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Research Article

Developing Well Performance Analysis for Improving the pump capacity of Jet Pumps using SNAP software

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Abstract

Oil wells which are being produced having liquid in it having reservoir pressure, those wells have energy through which liquids are being pushed to lower pressure areas. Artificial lift methods defined as to application of artificial method through which flow of crude oil production can be increased or improved from production well. In general, this could be done through a mechanical device that are used inside the well like pump or velocity string, this method is working through decreasing the weight of the hydrostatic column with injecting gas into the liquid phase distance down the well. To develop a troubleshooting model of pumping capacity of jet pump to achieve optimized flow rate using well performance nodal software (SNAP). To abridge the pump selection technique by conducting sensitivity analysis over nozzle and throat size. In this studies SNAP Software is used to select proper nozzle and throat for jet pump in various conditions, to avoid the problems. Through SNAP can analyze relationships between the reservoir, wellbore, and surface equipment to determine a wells' production capacities. After that in this study troubleshooting for jet pump will also be discussed, in which most common problem of jet pump occurred during operation and installation will be indicated. Proper specific gravity ratio of reservoir fluid and power fluid can optimize high efficiency of jet pump. It is also observed that viscosity ratio of reservoir fluid to the power fluid can reduce the quantity of light oil in power fluid. (again economical). It is better to select nozzle and throat size through computer software because software gives accurate result then human & also gives good recommendation for selecting best nozzle and throat size for given conditions. It is better to simulate first then apply.

Keywords: *Jet Pump, Nozzle and Throat size, Selection of Jet pump, Simulation of Jet pump, Artificial Lift.*

1. Introduction

Artificial lift methods defined as to application of artificial method through which flow of crude oil production can be increased or improved from production well. In general, this could be done through a mechanical device that are used inside the well like pump or velocity string, this method is working through decreasing the weight of the hydrostatic column with injecting gas into the liquid phase distance down the well. Artificial lift is required in wells when they do not have enough energy left in the reservoir to push the reservoir fluids from subsurface to surface, sometimes used in naturally flowing wells most of them which do not technically need it, to increase the production rate above that they wanted which is naturally flowing. The producing fluid could be oil may have little quantity of gas in it. Most of the wells which are oil producing reservoirs can flow naturally for initial period, after they are initially started to produce.

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Reservoir and formation gas pressure give energy to take the fluid from subsurface to surface in a producing well. As the well initially started produce, this energy decreases after some period that energy is not sufficient to bring the fluid form subsurface to the surface. Oil reservoirs then eventually not be able to produce fluids at its economical rates unless naturally drive mechanisms like aquifer or gas cap and pressure maintenance mechanisms like water flooding or injecting gas are available to maintain reservoir energy. When that reservoir energy could be insufficient for the well to flow up to surface, or the oil producing rate that is desired is greater than the reservoir energy that is not enough to deliver, it although very essential to put that well on some sort of artificial lift to push and give the energy required to bring the fluid up to the surface. By employing artificially lift methods, the bottomhole pressure is reduced, providing increased drawdown to obtain increased production. Therefore, artificial lift is described as "use of artificial means to boost the flow of crude oil from producing well".

Jet pumps are a type of artificial lift method for downhole pump that are made for hydraulic pumping systems whereas they are different from reciprocating piston pumps. It may be opted to sit interchangeably into the Bottom hole assemblies designed to the stroking pumps. Furthermore, special designed BHAs have been set for jet pumps to take benefits of its small-sized and their greater-volume characteristics. Due to its distinctive characteristics under various conditions, jet pumps must be opted as the option of the conventional stroking pumps.

1.1 Benefits of Artificial Lift Techniques

The purpose of artificial is very necessary because when wells are not producing at desire rate or economically viable, then artificial lift performs, 1: Compensates for the declining reservoir pressure. That maintains the required production rate 2: Offsets the effect of rising water production 3: Overcomes high frictional pressures related to the production of denser or waxy crudes 4: Kicks off high liquid-gas ratio wells that can die when they are shut in 5: Reduces the effect of back pressure in flow line 6: Keeping a rate of production which decreases waxy layer or scale deposition.

