Optimization and Prediction of Sucker Rod Pump Performance on Well X-1 in Field X in the Future

(Optimasi dan Prediksi Kinerja Pompa Angguk pada Sumur X-1 di Lapangan X di Masa Mendatang)

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Abstract
The performance of the sucker rod pump is influenced by the characteristics of the well and reservoir such as pressure, well productivity, physical properties of the fluid, depth and diameter of the well. Therefore, pumping pumps need to be designed and optimized taking into account these conditions. As time goes on production changes in physical properties occur in the reservoir such as a decrease in reservoir pressure and a decrease in well productivity. Changes in the physical properties of the reservoir will affect the performance of the sucker rod pump. The purpose of this study is to design a sucker rod pump at X-1 well and forecast production in the future. The flow rate determination is obtained from the point of intersection between the pump intake pressure curve and IPR curves both in the present and in the future. In this study the pump speed is set at 10 SPM. Based on this method it was found that the well can produce with a flow rate of 1132 bpd with an oil flow rate of 27 bpd. The stroke length for this condition is 304 inch. Over time the production is estimated to cause the pressure to decrease to 1010 psi in 2040. The decrease in reservoir pressure causes the reduction in the flow rate of sucker rod pump to 1046 bpd with an oil flow rate of 14.6 bopd. So that the magnitude of the reduction in the flow rate of liquid between 2019 and 2040 was 7.6%, while the decrease in the oil flow rate was 45.9%. If the speed is set at 10 SPM, the stroke length needs to be reduced with time. The stroke length was designed to be 304 inches in 3019 and reduced to 281 inches in 2040.

Keywords: Sucker rod pump, Pump speed, Stroke length, Optimization, Future

I. INTRODUCTION
Field X is a field that has long been produced. Therefore Field X is included in a mature field. The field is located in South Kalimantan Province. As the production time goes on, changes in the physical properties of the reservoir occur. The initial pressure of Reservoir X at Field X at the beginning of production was 1628 psi. At this time reservoir X pressure drops below bubble point pressure to 1100 psi. Most of the wells in Field X produce fluid using artificial lift equipment. The artificial lifting equipment that is commonly used...
in Field X is sucker rod pump (SRP) and electric submersible pump (ESP).

In this study, an SRP design was conducted to be applied on well X-1. The well produces fluid from Reservoir X, one of the reservoirs in Field X. In order to produce fluid using the pump optimally, it is necessary to adjust the pump speed (N) and stroke length (S). Pump speed was set at 10 rpm. So that in this study an allowable stroke length was selected that produces at the optimum flow rate.

As mentioned above that reservoir pressure declines as production time increases. A decrease in reservoir pressure results in a decrease in flow rate in the future. Accordingly it is necessary to adjust stroke length in the future. In addition, the decline in production rate and reservoir pressure will affect the requirement of horse power.

Based on the background that has been described, then several things can be analysed, such as the allowable stroke length for X-1 well that provide optimum production rates and future production rate and stroke length adjustment due to reservoir pressure decline. Then, the purpose of this study is to design a pump pump at X-1 well and to analyze production rate changes and stroke length adjustment in the future.

II. METODOLOGI

The research procedure carried out in this study is shown in Figure 1. Basically the research stages include data collection, pump optimization, and prediction of pump performance in the future. The procedure of the research is as follows:

1. Plot the Inflow Performance Relationship (IPR) Curve (Inflow Curve) [1, 2]
2. Prepare the Pump Intake Pressure Curve [3, 4, 5]. To make a pressure curve into the pump (plunger) it is necessary to calculate constants a, b, c. The steps required are:
   a. Select the type of Sucker Rod and rod weight.
   b. Select the steel quality (in this study is API grade C with a service factor of 0.65 and a minimum tensile strength, T of 90000 psi).
   c. Determination of Crank to Pitman ratio (c/p).
   d. Determination of Plunger cross-sectional area.
   e. Determination of the constant K.
   f. Determination of weight of Sucker Rod in the air, Wr.
   g. Determination of constants b and c.
   h. Calculation of Sectional Sucker Rod Top Sect Area, Ar.
   i. Specific calculations of fluid gravity (oil and water).
   j. Calculation of fluid (water and oil) weight that fill in the Plunger (Wf).
   k. Determination of parameter a.
   l. Plot Pump Intake Pressure Curve (Outflow Curve).
   m. Determination of Flow Rate (q) in the Present and Future [6, 7].
4. Calculation of Polished Rod Material Strength

   The strength of the polished rod material needs to be calculated. The calculated parameters are:
   a. Maximum polished rod load (Peak Polished Rod Load).
   b. Minimum polished rod load (Minimum Polished Rod Load).
   c. Constants α1 dan α2.
   d. Maximum stress, σmax, minimum stress, σmin, allowable, and allowable stress, σallowable-

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**Figure 1. Flow Diagram of the Research**

The first step is data collection and preparation. The collected data include the data of reservoir...
physical properties and data of Well X-1, as shown in Table 1. The change in reservoir pressure and water cut (WC) [8] in the future can be predicted by using the regression equation as shown in Figures 2 and 3, respectively. The estimated decline of the reservoir pressure was used to construct inflow performance relationship curves at years 2025, 2030, 2035, and 2040.

