# Production Data Analysis and Sonolog for Determining Artificial Lift Design and Well Characteristic

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## ABSTRACT

Tarakan Field, North Kalimantan is a part of PT. Pertamina EP Asset 5. The Tarakan Field has 5 structures in the form of Pamusian, Juata, Sesanip, Mangatal, and Sembakung. The Tarakan Field has 57 production wells and 6 injection wells. The wells at Tarakan field are produced with artificial lifts in the form of Sucker Rod Pump (SRP) totaling 25, Hydraulic Pumping Unit (HPU) totaling 11, Electric Submersible Pump (ESP) totaling 19 and Progressive Cavity Pump (PCP) totaling 2. The determination of artificial lifts is carried out by the design of well characteristics and production history. The design at Tarakan Field was carried out with an artificial lift in the form of ESP (Electric Submersible Pump). ESP is used according to reservoir and formation characteristics in Tarakan Field.
Water Control Diagnostic Plot is a method used to analyze the effect of control on produced water. Water Control Diagnostic plot is plot between WOR and WOR derivative vs time. The plot was carried out on a log-log scale. The plot on the Water Control Diagnostic Plot is then analyzed against the graph created by the KS Chan. So from the analyzed plot, it is found whether or not there is a problem in the well at Tarakan Field. The results of the graph analysis on the well at Tarakan Field on the chart show that the field does not indicate a problem.

**Keywords:** chan plot; design; esp; production

## I. INTRODUCTION

### 1.1. Field Review

PT. Pertamina EP has 5 work areas/assets such as assets 1, 2, 3, 4, and 5. Asset 5 has a work area of 5, namely in Sangata, Bunyu, Tanjung, Sanga-Sanga, and Tarakan Fields. The Tarakan Field is located in North Kalimantan. Tarakan Field changed ownership in several periods from 1905 to the present. In the previous period from 1992 to 2008 Tarakan Field ownership was owned by Medco / TAC Exspan. Production for the 1992-2008 period by Medco amounted to 2,864 BOPD. In 2008 until now the Tarakan field is owned by Pertamina. The actual total production rate every month in the Tarakan field is 2902,182 BOPD. The production rate exceeds the target production rate of 2681,746 BOPD as Net production. The rate obtained experienced a gain of 108.220%.

Tarakan Field has 5 active structures there is Pamusian (6.28 km2), Juata (2 km2), Sesanip (0.67 km2), Mangatal (0.9 km2), and Sembakung (23.37 km2). The Tarakan Field has 57 production wells and 6 injection wells. Oil production at Tarakan Field is carried out using an artificial lift. Artificial lifts used in this field are SRP (Sucker Rod Pump), HPU (Hydraulic Pumping Unit), ESP (Electric Submersible Unit) and PCP (Progressive Cavity Pump). The use of SRP in Tarakan Field is 25 units, HPU is 11, ESP (innovation) is 19 and PCP is 2.

The wells produced at Tarakan Field are old wells that had more than 95% water cut. Production of wells in the Tarakan Field is carried out with an artificial lift supported by Workover and Well Service programs at the well to optimize production.

### 1.2. Literature Review

In the knowledge of petroleum engineering in a field is divided into several aspects, there's exploration, reservoir, drilling, production, and WOWS. Each of these aspects is related to one another. For example in the aspect of production is closely related to the reservoir aspect in knowing the performance of wells and reservoir characteristics in planning the optimal production steps in the well.

The production aspect is explained regarding the direction of production flow from the well (artificial lift) and from the wellhead to the surface production facility. Artificial lift is a method of producing well fluid by providing additional energy to the well (not into the reservoir). The additional resources available include:

1. Pump, Consist of:
    - Sucker Rod Pump

- Progressive Cavity Pump (PCP)
- Hydraulic Pumping Unit (HPU)
- Hydraulic Jet Pump (HJP)
- Electric Submersible Pump (ESP)

2. Gas Lift, Consist of:
    - Continous gas-lift
    - Intermittent gas-lift

Sucker Rod Pump is an artificial lift system that has been used extensively in oil fields. Sucker Rod Pump is controlled by pump stroke and pump rate. The mechanism of sucker rod pump is the rotational motion of the prime mover is converted into an up and down motion by the pitman-crank assembly system, then this up and down motion by the horse head is used as a straight up and down motion (bobbing) to move the plunger through the series of rods. During the upstroke, the plunger moves upward causing the downward pressure to fall. Because the bottom well pressure is greater than the pressure in the pump, as a result, the standing valve opens and oil enters the working barrel. At the downstroke of the fluid load in the barrel and the pressure caused by the plunger rises, the standing valve closes while the traveling valve on the plunger opens due to oil pressure not in the barrel, then at the maximum upstroke the oil will be moved into the tubing.

