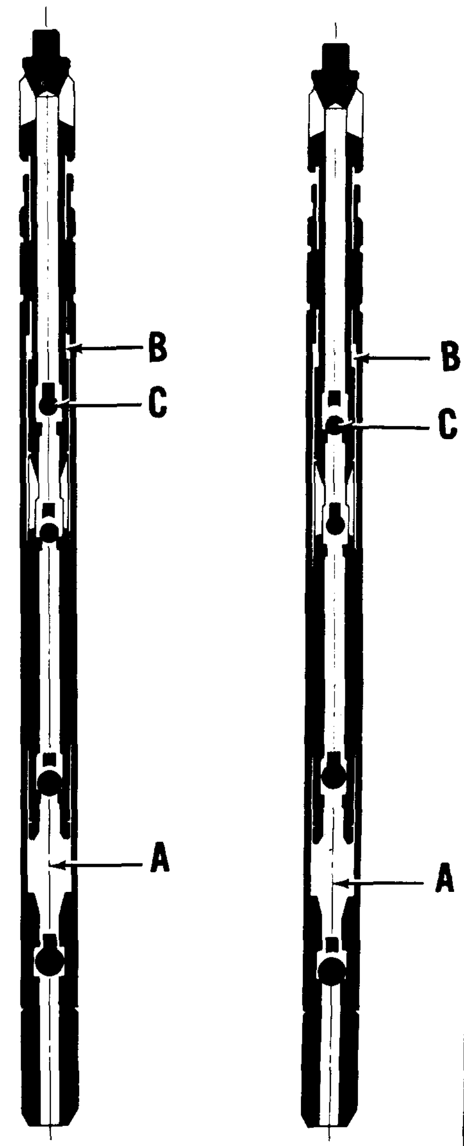
It should also be noted that the rapid passage of gas through the valves accelerates the wear on the ball guides in the cages. However, snubber cages, rubber or stellite lined cages are available tc combat this. And, as a aid to close spacing of the valves, there is a screw device which can be installed in place of the pumping unit carrier bar and which enables one man to lower the polished rod to where the pump will "bump bottom". And it should be borne in mind that the pump hits at the top of the barrel and never at the bottom or traveling valve cage. The bumping of pumps will sometimes jar a ball off seat and break a gas lock, and it also insures maximum compressions at least during the bumping period. Pumps can be built so that a clearance of 1/16 in. or less between the standing valve cage and the seat retainer in the traveling valve can be obtained. Generally this clearance will secure enough compression to successfully handle the high GOR wells.

In summary, an adequate gas anchor of either the forced flow, baffled type, or oversize anchor used in conjunction with a closely spaced, single valved, stationary barrel pump will usually do the best job in the high GOR well.

Next, one whould look at the application of equipment in the foamy well. This condition creates a problem that is sometimes greater than the high GOR well.

When pumping at a steady rate in most foamy wells there is not sufficient time available to allow the gas to

FIG. 1



UP-STROKE D+B TWO-STAGE PUMP

DOWN-STROKE D+B TWO-STAGE PUMP

separate from the oil. Therefore, a considerable amount of gas must be handled by the pump.

Where the wells productivity is ample one solution to this problem is to time clock the well and thereby allow time for separation. The timing sequence must be determined by a study of the individual well and will probably require some experimentation to find the optimum production rate. In this type of production pump bores become very important since, if the pump is too large, the dead fluid will be drawn off too rapidly and allow foam to enter the chamber and gas lock the pump. But at the same time, the pump capacity should be enough to compensate for the gas which will be handled by the pump.

Since some gas will be separated by a good gas anchor in even a stable foamy well, it is important to place the inlet ports in the anchor as deep as possible. Further, a top anchored pump immersed in the gas anchor will give the greatest efficiency at the tank.

The foregoing infers that a really good job cannot be done in pumping foamy wells. This inference is true if one counts only the barrels of oil in the tank, but one must also count the volume of gas produced through the pump. A conventional pump run in a foamy well almost always shows a gas pound on a dynamometer. This gas pound can be eliminated and the overall efficiency of the well improved by the use of a Two Stage pump. (See Fig. 1). In this pump, a compression factor is achieved on both the up and down stroke; and, by virtue of this multiplication of compressions, the pump can neither gas lock nor pound when properly designed for the well.

In normal pumping operations with a conventional pump, closely spaced, compression ratios of 25 or 30:1 are achieved. And, in the two stage pump, insofar as the lower or primary stage is concerned, these same ratios can be secured because the lower portion of both pumps are the same. However, the Two Stage has an upper or secondary chamber, which in the case of the 1-1/2 x 1-1/16 in. plunger sizes, is one half of the lower, (the 1-1/2 x 1-1/4 in. has an upper capacity of 30.6 per cent of the lower); therefore, one has compounded the compression factor of the lower chamber by 2 in one case and by 3.26 in the other. This occurs only if the pump is sized so both chambers are swept to the fullest extent on both the up and down stroke. In other words, the pump barrel tube should be the stroke length plus the plunger length plus the minimum amount for spacing. However, in the event this sizing cannot be done; but to produce the maximum multiplication of the compression ratios, this pump should be spaced at the top of the stroke rather than at the bottom as in a conventional pump. If one has a Two Stage pump which is not producing to his satisfaction, he may try gently bumping the top rather than bumping down as is customary to improve efficiency.

There have been cases in which were applied Two Stage pumps of such length that the upper chamber was larger than the lower chamber. And this application actually created a reverse ratio for the compressed gases were being allowed to expand into the upper chamber rather than being further compressed. On the other hand, when properly applied the Two Stage pump can be the best pump for the foamy well.

A third type of troublesome well is that of the well with gas held in solution. In this type well, the best application found is much the same as is that for the foamy well: complete pump submergence with a top hold down pump, large pump intake to avoid gas break out as far as possible. These wells should be pumped from as near bottom as possible. This position will hold some fluid head on the fluid and assist in filling the pump with a minimum of gas coming out of solution.

Another well-accepted method of controlling gas lock in the saturated well is the use of a back pressure valve. By holding a steady pressure on the well fluids, one can keep much of the gas in solution, at least until it gets into the pump. The use of a Two Stage is then suggested to handle the gas which is flashed out at the beginning of each up stroke.

Considerable success has been achieved in pumping the gas saturated well by using the largest bore pump with the longest and slowest stroke possible considering the unit sizes and the well's ability to produce. This size pump reduces the gas break out because of the flashing at each up stroke. And one should, by all means, avoid using traveling barrel pumps and long "mosquito bills" with the "Poor Boy" anchor.

To summarize, one should carefully analyze the particular well we are trying to pump and determine the characteristics of the well, such as, G. O. R., productivity, present efficiency, etc. In general, oil wells will fall into the three basic classes discussed above, the high G. O. R. well, the foamy well, or the gas saturated well. The rather general guides, for the various conditions, that have presented should one in selecting the best combination of equipment to produce his well.