2. Methodology

The jet pump foremost commonly used artificial lift method in Pakistan as well as in globe, so to know the mechanism & selection of its parts, it is essential to have a thorough studies of jet pump. In jet pump to Optimum production is mainly based on nozzle and throat, the important factor is to identify the problem and proper solution or proper action that is be taken. So, in my studies the almost all problems will be indicated which can be happen in jet pump and their best solutions, like the selection of nozzle and throat and this study is based on software approach by using various parameters to optimize the productivity of the well. It involves the comparison of different nozzle and throat sizes, grades, and manufacturer specification. Further, it elaborates various problems regarding the jet pump and its remedial action. In this studies SNAP Software is used to select proper nozzle and throat for jet pump in various conditions, to avoid the problems. Through SNAP can analyze relationships between the reservoir, wellbore, and surface equipment to determine a wells' production capacities. After that in this study troubleshooting for jet pump will also be discussed, in which most common problem of jet pump occurred during operation and installation will be indicated.
This paper is based on a software approach, it means that a real well data is being taken and evaluated through software then results are generated on suitable selection.

In this paper SNAP software is used to evaluate the condition of well and for selection of nozzle and throat of jet pump. SNAP is a method designed to use nodal analysis to conduct well-performance predictions. In order to assess the output potential of a well, SNAP will analyze interactions between the reservoir, wellbore, and surface equipment. This research is called nodal analysis since, to better describe their relationships, these areas are segmented into nodes.

2.1 Development of Jet Pump Model

The software offers the tools to maximize well production rates, estimate production history reservoir variables and forecast a well's potential production schedule with transient pressure outcomes.

2.2 Well input parameters.

A 6,130 ft deep well named as AZ has a potential to produce 41o API oil with GOR 350 scf/stb and 63.2% water cut through a 2.875-in. (2.441-in. ID) tubing in a 7-in. casing with a pump installation. Gas- and water-specific gravities are 0.77 and 1.06, respectively. The wellhead and bottom-hole temperatures are 120^{o} F and 196^{o} F, other data as given in **Table 1 & 2.**

Table 1 Well Data

Oil API Gravity	41^{o}API
Gas Specific Gravity	0.770
Water Specific Gravity	1.060
Well static pressure BHP	2100 Psia
Well bottom temp	196^{o}F
Well head temp	120^{o}F
Produced oil water cut	63.2%
Tubing ID	2.441 inch
Tubing OD	2.875 inch
Perforation Depth	4885 ft
Casing ID	6.148 inch
Casing OD	7.000 inch
Tubing length	4668 ft

In this well AZ power fluid is selected water, because well AZ has water cut up to 63.2%. If a well has low water cut it is better to select oil (diesel, or other fluid), due to these conditions well is suitable for Jet pump installation, and for proper circulation of power fluid water was considered.

Table 1 Additional Data For Jet Pump Design

Well static BHP	2100 Psia
Wellhead Pressure	130 Psia
Net pay thickness	30 ft
Permeability	185 md
Wellbore Radius	0.256 ft
Power Fluid	Water
Minimum pressure for power fluid	3300
Maximum pressure for power fluid	3350
Power fluid Spec: gravity	1.060
Packer at	4990 ft
End of tubing (EOT)	4999 ft
Plug back true depth (PBTD)	6310 ft
Gas oil ratio (GOR)	350 scf/STB
Perforation diameter	0.50 inch
Perforation penetration	8.00 inch
Perforated interval	20.00 MD ft
Shot Density	6.00 SP/ft
Desire Production rate	5000 BLPD (Total liquids)

3. Results and Discussion

The well AZ has properties mentioned above, the oil produced by well AZ shown in **Fig. 1** and IPR curve for this AZ well is shown in Fig. Here it is being seen that oil production is decreasing and water production is increasing by time as shown, after few years wellhead pressure has been depleted and now well AZ hits the economic limit (as per company policy) now to produced economically, it is necessary to use artificial lift method.

Although the contribution of jet pumping to the artificial lift method is relatively low, it has been become more attractive in recent years. Many publications have been appeared in which the theory of jet pumping is represented and the used of the jet pumps in oil well pumping is described. However, cases some practical question arise, and specific problem must be solved. To select the optimum jet pump's nozzle and throat size within a horsepower constraint. The power required depends on the nozzle size, the operating pressure, the depth of the well, and the pump intake pressure. By trying a couple of sizes one can quickly determine the largest nozzle size that will match the horsepower limit. For a given nozzle size, there will be an optimum throat size (area ratio) to maximize production at a given power fluid pressure and pump intake pressure. By trying different ratios with the same nozzle size, the optimum ratio can be determined.