ESP (electric submersible pump) is a centrifugal pump driven by a motor with electric power where in the operation, the pump and motor are below the fluid level (immersed in fluid). In ESP pumps, each stage consists of one impeller and one diffuser. On the impeller, there are two disks in which it is used to flow fluid. The working principle of the esp pump is that the fluid entering the pump through the intake will be rotated by the impeller with a high rotational speed resulting in a centrifugal force, then the fluid will be thrown into the diffuser, then the fluid will flow through the tubing.

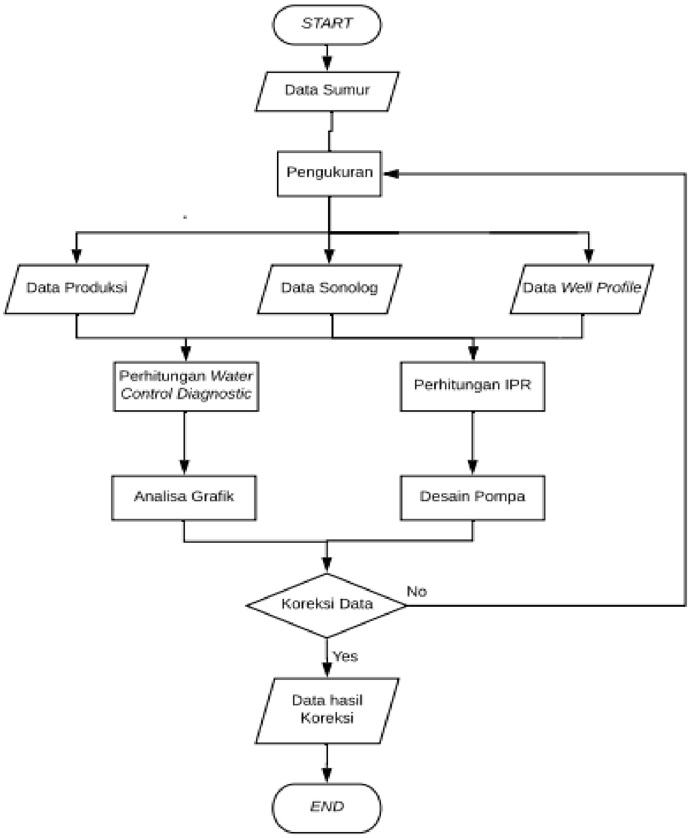
Progressive Cavity Pump (PCP) is a type of rotary pump that consists of two main components, namely Rotor and Stator. The working principle of PCP is to work by relying on 2 main elements (rotor and stator). The rotor rotates eccentrically on the stator, this rotation of the rotor will form cavities which will push the fluid up through the tubing up to the surface.

The determination of the artificial lift that will be used will be adjusted to the characteristics of the well and production history. From this analysis, production data, sonolog data, and well profile data were obtained. Then analysis and calculation of the artificial lift are suitable. Then there are surface production facilities that are used to treat the produced oil. An example of determining an artificial lift is the determination of ESP design.

The determination of the ESP design was done by making the first IPR. Then the plot of the distribution of production data will be analyzed. Then the production data is processed with sonolog data. After that the calculation is done regarding static pressure and flowing pressure. From this pressure, the IPR design can be adjusted later in the pump selection. Then determine the optimum flow rate to be designed. The flow rate has a 70-80% maximum production rate. After determining the design flow rate, the ESP pump is determined. If the ESP pump has been determined the stages are calculated. The calculation of these stages includes TDH (Total Dynamic Heaf), and HP motor. The TDH includes the Net Vertical Lift, Tubing Head and Friction. Then the stage is calculated by dividing TDH with Head/stages in the pump specifications and determining the motor HP.

## II. METHODS

The methodology used in this observation is in the form of literature studies and field observations. The data obtained are primary data and secondary data.




