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

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Kinerja pompa angguk dipengaruhi oleh sifat-sifat sumur dan reservoir seperti tekanan, produktivitas sumur, sifat fisik fluida, kedalaman dan diameter sumur. Oleh karena itu, pompa angguk perlu didesain dan dioptimasi dengan mempertimbangkan kondisi tersebut. Dengan berjalannya waktu produksi terjadi perubahan sifat fisik pada reservoir seperti penurunan tekanan reservoir dan penurunan produktivitas sumur. Perubahan sifat fisik reservoir tersebut akan mempengaruhi kinerja pompa angguk. Tujuan kajian ini adalah mendesain pompa angguk di sumur X-1 dan peramalan produksi di masa mendatang. Penentuan laju alir diperoleh dari titik perpotongan antara pump intake pressure curve dan kurva-kurva IPR baik dimasa sekarang dan di masa mendatang. Dalam kajian ini kecepatan pompa ditetapkan pada 10 SPM. Berdasarkan metode tersebut diperoleh bahwa sumur tersebut dapat berproduksi dengan laju alir sebesar 1132 bpd dengan laju alir minyak sebesar 27 bpd. Stroke length untuk kondisi tersebut adalah 304 inch. Dengan berjalannya waktu produksi diperkirakan menyebabkan tekanan berkurang menjadi 1010 psi pada 2040. Penurunan tekanan reservoir menyebabkan penurunan laku alir pompa angguk menjadi 1046 bpd dengan laju alir minyak sebesar 14.6 bopd. Sehingga besarnya penurunan laju alirliquid antara 2019 hingga 2040 adalah sebesar 7.6%, sedangkan penurunan laju alir minyak sebesar45.9%. Apabila kecepatan ditetapkan pada 10 SPM, maka stroke length perlu dikurangi dengan berjalannya waktu. Stroke length didesain sebesar 304 inch pada 3019 dan berkurang menjadi 281 inch pada 2040.

Kata-kata kunci: Pompa Angguk, Kecepatan Pompa, Panjang Langkah, Optimasi, Masa Mendatang

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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 spm. 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.
f. Determination of the constant K.
g. Determination of weight of Sucker Rod in the air, W_r.
h. Determination of constants b and c.
j. Calculation of Sectional Sucker Rod Top Sect Area, A_{Tr}.
k. Specific calculations of fluid gravity (oil and water).
l. Calculation of fluid (water and oil) weight that fill in the Plunger (W_f).
m. Determination of parameter a.
n. Plot Pump Intake Pressure Curve (Outflow Curve).

3. 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 α_1 dan α_2.
d. Maximum stress, σ_{max}, minimum stress, σ_{min}, allowable, and allowable stress, $\sigma_{allowable}$.

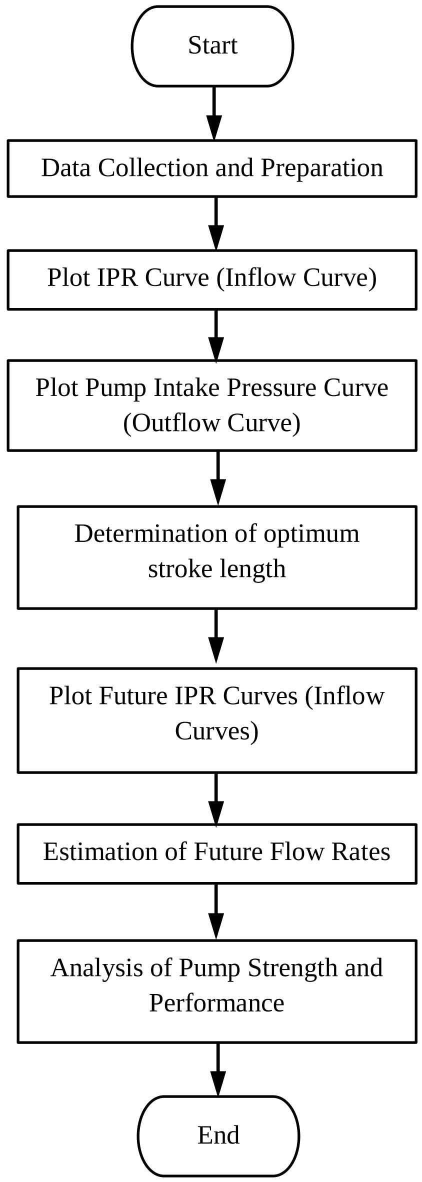

Figure 1. Flow Diagram of the Research

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, ^oF	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_{max}, bpd	2187
Reservoir Pressure, P_r, psi	1100
Bubble Point Pressure, P_b, psi	1400
Water Cut, WC, %	97.6

