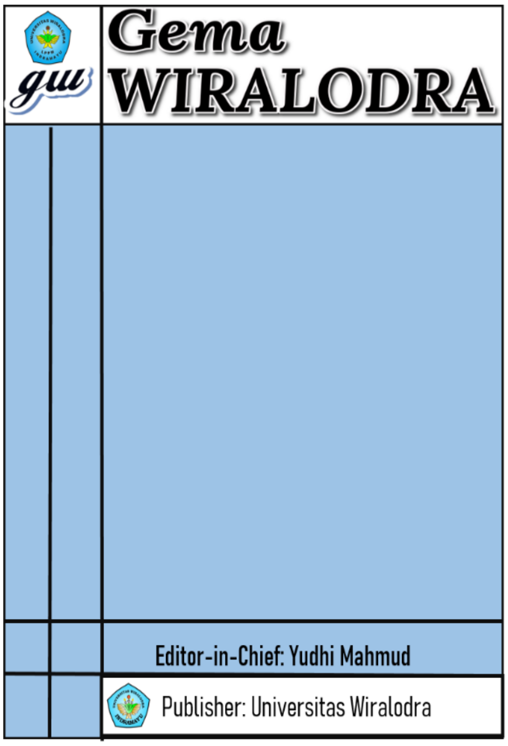

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Abstract
In the "BTN-01" well, one of the wells is owned by KSO PT PERTAMINA EP PT Sarana GSS Trembul. The "BTN-01" well is installed with a hydraulic pumping unit pump that experiences decreasing production, and based on tests on January 30, 2023, the output of the "BTN-01" well produces only 216 bfpd with 98% of water cut. The pump operates on 8 SPM of pump speed and 74-inch stroke length, with 43% of volumetric efficiency. As per theory, a proper design of hydraulic pumping unit pump will produce a volumetric efficiency value above 70%. To overcome this problem, it is necessary to perform research, started with an evaluation on the existing design and continue to quantitative research by recalculating the optimum production rate from IPR calculation, recalculating pump speed, recalculating pump stroke length, and recalculating volumetric efficiency to achieve higher value on both production rate and volumetric efficiency of the pump. In the "BTN-01" well, IPR was calculated by the Wiggins method, and it is known that the oil production rate is 5.53 bopd, 421.96 bwpd of water rate, and the fluid production rate is 427.5 bfpd. Based on the results of HPU redesign and recalculation of the optimum production rate, the new value of pump speed is 7 SPM (existing 8 SPM), the pump stroke length is 70 inches (existing 74 inches) with a volumetric efficiency of 78.45% (existing 43%) that can be called optimal.
Keywords: efficiency volumetric, hydraulic pumping, pump speed, stroke length

1. Introduction

The process of lifting fluid from the well to the surface consists of several methods, including natural wells, which lift reservoir fluid from the bottom of the well to the surface with the natural ability of formation pressure. and some are assisted with artificial lifts, often called artificial wells. However, what will be discussed here is the Hydraulic Pumping Unit (HPU) installed in the "BTN-01" well.

"BTN-01" was produced naturally at the beginning of production because the reservoir pressure was still sufficient to push the production fluid to the surface. However, gradually, the well experienced a decrease in pressure so that it could not push the production fluid to rise to the surface. Therefore, the artificial lift method was chosen with the type of Hydraulic Pumping Unit. The reason for using this pump is that it is very suitable for very low to medium production rates. However, after installing the HPU pump for a long time, the well experienced a decrease in production and a decrease in volumetric efficiency below 70%, and based on the last test, the production of the "BTN-01" well was less than optimal, fluid rate is 214 bfpd with 98% of water cut.

For this background, it is necessary to conduct research that evaluates the design of the installed pump. Thus, the factors that cause a decrease in production can be known. After evaluation, optimization calculation can be done by changing the pump design parameters according to the recent well conditions. So, it is hoped that the rate of production will increase again.

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2. Method

For this case study of recalculation production on "BTN-01" well, the research method that applied is mix method (qualitative & quantitative). The qualitative research conducted by studied the existing production data and well condition. The quantitative research was conducted as the following procedure:

(1) Calculation of Productivity Index (PI)

Below is the data that is needed for the calculations in this study.