**IPR and ESP Pump Design (Well X4)**

1. Sonolog and Production Data Matching
   Matching is done by equating the date between sonolog data and production data.
2. Fluid Data Analysis

**Table 1.**
**Fluid Data from Well X4**

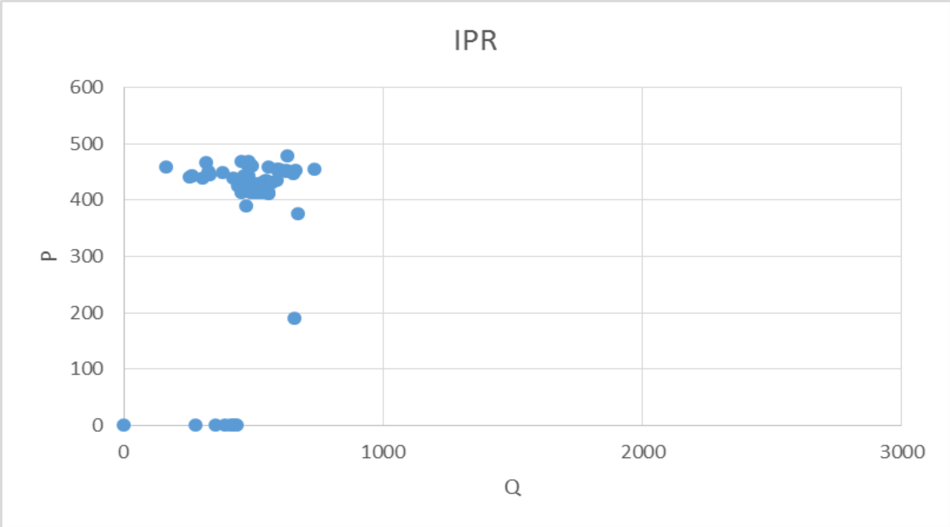
| | | | | | | |
|---|---|---|---|---|---|---|
| DATA FLUIDA | | | WC | 97% | | |
| API | 23 | | Pcasing | 7.053086 | psi | |
| SGf | 0.92 | | Perforasi | 348.8 | 351.65 | m |
| SG mix | 0.997 | | | 354.5 | | |
| Gf | 1.42 | psi/m | | | | |

3. Determine Pwf

**Table 2.**
**Pwf Data from Well X4**

| Tgl.pengambilan | Gross | DFL | Pwf |
|---|---|---|---|
| | | | |
| 3-Jan-18 | 164.12 | 27.69 | 459 |
| 9-Jan-18 | 319.44 | 22.61 | 466 |
| 12-Jan-18 | 324.72 | 33.65 | 451 |
| 16-Jan-18 | 382.8 | 34.75 | 449 |
| 19-Jan-18 | 588.72 | 43.99 | 436 |
| 24-Jan-18 | 549.3807 | 43.81 | 436 |

4. Graphic Plot betweel P vs q




**Graphic 1.**
**Distribution of Production Data**

5. Assume that

**Table 3.**
**Well Productivity**

| Assume | |
|---|---|
| Ps | 500 |
| Q | 319.44 |
| Pwf | 466 |

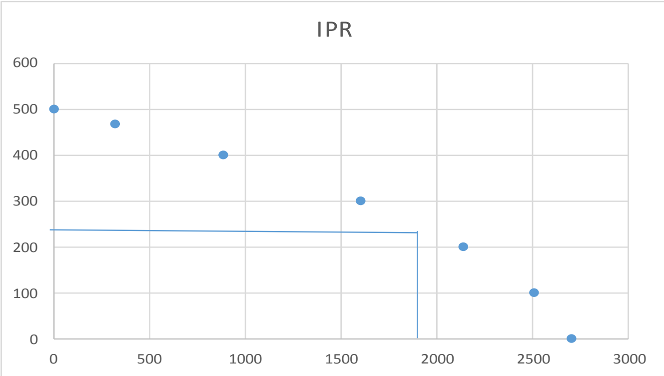
| | | |
|---|---|---|
| PI | 9.43733 | |
| Qomax | 2702.8 | BFPD |

6. Assume Pwf

**Table 4.**
**Vogel IPR Determination**

| Q | P |
|---|---|
| 0 | 500 |
| 319.44 | 466.151 |
| 886.5192891 | 400 |
| 1600.059205 | 300 |
| 2140.619747 | 200 |
| 2508.200915 | 100 |
| 2702.802711 | 0 |

7. IPR Curve




**Graphic 2.**
**Inflow Performance Relationship (IPR)**

8. Flow Rate (q) Design

Q desgin = 70% x Qo max = 1891,962 bpd

9. ESP Pump Data (REDA)

**Table 5.**
**Pump Specification**

| | | |
|---|---|---|
| HP | 0.33 | hp/stage |
| Head | 5.486132 | m/stage |
| Effisiensi | 70 | % |