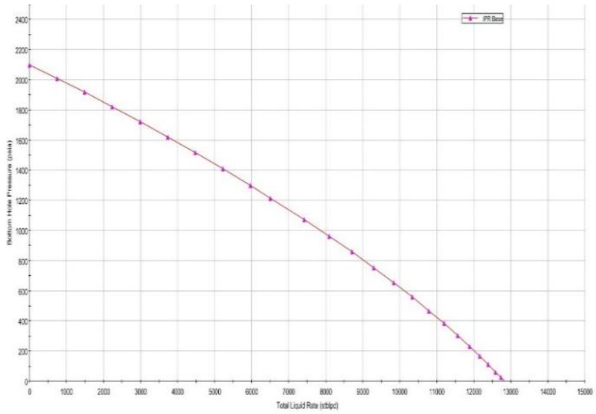

Fig. 1 Shows IPR (inflow Performance Relation) For the well

This above **Fig 1** shows the well performance before installation of Jet pump.

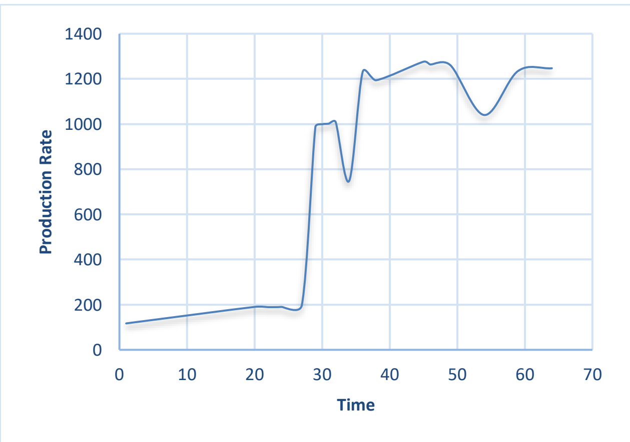

Fig. 2 Time vs Water Production by Natural Recovery

These graphs show water production, oil production and wellhead pressure.

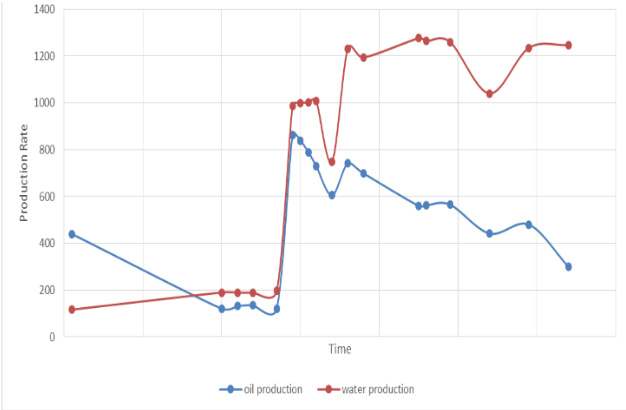

Fig 3 Water and Oil Production Rate Comparison

The above **Fig 3** shows the comparison of both water and oil production it shows that the water production is increasing as oil production is decrease.

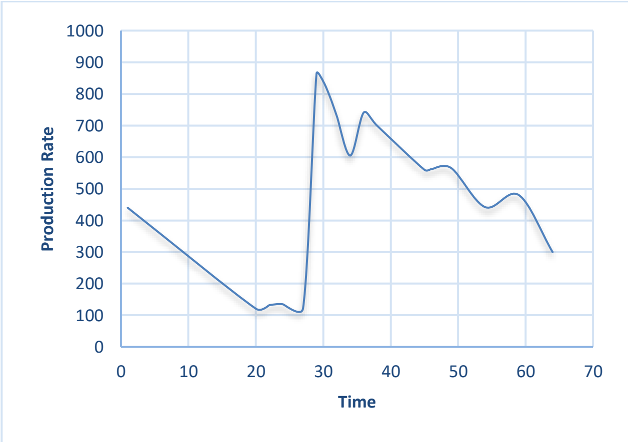

Fig. 4 Time vs Oil Production by Natural Recovery

The above **Fig 4** shows oil production rate at natural recovery method and can be seen that its decline is very rapid, this is due to increase production of water from the well