Table 1

Well Data

Data	Value	Unit
Pump Setting Depth (L)	1732	ft
Dynamic Fluid Level (DFL)	1519	ft
Static fluid level (SFL)	587	ft
Total production fluid rate (Qf)	211	BFPD
Oil rate (Qo)	3	BOPD
Water rate (Qw)	208	BWPD
Static Reservoir Pressure (Ps)	318	psi
Bottom-hole Reservoir Pressure (Pwf)	183	psi
Pump Speed (N)	8	SPM
Pump Stroke Length (S)	74	inch
Pump Size/Plunger diameter (dp)	2,75	inch
Plunger area (Ap)	5,94	$inch^2$
Top Rod diameter (dr)	0,875	inch
Top Rod area (Ar)	0,601	$inch^2$
Total length of Rod $^7/_8$	38	jts (1 joint = 25,48)
Total length of Rod $^3/_4$	30	jts (1 joint = 25,48 ft)
SGoil	0,83	Fraksi
Sgwater	1,01	Fraksi
Sgmix	1,006	Fraksi
Elasticity Constant €	3×10^7	Fraksi
Service Factor (SF)	0,35	Fraksi
Tensile Strength (T)	115000	psi
Existing Volumetric Efficiency	43%	
Tubing ID (dt)	2,99	inch
Tubing area (At)	7,03	$inch^2$
Top Perforation	2122	ft
Bottom Perforation	2158	ft
Mid Perforation	2140	ft

A productivity index is a number or constant of well production capability which is defined as the ratio of the rate of fluid production to the difference between the static well pressure and the well bottom flow pressure. This can be known based on the following equation:

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$$PI = \frac{Qf}{Ps - Pwf} \quad (1)$$

$$PI = \frac{211\ bfpd}{318\ psi - 183\ psi}$$

$$PI = 1.5\ bfpd/psi$$

(2) Calculation and generation of the IPR curve

The Wiggins method that will be used to generate the IPR of the "BTN-01" well, which is an advance of the Vogel method that equates the two-phase method from Vogel with the three-phase method, thus obtaining a three-phase method that is simpler than the existing three phases. The Wiggins method (three-phase IPR equalization) assumes that each phase can be treated separately, so that the oil rate (Qo) and water rate (Qw) can be calculated separately. Empirically Wiggins states the basic equation of the three-phase IPR curve as follows:

For Oil:

$$Qo = Qomax\ X\ (1 - 0.51\left(\frac{Pwf}{Pr}\right) - 0.48\left(\frac{Pwf}{Pr}\right)^2) \quad (2)$$

For Water:

$$Qw = Qwmax\ X\ (1 - 0.72\left(\frac{Pwf}{Pr}\right) - 0.28\left(\frac{Pwf}{Pr}\right)^2) \quad (3)$$

For Fluid:

$$Qf = Qo + Qw \quad (4)$$

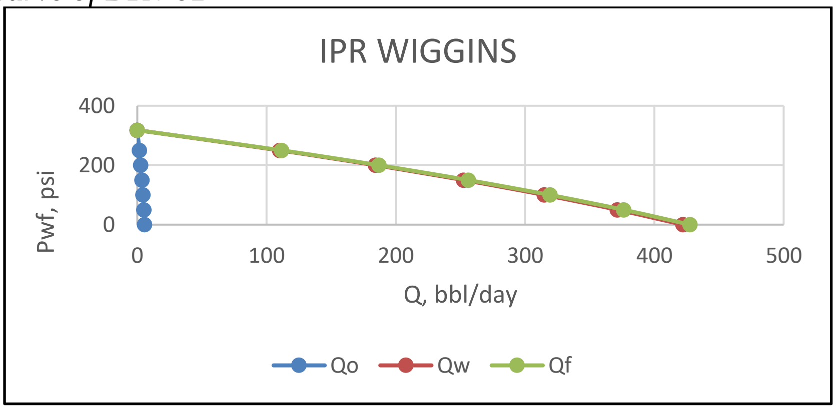
Table 2

Pwf, Qo, Qw and Qf

Pwf (psi)	Qo (bopd)	Qw (bwpd)	Qf (bfpd)
318,00	0,00	0,00	0,00
250,00	1,63	102,09	111,72
200,00	2,67	184,15	186,83
150,00	3,59	252,37	255,95
100,00	4,37	314,74	319,11
50,00	5,02	371,27	376,29
0,00	5,54	421,96	427,50