10. Determination of the type of pump

**Table 6.**
**Rate Design**

| | | |
|---|---|---|
| Data Pompa | | |
| Q | 1891.962 | BFPD |
| Pwf | 240 | psi |
| Depth | 169.4076 | m |

11. Total Dynamic Head (TDH) Determination

$$\textbf{HT} = \frac{Tubing\ Pressure\,(psi)\ x\ 2.31\,ft\,/\,psi}{Sp.Gr.\ Campuran}$$

= 11.296 m

$$\textbf{FT} = Ft = \frac{2.083\left(\frac{100}{C}\right)^{1.85}\left(\frac{Qt}{34.3}\right)^{1.85}}{ID^{4.8655}}$$

$$\textbf{PSD} = \text{Depth} + \frac{\text{Pc}}{\text{Gf}} + \frac{100}{3.281}$$

= 5.58515 ft/1000 ft

= 672,161 ft

**HF** = Ft x PSD = 1,442 m

**HD** = Depth = 169,408 m

**TDH** = 11,296 + 1,1442 + 169,408 = 1831,848 m

12. Determination of Motor Pump

Stage $= \frac{\text{TDH}}{\text{Head}} = 34\ \textit{Stages}$

HP motor = Sgf x Stage x Hp

= 0,997 x 34 Stages x 0,33

= 10,9079 Hp

## III. RESULTS AND DISCUSSION

### 3.1. Pump Design

The determination of the artificial lift used is the design first. The design is carried out in accordance with production data, sonolog data, and well profile data. Each of these data has different parameters. Production data is obtained from the daily production data of the well which is correlated with the well's history. In addition, there are sonolog data obtained from the sonolog process.
Production data generated on a certain date will describe the production of these wells at specified intervals. The data includes gross flow rate data including oil and water, net production rate includes oil, water cut data, and information. From the production data, it can be averaged about the production rate either gross or net.

Sonolog is a tool used to determine the depth of a fluid column. In the sonolog activity, it is carried out with sonolog software with an instrument called an echometer. In software, there are several lines. The first step in the software in line F2 is acquire mode, then choose to obtain zero offset pressure equal to 20.1 psi (g). Then choose the well that will be done by a sonolog. Then select line F5, a graph appears showing the level of liquid which will be fired Nitrogen ($N_2$). Wait 20 seconds to shoot Nitrogen (click the Fire Shoot button). Then a liquid level chart appears after $N_2$ firing and scaling down. On the graph, read the initial reflection (DFL). Then proceed to the next column and determine the time needed for the $N_2$ shooting. If less than 1 second is included in Acoustic. In the pressure casing column can be read the pressure on the casing and do the pressure reading for 2 minutes. Then in the next column (BHP) write the data recorded in the form of pump intake, fluid depth, fluid content, gas content, casing pressure and the time of the job. From sonolog data, SFL (Static Fluid Level), DFL (Dynamic Fluid Level), casing pressure, and time parameters can be obtained. The sonolog process is carried out over a period of time.

Correlation between production data and sonolog data produces data that covers both data. From this data, it can be used to design the IPR (Inflow Performance Relationship). IPR is a graph that shows reservoir productivity in a layer. The data used in the production data are the rate of gross, net and water cut production. In Sonolog, the data used is like SFL is used to determine static pressure. DFL data is used to determine flowing pressure. Also, there are water cut and casing pressure data that are averaged. Then from the data, a plot is made between the production rate vs. Pwf. From the plot that has been done, the data distribution is obtained to determine the static pressure and production rate data that represents all. Then the pump design calculation is performed. The design of the pump is done on the design of artificial lift pumps in the form of ESP. The use of the ESP design was obtained based on the characteristics of the wells against screening criteria with a predetermined production rate design. Then it can be seen the type of pump that will be used by the calculation of the analyzed data.

### 3.2. Water Control Diagnostic Plot

Data needed in the next analysis is water cut data. In the water cut data obtained an average value of 97% water cut. Analysis of the water cut shows that the water cut at the well in Tarakan Field is relatively high. High water cut caused by wells in the Tarakan Field, including the old well that was first drilled in 1897. Then when production is carried out from that year until now, it is proven that water production continues to increase. The increase in gross production, especially in the production of water is caused by the existence of an aquifer zone which may indicate large. The indication of the large aquifer zone can be analyzed that the driving force in the reservoir is the strong water drive. In addition, an analysis was conducted regarding the indication of problems with high water production with a water control diagnostic plot.

Water control diagnostic plot is a method used to analyze the effect of control on produced water. This Water Control Diagnostic Plot was created by K.S Chan. This Water Control Diagnostic plot plots between WOR and WOR derivative vs time. The plot was carried out on a log-scale scale. Then do a comparison of the Chan chart. From the comparison that has been done it can be seen whether or not there is a probel that occurs in the field.

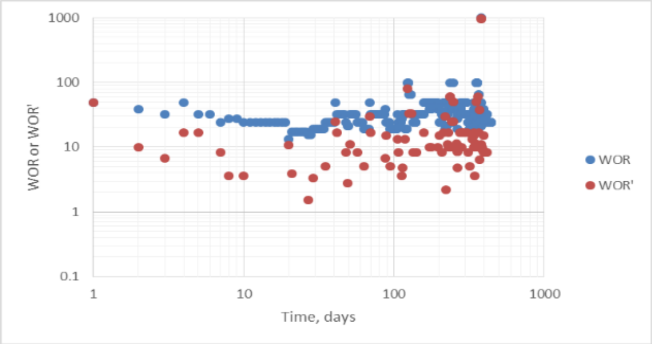



**Figure 1.**
**Chand Plot from Well X1**

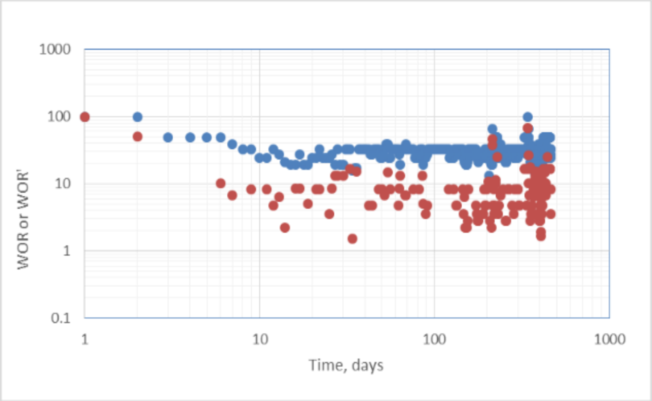



**Figure 2.**
**Chand Plot from Well X2**

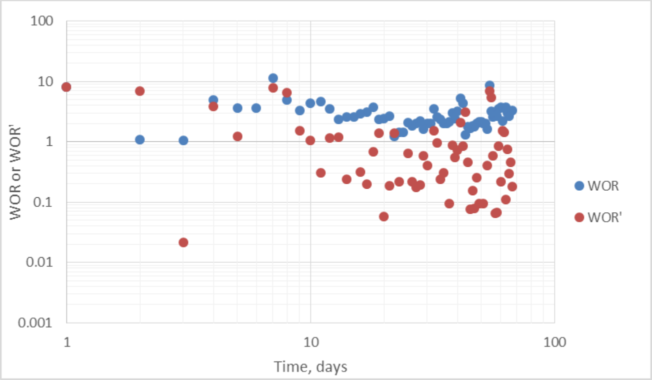



**Figure 3.**
**Chand Plot from Well X3**

The results of the graph analysis on the well at Tarakan Field on the chart shows that the field does not indicate a problem. The intended problem is channeling and coning problems. So that the graph is more inclined on the graph with normal displacement. The rising WOR and WOR Derivative prices are caused by the large possible aquifer zones and high water production with high latrines. So it is implemented in a graph with a rising curve.

## IV. CONCLUSION

- Tarakan Field has 5 structures in the form of Pamusian, Juata, Sesanip, Sembakung, and Mangatal.
- The Tarakan Field has 57 production wells and 6 injection wells.
- The wells at Tarakan Field are produced with
- artificial lift with type 25 Sucker Rod Pump (SRP), Hydraulic 11 Pumping Unit (HPU), 19 Electric Submersible Pump (ESP) and 2 Progressive Cavity Pump (PCP)

- The actual total production rate every month at the Tarakan field is 2902,182 BOPD. The production rate exceeds the target production rate of 2681,746 BOPD as Net production.
- The design for determining artificial lift is adjusted to production data, sonolog data, and well profile data.
- Production data generated on a certain date will describe the production of these wells at specified intervals.
- Sonolog is a tool used to determine the depth of a fluid column.
- Correlation between production data and sonolog data produces data that covers both data. From this data it can be used to design IPR (Inflow Performance Relationship).
- Determination of artificial lift design can be determined based on the characteristics of the wells on the rate of production produced.
- Water control diagnostic plot is a method used to analyze the effect of control on produced water.

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