Table 1. Reservoir and Well Data

| Parameter                        | Well X-1               |
|----------------------------------|------------------------|
| Casing Diameter (ID), inch       | 6.336 (7”OD)           |
| Tubing Diameter (ID), inch       | 2.875                  |
| Wellhead Pressure, $P_{wh}$, psi | 110                    |
| Pump Depth, ft                   | 3788                   |
| Bottomhole Temperature, °F       | 140                    |
| Specific Gravity of Water, SGW   | 1.06                   |
| Specific Gravity of Oil, SGO     | 0.83                   |
| Specific Gravity of Gas, SGG     | 0.6                    |
| Maximum Flowrate, $q_{\text{max}}$, bpd | 2187               |
| Reservoir Pressure, $P_r$, psi   | 1100                   |
| Bubble Point Pressure, $P_{bp}$, psi | 1400               |
| Water Cut, WC, %                 | 97.6                   |

![Figure 2](image-url)  
Figure 2. Reservoir Pressure Decline.

![Figure 3](image-url)  
Figure 3. The Trend of Water Cut

![Figure 4](image-url)  
Figure 4. Present Flow Rate of Well X-1

### III. RESULTS AND DISCUSSION

At the condition of reservoir pressure $P_r$, under bubble / boiling pressure, the Vogel IPR equation can be used to depict the relationship between flow rate and bottom hole pressure. Based on the data given in Table 1 where $q_{\text{max}}$ is 2187 bpd and reservoir pressure $P_r$ is 1100 psi, then the IPR curve shown in Figure 4. Future IPR curves can be made using Eickmeier [6] based on estimated future reservoir pressure shown in Figure 4.

![Figure 5](image-url)  
Figure 5. Pump Intake Pressure Curve

The possible flow rates in the present and future time can be obtained from the intersection between the IPR (inflow) curve and the P3 pump inlet pressure curve as shown in Figures 4 and 5, respectively. The possible flow rates are shown in Table 2. In this study, the pump speed (N) was set...
at 10 spm. Since the present flow rate that was obtained from the intersection of the curves was 1132 bpd then the stroke length (S) was 304 inch. The future stroke lengths are given in Table 2. The table show that the stroke length decreases as flow rate declines. Therefore the stroke length of the pump should be adjusted in the future.

Table 2. Determination of Flowrate (q) and Stroke Length (S)

| Date           | N, spm | q, bpd | S (inch) |
|----------------|--------|--------|----------|
| 1 April 2019   | 10     | 1132   | 304      |
| 1 January 2025 | 10     | 1106   | 297      |
| 1 January 2030 | 10     | 1088   | 292      |
| 1 January 2035 | 10     | 1067   | 286      |
| 1 January 2040 | 10     | 1046   | 281      |

The maximum polished rod load occurs in the upstroke motion of the rod where the plunger has to lift up the fluid. While the minimum polished rod load (Minimum Polished Rod Load) occurs when the equipment moves down. Table 3 shows the results of the calculation of constants $\alpha_1$, $\alpha_2$, PPRL, and MPRL.

Table 3. Calculation of Constants $\alpha_1$, $\alpha_2$, PPRL, and MPRL

| Date             | $\alpha_1$, ft/sec$^2$ | $\alpha_2$, ft/sec$^2$ | PPRL, lb | MPRL, lb |
|------------------|------------------------|------------------------|----------|----------|
| 1 April 2019     | 0.573                  | 0.289                  | 16573    | 5586     |
| 1 January 2025   | 0.560                  | 0.282                  | 16595    | 5647     |
| 1 January 2030   | 0.551                  | 0.277                  | 16610    | 5689     |
| 1 January 2035   | 0.540                  | 0.272                  | 16628    | 5738     |
| 1 January 2040   | 0.529                  | 0.267                  | 16646    | 5787     |

The stress experienced by the material lies between the maximum stress, $\sigma_{max}$, and minimum stress, $\sigma_{min}$. And the maximum stress must be lower than the allowable stress, allowable. Table 4 shows the value of maximum stress, max, minimum stress, min, and allowable stress, $\sigma_{allowable}$, for each combination of time, N, and S.

Table 4. Determination of Maximum Stress, Minimum Stress, and Allowable Stress

| Date       | $\sigma_{max}$, psi | $\sigma_{min}$, psi | $\sigma_{allowable}$, psi | Remarks  |
|------------|---------------------|---------------------|---------------------------|----------|
| 1-4-2019   | 16681               | 5623                | 17788                     | acceptable |
| 1-1-2025   | 16703               | 5684                | 17822                     | acceptable |
| 1-1-2030   | 16719               | 5726                | 17846                     | acceptable |
| 1-1-2035   | 16737               | 5775                | 17874                     | acceptable |
| 1-1-2040   | 16755               | 5824                | 17901                     | acceptable |

IV. CONCLUSIONS

Based on the results discussed above, it can be concluded that:

1. At pump speed (N) of 10 spm, the sucker rod pump is estimated to produce liquid flow rate of 1132 bpd and stroke length (S) of 304 inch.
2. The flow rate of the sucker rod pump is reduced to 1046 bpd by 2040 due to a decrease in reservoir pressure in the future.
3. The pump stroke length (S) needs to be reduced to 281 inches due to the decrease of flow rate to 1046 bpd.

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