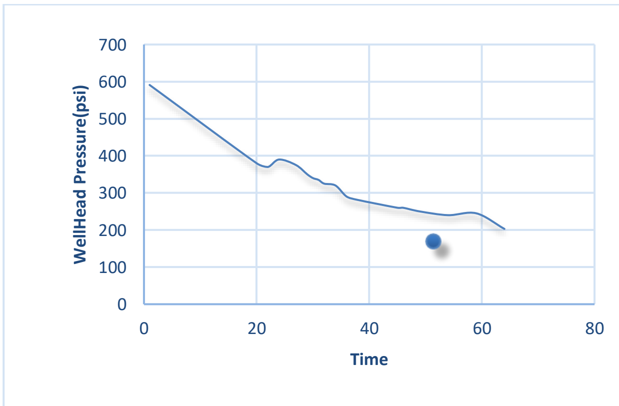

Fig. 5 Time vs Wellhead pressure by Natural Recovery

In **Fig 5** it represents the wellhead pressure is decreasing due to loss of water (water was acting as natural recovery method), so due to that well is losing its capacity of natural recovery.

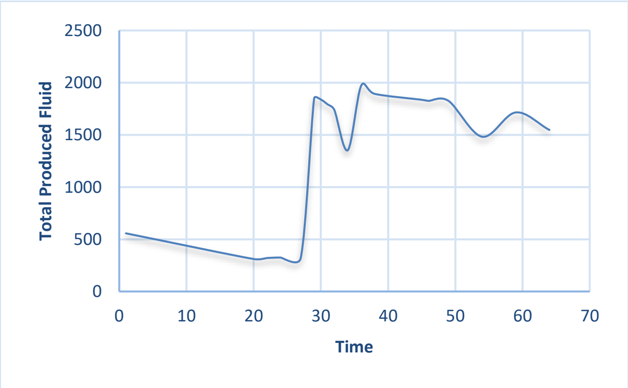

Fig. 6 Time vs Total produced fluid by Natural Recovery

The total produced fluid is a combined production of oil and water that is produced by natural recovery, the trend of production from a particular well as shown in **Fig 6**.

3.1 Software Results for Nozzle and Throat Size

Different sizes of nozzle and throat for well AZ designed results are shown following.

3.1.1 KOBE 12C nozzle and throat size

For 12C the **Fig 7** shows pressure line enters the cavitation zone. This nozzle and throat size will not be suitable for well AZ. It is better to select another nozzle and throat size.

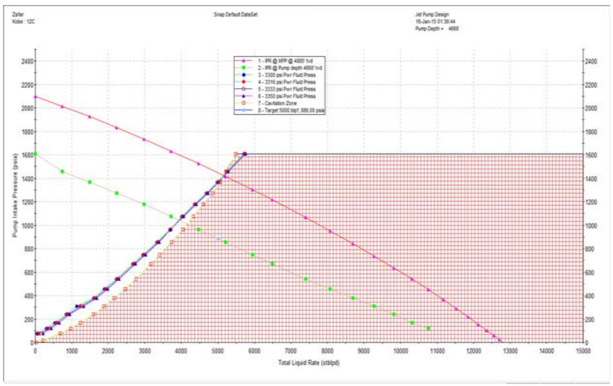

Fig 7 KOBE 12C Nozzle and Throat size for well AZ

3.1.2 KOBE 11A nozzle and throat size

The 11A nozzle and throat size is also not suitable for well AZ, because pressure line total is at desire rate of production and pressure are entering in cavitation zone. The select totally bad for nozzle and throat as shown in **Fig 8**.

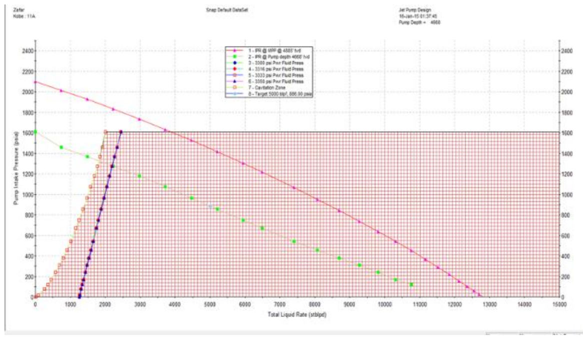

Fig 8 KOBE 11A Nozzle and Throat size for well AZ

3.1.3 KOBE 13B nozzle and throat size

The 13B nozzle and throat size is also not suitable for well AZ as shown in **Fig 9**, because pressure line total is at desire rate of production and pressure are entering in cavitation zone.