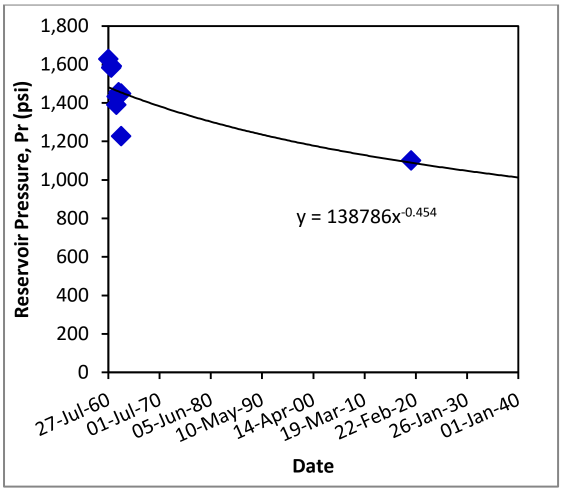

Figure 2. Reservoir Pressure Decline.

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_{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.

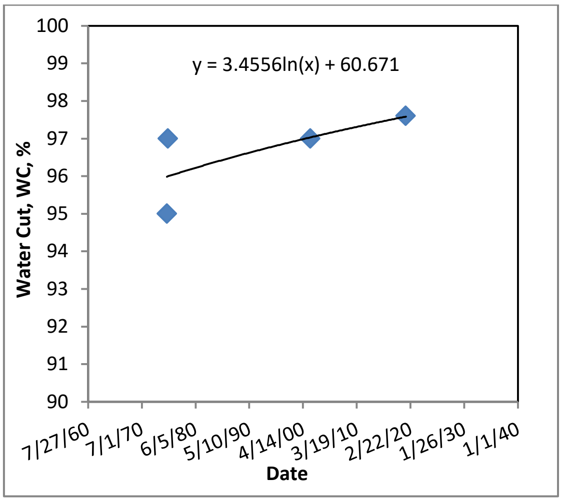

Figure 3. The Trend of Water Cut

Pump intake pressure curve is a curve that relates fluid pressure (P3) and flow rate (q) that enters the pump. If the plunger is located at the bottom of the well, the pump inlet fluid pressure (P3) is equal to the bottom well pressure (Pwf). The pump intake pressure curve is shown in Figures 4 and 5.

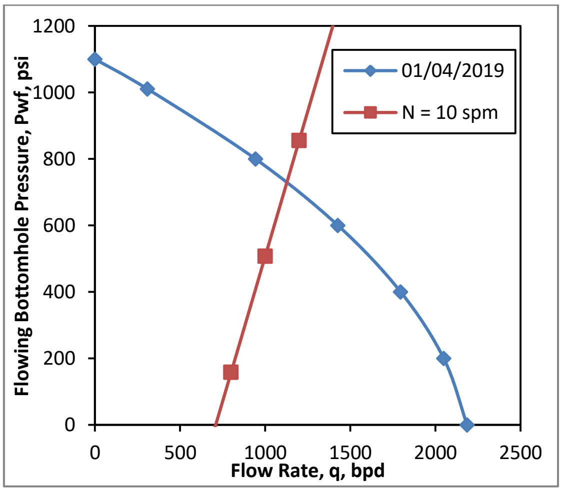

Figure 4. Present Flow Rate of Well X-1

The possible flow rates in the present and future time can be obtained from the intersection between the IPR (inlow) 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 move down. Table 3 shows the results of the calculation of constants α_1, α_2, PPRL, and MPRL.

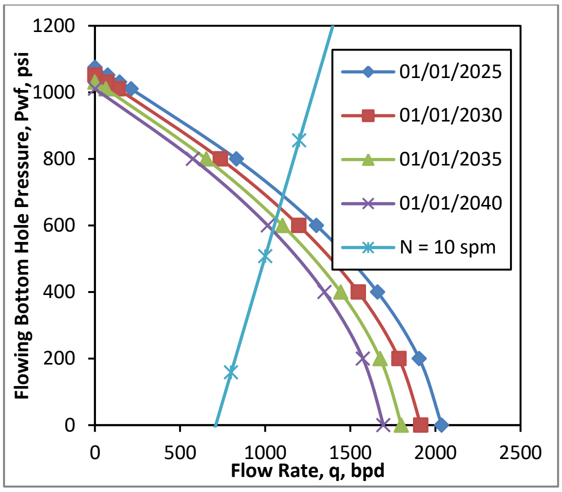

Figure 5. Future Flow Rate of Well X-1

The stress experienced by the material lies between the maximum stress, σ_{max}, and minimum stress, σ_{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 3. Calculation of Constants α_1, α_2, PPRL, and MPRL

Date	α_1, ft/sec^2	α_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

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

Date	σ_{max}, psi	σ_{max}, 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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