Figure 1

Wiggins IPR Curve of BTN-01



(3) Calculation and generation of IPR curve and pump speed (N)

The new calculation aims to increase the production rate of well BTN-01, by changing the pump design parameter according to the current well conditions. By finding the appropriate stroke length (S) and pump speed (N) for the production rate obtained from the constants a, b, and c, the appropriate values for S and N are obtained without exceeding the maximum speed obtained from the IPR curve. The following is the equation used to optimize the HPU pump below:

$$a = \frac{1}{Ap}\left[wf + (0.9 - 0.5063\ x\ Sf)x\ Wr - \left(\frac{T}{4}xSfxAr\right)\right] \quad (5)$$

$$b = \frac{Wr\ x\ N}{56400\ x\ K\ x\ Ap}\left[\left((1 + (0.5625\ x\ Sf)\right) + \left(1 - (0.5625\ x\ Sf)\right)\right)\right] \quad (6)$$

$$c = \frac{Wr}{45120\ x\ K^2\ x\ Ap\ x\ S}\left((1 + 0.5625\ x\ Sf)\right) + \left(1 - (0.5625\ x\ Sf)\right) \quad (7)$$

After getting the values of the constants a, b, and c, they are substituted with the pump intake equation, refer to the following equation:

Pi = a + (b*N) x Q (8)

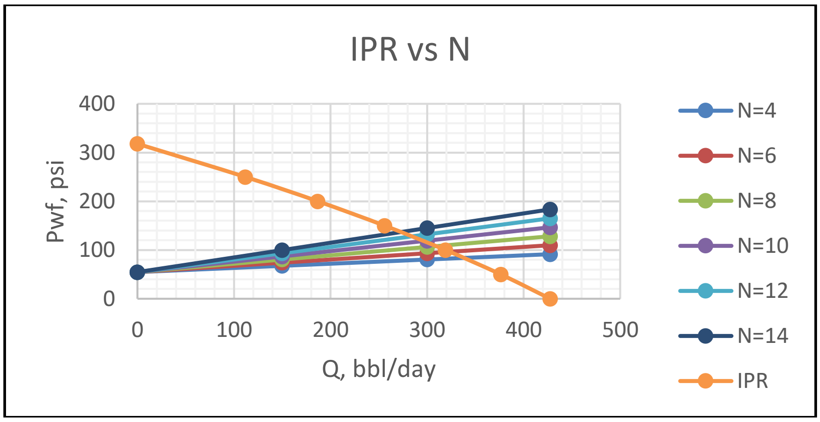
Pi = a + (c/S) x Q^2 (9)

Determine several values of N and assume for several values of Q so that the price of the intake pump can be obtained. Then plot the pair of data (q,Pi) for each N value on the IPR curve.

Table 3
Pi, N & Q

Qo (BFPD)	Intake Pressure (Pi), psi					
	N=4	N=6	N=8	N=10	N=12	N=14
0,00	54,63	54,63	54,63	54,63	54,63	54,63
150,00	67,54	73,99	80,45	86,90	93,35	99,81
300,00	80,45	93,35	106,26	119,17	132,07	144,98
427,50	91,42	109,81	128,20	146,59	164,98	183,38

Figure 2
IPR Curve vs N



(4) Calculation and generation of IPR curve and pump stroke length (S)

Determine the various values of stroke length (S) (inch) and assume for several values of

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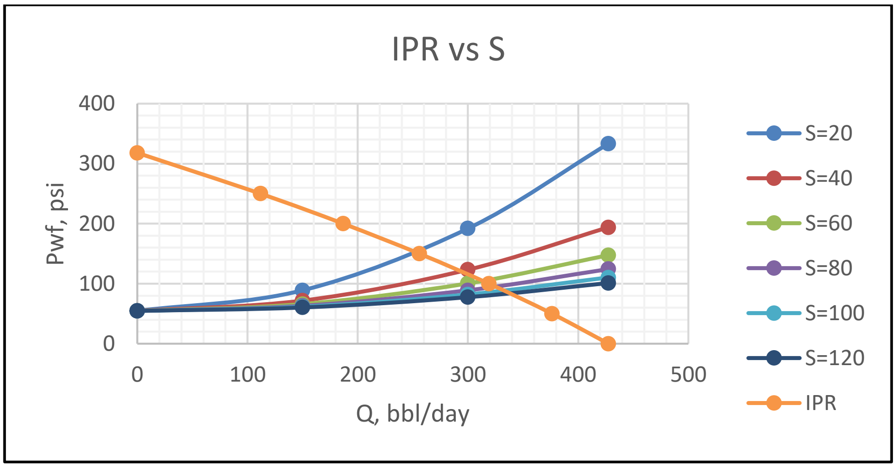
q so that the price of Pi can be obtained. Then plot the pair of data (q,Pi) for each S value on the IPR curve.

Table 4
Pi, S and Q

Qo (BFPD)	Intake Pressure (Pi), psi					
	S = 20	S = 40	S = 60	S = 80	S = 100	S = 120
0,00	54,63	54,63	54,63	54,63	54,63	54,63
150,00	88,95	71,79	66,07	63,21	61,50	60,35
300,00	191,90	123,27	100,39	88,95	82,09	77,51
427,50	333,37	194,00	147,55	124,32	102,38	101,09

Figure 4
IPR Curve vs S



From the intersection of both IPR vs N and IPR vs S curves, a pair of flow rate data is obtained for each Stroke Per Minute (N,q) price and flow rate for each Stroke Length (S,q) price, then plotted to obtain a relationship curve between N and S to q.

Figure 5
Curve of S,N vs Q

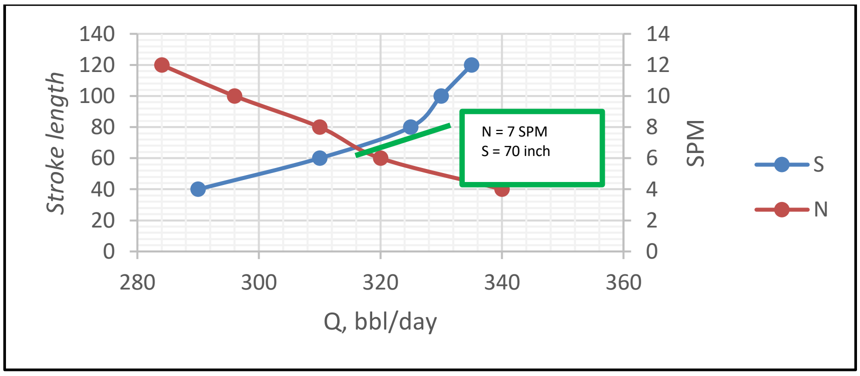


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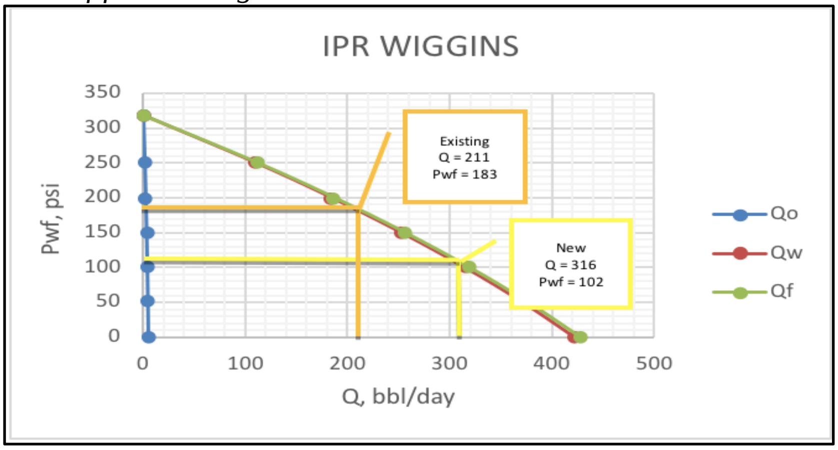
Figure 6
Comparison Q vs Pwf for Existing and New Calculation



From Figures 5 and 6, it is known that the production rate of BTN-01 well can increase to 316 bfpd, Pwf 102 psi, with HPU speed (N) 7 SPM and stroke length (S) 70 inches.

(5) Determination of Volumetric Efficiency (Ev)

The volumetric efficiency (Ev) of the pump is defined as the ratio between the actual production and the theoretical pump displacement (V). The value of volumetric efficiency (Ev) gives an idea of the level of success of a pump installation.

The volumetric efficiency value is considered optimum if the volumetric efficiency value is more than 70%, if the efficiency value is less than 70% then it is said to be less optimum (Kermit, 1980). The calculation of the volumetric efficiency of the Hydraulic Pumping Unit is used to determine the efficiency of the hydraulic pump unit (HPU) pumping ability. Based on (Musnal, 2015):

$$Wr = M \times L \quad (10)$$

$$Wf = 0.433 \times G \times (L \times Ap) - (0.294 \times Wr) \quad (11)$$

$$\text{Total } \mathit{Load} = Wr + Wf \quad (12)$$

$$\alpha = \frac{S \times N^2}{70500} \quad (13)$$

$$ep = \frac{40.8 \times L^2 \times \alpha}{E} \quad (14)$$

$$Sp = S + ep - (et + er) \quad (15)$$

$$k = 0.1484 \times Ap \quad (16)$$

$$er = \frac{5.20 \times G \times DFL \times Ap \times L}{E \times Ar} \quad (17)$$

$$et = \frac{5.20 \times G \times DFL \times Ap \times L}{E \times At} \quad (18)$$

$$V = k \times Sp \times N \quad (19)$$

$$Ev = \frac{Q}{V} \times 100\% \quad (20)$$

$$Ev = \frac{Qt}{V \, x \, 100\%}$$
$$Ev = \frac{316}{402.77 \, x \, 100\%}$$
$$Ev = 78.45\ \%$$

3. Results and Discussion

In this final section, the scope of the problem in the HPU pump is limited regarding optimizing the HPU pump performance in the BTN-01 well in the Kawengan field. Wells in the Kawengan field, BTN-01 wells have low volumetric efficiency. Volumetric efficiency is an indication of the feasibility of pump capacity at a certain period. This situation can occur due to several mechanical factors as well as production problems. Based on the results of research calculation that has been carried out above, the comparison design parameters of existing and optimization condition of the "BTN-01" well are shown in Table 6 below.

Table 6
Parameter Comparison of Existing Design and New Calculation

Parameter	Existing Design	New Calculation	Unit
Pump Speed (N)	8	7	SPM
Pump Stroke Length (S)	74	70	inch
Production Rate	211	316	bfpd
Pressure Well Flow (PWF)	183	102	psi

From data on Table 6, known that the production rate of Well BTN-01 is still able to increase up to 316 bfpd (before 211 bfpd), with Pwf 102 psi, and changing the HPU speed (N) to 7 SPM (before 8 SPM) and stroke length (S) to 70 inch (before 74 inch).

4. Conclusion

Based on the results of the discussion carried out several conclusions can be drawn, including: (1) From the calculation of the PI in the "BTN-01" well, a PI value of 1.5 bpd/psi is obtained, which means that based on the classification it includes "moderate".(2) From the IPR calculation the Wiggins method on the "BTN-01" well obtained a water production rate (Qw) of 421.96 bfpd, an oil production rate (Qo) of 5.53 bfpd and a total production rate (Qmax) of 427.5 bfpd. (3) From the new calculation of pump speed (N) and stroke length (S) obtained from the intersection from the N vs S curve where the new N value is 7 SPM (existing 8 SPM) and the new S value is 70 inches (exiting 74 inches). (4) From the new calculation of production rate, can be determined the volumetric efficiency is 78.45% (existing 43%) which means there is increasing and this value (78.45%) can be called already optimum.

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