# THE EVALUATION OF HYDRAULIC PUMPING UNIT PUMP AS AN ARTIFICIAL LIFT METHOD IN WELL BUDI#04

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ABSTRAK: Minyak mentah di suatu lapangan seiring berjalannya waktu akan mengalami penurunan baik laju produksi maupun tekanan reservoir yang berfungsi untuk mengangkat ke permukaan secara alamiah. Oleh karena itu, apabila produksi minyak mentah dan gas bumi suatu sumur telah mengalami penurunan laju produksi dan tekanan reservoir, maka diperlukan upaya lebih lanjut untuk mempertahankan dan meningkatkan produksi sumur tersebut. Kegiatan produksi minyak dari suatu sumur dapat dilakukan dengan dua pengalaman, yaitu penurunan produksi yang pada awalnya dapat menghasilkan kurang lebih 150 BOPD, turun menjadi 70 BOPD hingga 20 BOPD, namun produksi kembali meningkat hingga 150-190 BOPD setelah dipasang Hydraulic Pumping Unit (HPU). Setelah pemasangan pompa HPU, dilakukan evaluasi untuk melihat efisiensi volumetrik pompa. Berdasarkan hasil analisis data sumur, data produksi, data reservoir, dan data pompa dengan laju produksi total (Qt) sebesar 254.663 BFPD, laju produksi minyak (Qo) sebesar 164.211 BOPD, water cut sebesar 34,2%, kecepatan langkah pompa (N) sebesar 5 SPM, dan langkah pompa (S) sebesar 120 inchi, maka didapatkan efisiensi volumetrik pompa sebesar 92,32% dengan kapasitas pompa sebesar 275.850 BFPD.

Kata Kunci: Efisiensi Volumetrik Pompa, Perpindahan Pompa, Produksi, Pengangkatan Buatan dan Unit Pemompaan Hidraulik.

*ABSTRACT: Crude oil in a field by the time will experience a decrease both in its production rate and reservoir pressure, which functions to lift to the surface naturally. Therefore, if a well's crude oil and gas production has experienced a decrease in production rate and reservoir pressure, further effort is needed to maintain and increase the well production. The oil production activity of a well can be conducted in two experience: production decreases, which at the beginning could produce approximately 150 BOPD, decrease to 70 BOPD until 20 BOPD, but the production increases again up to 150-190 BOPD after a Hydraulic Pumping Unit (HPU) was installed. After installing the HPU pump, an evaluation was carried out to observe the pump's volumetric efficiency. Based on the analysis of the well data, production data, reservoir data, and pump data with the total production rate (Qt) of 254,663 BFPD, the oil production rate (Qo) of 164,211 BOPD, the water cut of 34,2%, the pump stride speed (N) of 5 SPM, and the pump stride (S) of 120 inches, the pump volumetric efficiency obtained was 92,32% with pump capacity of 275,850 BFPD.*

*Keywords: Pump Volumetric Efficiency, Pump Displacement, Production, Artificial Lift and Hydraulic Pumping Unit.*

## INTRODUCTION

Petroleum owned by a field over time will experience a decrease in production rates and reduced reservoir pressure that serves to raise fluid up naturally, therefore when a well's oil and gas production has experienced a decrease in production rates and pressure, it is necessary to carry out further activities to maintain and increase the production of a well. In oil and gas production activities from a well can be done in two ways, namely by the natural flow method (natural blowout wells) and artificial lift (artificial lift method). Natural blowout wells themselves are a method of lifting fluid to the surface using power or pressure coming from the reservoir or formation of the well itself, while artificial lift is used when the reservoir pressure is no longer able to produce fluid naturally anymore because the pressure in the well has decreased pressure.

Artificial lift itself has various types, such as: Gas Lift, Sucker Rod Pump (SRP), Hydraulic Pumping Unit (HPU), Progressing Cavity Pump (PCP), Jet Pump and Electric Submersible Pump (ESP). The use of each artifial lift is adjusted to the well conditions in a field. As one example of artificial lift installation activities is: hpu

installation, where HPU is suitable for use in shallow well depths such as data on the Budi#04 well with a depth of 650 m. And wells in the sandstone zone as in the condition of the existing wells in the Budi field.

## METHOD

### Data Capture Stage

The research is organized in several steps and stages, as follows:

a. Literature study is carried out as an initial stage of solving a problem by using a literature approach to problems related to the writing of this final project, which is in the form of theory, data processing formulation, discussion and problem solving as well as archives from the company for the data that will be needed.
b. In this method, researchers conducted direct discussions with field supervisors and parties related to information collection activities.
c. The data used in this study were obtained through daily production data and company archives related to increasing HPU pump production at the BUDI#04 Well.

### Data Calculation Stage

To perform optimization, it is necessary to evaluate first to determine whether the well has reached volumetric efficiency (>70%). If it has not been achieved, it is necessary to optimize the well to achieve volumetric efficiency to reach the optimum production rate of the well by simply increasing or decreasing the stroke per minute (SPM) and stroke length (SL) of the pump or by changing the size of the plunger and repairing damaged pumping equipment.

| No | Parameter | Symbol | Value | Unit |
|---|---|---|---|---|
| 1. | Depth of Well | ID | 2132 | Ft |
| 2. | Middle of Perforation | H | 1583,42 | Ft |
| 3. | Static of Fluid Level | SFL | 1025 | Ft |
| 4. | Dynamic of Fluid Level | DFL | 1125 | Ft |

## RESULT

The BUDI#04 well is an oil production well managed by PT Tately N.V, currently the well is producing using the Hydraulic Pumping Unit method.

Reservoar Data

| No | