American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-6, Issue-12, pp-262-266
www.ajer.org
Research Paper Open Access

Analysis of Down hole Gas Separators In Sucker Rod Pumping

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ABSTRACT: *Oil exploration phase consists of prospecting, drilling, completion and production. Initially, oil can be producedby natural elevation, using the reservoir's own energy. However, the well loses energy with the time and it becomes feasible the implantation of an artificial lift method. The sucker rod pumping is the most worldwide used method in the oil industry, especially in Brazil in onshore wells. One of the problems on the operation of this method is the presence of gas at the bottom of the well. The most commonly way to avoid this problem is to use a natural gas anchor, which employs gravity and physical properties of the fluids for an effective separation. If the amount of gas produced is greater than the capacity of the separator, the separation will not occur effectively. The excess of gas will then enter the pump, reducing its volumetric efficiency and the liquid output will also be reduced. The aim of this work is to simulate gas separationin five separators with different geometries using the Total Well Management (TWM) software provided by Echometer company. It could be observed from the results that among the five different geometries, number 4, with Pdmax = 190 BPD, is the one that most closely approximates to the setted flow rate, so it would be the most appropriated one.*

Keywords: *Artificial lift method,Downhole gas separator,Production, Sucker rod pumping.*

Date of Submission: 11-12-2017 Date of acceptance: 21-12-2017

I. INTRODUCTION

There are big challenges on the oil industry and the development of knowledge in this area makes it possible to overcome them. When a reservoir presents low pressure, the fluids do not reach the surface without the addition of an artificial lift method. The objective of artificial elevation is to increase the pressure difference between the reservoir and the bottom of the well [1].The sucker rod pumping (SRP) is the most worldwide artificial lift method used in the oil industry. However, it has some limitations, one of which is in relation to the gas. The bottom pump does not operate with high efficiency when gas is present. Therefore, there is a need to separate the gas and to prevent it from entering the pump. Generally the gas separation is accomplished due to the differences of the densities (ρ) of the fluids involved. However, there are also several arrangements that can be used in the bottom of the well for this separation, called gas anchors. This analysis also takes into account constructive aspects of the pump, the diameters of the tubes involved in the intake and the annular space.This work will study how these variables will influence the gas separation. For this purpose, the Total Well Management (TWM) software provided by Echometer company was used. This software can be used to simulate several wells located in the Brazilian territory producing by SRP, since most of the onshore wells produce with this method. This paper contributes to the understanding and more efficient design of the gas separator at the bottom of the well.

Since the SRP is also the most used artificial lift method in the world [2], there are exhaustive bibliographic materials about it. For that reason, the main problems are already known, allowing opportunities for improvements in the efficiency of the method [3]. One of the problems on the operation of this method is the presence of gas at the bottom of the well. The gas that enters the bottom pump in solution is just as damaging as that which is in the free form. The gas in solution contributes to a reduction in the volume of fluid measured at the surface, since under surface conditions it will be free [4]. Once admitted by the pump, the oil has a fraction of dissolved gas due to the temperature and pressure conditions. After passing through the pump and moving towards the production column, the oil will be subjected to different values of temperature and pressure, so this dissolved gas will now be released. On the other hand, the free gas at the time of admission interferes with the volumetric efficiency of the pump, occupying an undesired space [5].

Oil and gas are fluids of different specific gravities. Therefore, the gas compression may not be sufficient to achieve the pressure required by the liquid to be raised. This may interfere with elevation since the system understands that the pressure required to reach the well head is less than the real one. If the pump is too full of free gas, in this case, the pressure value of the oil and gas assembly is much lower in relation to the pressure exerted by the liquid column on the pump. When this happens, the production is interrupted and the pump remains trapped. In other words, the presence of excess free gas in the pump causes gas blockedge [5].The natural gas anchor is most commonly used due to the ease installation. It is based only on the property of fluids and gravity. The pump inlet is installed below the perforated interval, so the liquids having a greater density (ρ) in relation to the gas tend to move down towards the inlet of the pump. In contrast, the gas will flow through the annular space between casing and production pipe in the opposite direction of the liquid [5].

There are some limitations about the quantity of gas that can be produced without using gas separator. If the amount of the produced gas is greater than the capacity of the separator, the separation will not be effectively managed. The excess of gas will enter the pump, decreasing its volumetric efficiency. Therefore, the oil flow rate will reduce and the production cost will increase. The situation gets worse when there is insufficient fluid compression, resulting in a gas blockedge, stopping production. For these cases, there is a need for a well dimensioned gas separator [5].

II. MATERIALS AND METHODS

In order to simulate gas separation at the bottom of the well, the Total Well Management (TWM) software (version 1.2.1) was used. The software is supplied by EchometerCompany and it is available on the company's website for free download.The software presents simple and intuitive interface. The initial screen shows the input variables, which are: casing size, separator size data, gas bubble rise velocity, pumping speed in strokes per minute and net pump displacement. As well as the casing size, the software offers a number of possibilities concerning the size of the separator. It is up to the user to choose the most suitable one for his purpose. These data include external and internal diameters of the separator and the dip tube, and length of the dip tube, the simulator interface is shown on figure 1.

Fig. 1 Simulator interface

There is also a last field in the left column of the screen, an output variable, which is the maximum separation capacity, read in the simulator as Max Separator Capacity (Pdmax) considering the selected measurements. The Pdmax value can not be changed directly, because it is a value proposed by the simulator for the capacity of the equipment considering the constructive dimensions of the separator. Table 1 lists all possible variables, which will be varied for the simulations.

Table 1.Simulator variables.

Input variables	Output variables
Casing ID (in)	Pdmax (BPD)
Separator OD (in)	
Separator ID (in)	
Dip tube OD (in)	
Dip tube ID (in)	
Net dip tube length (in) Gas bubble rise vel. (in/s) Pump speed (strokes/ min) Net Pump Displacement (BPD)	

Source: Author

The diameters presented in Table 1 are related to external (OD) and internal (ID) measurements of the variables involved.When entering the input data on the software, just click "RUN" to start the simulation. The program does not display diagnostic reports, only dynamic records. The gas is represented by red particles and oilby grey particles. The aim of the simulation is to maintain a good level of oil production with the gas in equilibrium at the inlet of the separator, and flowing through the casing annular space to the well head. Ifgas flows through the annular of the separator, the gas phase will reach the entrance of the dip tube, conform figure 2. Factors such as a lower pumping speed, and a longer dip tube length, may slow down this process, but not prevent it.

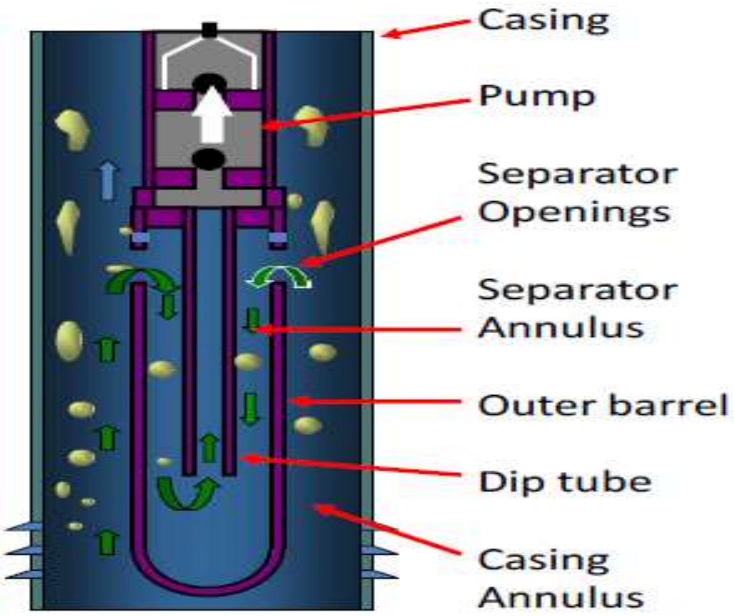

Fig.2 Downhole system

The simulation process consisted of a flow rate of 150BPD and the values of casing size, gas bubble rise velocity and pumbing speed in strokes per minute were set as Table 2, since they are the most common values in the literature and in the field work [6].

Table 2.Input variables values.

Casing size	Gas bubble rise velocity (in/s)	Pumping speed (strokes per minute)
10.75” 65.7 lbs/ft (ID 9.56”)	6	20

Source: Author.

Then five different separator geometries were chosen, aiming to determine the most appropriate one for the given flow rate value (150BPD).

1. Separator 1: 2 – 7/8 Collar Size Gas Separator;

2. Separator 2: 2 – 3/8 Poor Boy Gas Separator;
3. Separator 3: 2 – 3/8 Poor Boy Separator & Top Hold-down;
4. Separator 4: 2 – 7/8 Poor Boy Gas Separator;
5. Separator 5: Packer Separator in 7 inch Casing.

Table 3 shows the relation of the chosen separators and their respective dimensions.

Table3.Worked separators and its dimensions.

	Separator 1 (S1)	**Separator 2 (S2)**	**Separator 3 (S3)**	**Separator 4 (S4)**	**Separator 5 (S5)**
Separator OD (in)	3.75	2.375	2.375	2.875	6.003
Separator ID (in)	3.5	2	2	2.5	6.002
Dip tube OD (in)	1.315	1.315	1.76	1.315	3.5
Dip tube ID (in)	1.049	1.049	1.5	1.049	1.147
Net dip tube length (in)	56	72	180	72	70

Source: Author.

The criteria to select the appropriate separators were the comparison of the values of maximum separator capacity (Pdmax) and Net pump displacement (Pd). If Pdmax is equal to or greater than Pd, the separator is suitable. Otherwise, if Pdmax is smaller than Pd, it will not be suitable.

III. RESULTS AND DISCUSSION

The objective of the simulations was to determine the most suitable geometry of production taking into account a flow rate of 150BPD. The selected separators must consider a value of Pdmax greater or equal to 150BPD, in order to not reach over capacity. Three geometries were selected, given the objective proposed:

1. Separator 1: 2 – 7/8 Collar Size Gas Separator;
2. Separator 4: 2 – 7/8 Poor Boy Gas Separator;
3. Separator 5: Packer Separator in 7 inch Casing.

Consequently, these were considered to be inappropriate:

1. Separator 2: 2 – 3/8 Poor Boy Gas Separator;
2. Separator 3: 2 – 3/8 Poor Boy Separator & Top Hold-down;

The reached results with the selection of three separators are due to the dependence of Pdmax with a specific property of the separator. The value of the maximum separatorcapacity is a function of the area of the annular space of the separator. This area depends on the difference between the value of the internal diameter of the separator and the external diameter of the dip tube. This length was denominated d1. The calculation of the area of the annular space of the separator is similar to that realized in a cylinder.

The greater the value of d1, the larger the area of the annular space of the separator, the greater the maximum volumetric displacement. Table 4 shows the internal diameter values of the separator, outer diameter of the dip tube, d1 and Pdmax of all separators.

Table 4.Separators and variables with Pdmax relation.

	Separator 1 (S1)	**Separator 2 (S2)**	**Separator 3 (S3)**	**Separator 4 (S4)**	**Separator 5 (S5)**
Separator ID (in)	3.5	2	2	2.5	6.002
Dip tube OD (in)	1.315	1.315	1.76	1.315	3.5
d1 (in)	2.185	0.685	0.24	1.185	2.502
Pdmax (BPD)	443	96	38	190	1000

Source: Author.

The other inputs variables of the simulator: separator OD, dip tube ID and net dip tube length, do not influence the maximum separator capacity. This statement was evidenced by changes of these values in all proposed geometries, with no change in the value of the output variable, Pdmax.Separators 1, 4 and 5 were selected as suitable for the objective, since they have a Pd greater than or equal to the proposed 150 BPD flow rate. Among the mentioned geometries, number 4, with Pdmax = 190 BPD, is the one that most closely approximates to the setted flow rate, so it would be the most appropriated one. This would provide operational safety with reasonable economic viability. The other two suitable separators, numbers 1 and 5 shows Pdmax equal to 443 and 1000 BPD, respectively. Although they attend the operational criteria, their values are larger and may have the highest price, and no such investment is actually necessary.

IV. CONCLUSION

The annular space of the separator is essential for the required separation capacity at the bottom of the well. Through the simulations with a production flow setted to 150 BPD, a specific separator (number 4) was chosen from five different geometries, taking into account the production limit of the separator as well as the economic viability criteria.From the simulations it could be observed that the area of the annular space of the separator is the main variable that influences the maximum volumetric displacement. It is also possible to vary the diameters of the dip tube or the separator, in order to improve the Pdmax value.

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U. P. Santana "Analysis of Downhole Gas Separators In Sucker Rod Pumping." American Journal of Engineering Research (AJER), vol. 6, no. 12, 2017, pp. 262-266.