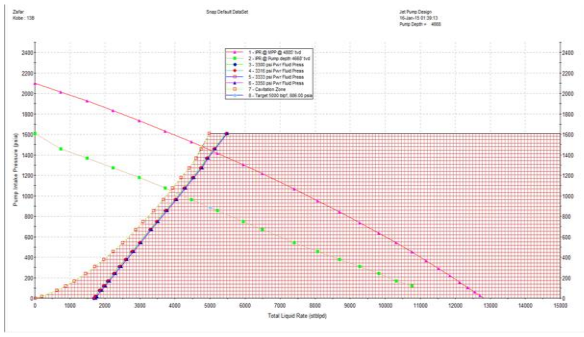

Fig 9 KOBE 13B Nozzle and Throat size for well AZ

From above figures it was concluded that all throat and nozzle sizes would be not suitable because these creates cavity problems in the throats. Therefore, the best select for well AZ will be the KOBE 12D & 14C.

3.1.4 KOBE 12D nozzle and throat size

In 12D the desire production rate and pressure at which power fluid will be injected, is not in cavitation zone as depicted in **Fig 10**. This is one of the best selections for well AZ.

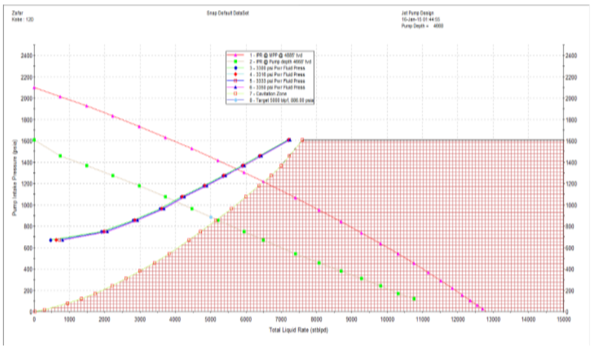

Fig 10 KOBE 12D Nozzle and Throat size for well AZ

3.1.5 KOBE 14C nozzle and throat size

In 14C the desire production rate and pressure at which power fluid will be injected, is not in cavitation zone as shown in **Fig 11**. This is one of the best selections for well AZ.

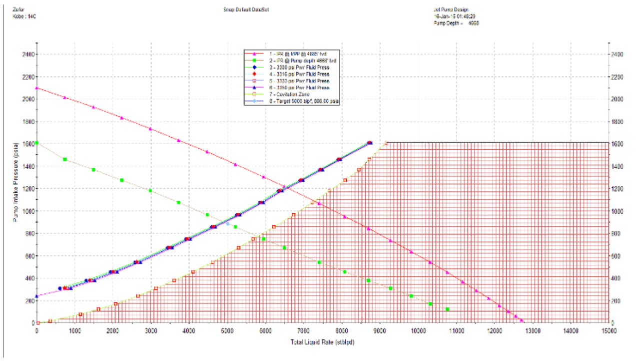

Fig 11 KOBE 14C Nozzle and Throat size for well AZ

Conclusion

It is necessary to discuss the appropriate mathematical model of the jet pump before the implementation and selection of auxiliary components of jet pump.

It is also observed that cavitation and critical two-phase flow can be avoided without damaging performance by operating jet pump at high throat entrance pressure relative to the pump intake pressure. Proper specific gravity relation of reservoir fluid and power fluid can optimize high efficiency of jet pump as this study recommends.

It is also observed that viscosity ratio of reservoir fluid to the power fluid can reduce the quantity of light oil in power fluid.

The production was inclined from 200 to 350 bbl/day which optimized the overall production rate by 150 bbl/day which is dramatic incline in overall production. This factor cannot be investigated in pilot projects as it requires huge capital expenditure, henceforth, this study provides the feasibility to adopt the optimum parameters within reasonable time.

To avoid any risk of loss of production or risk to troubleshooting, it is necessary to pre-plan all prevention methods before any problem or emergency occur.

Recommendations

Comparative analysis of different deep wells could be carried out by this SNAP software for validation and conformation of results.

These results can be compared to other artificial lift to check whether these result and selection are effective and appropriate for well.

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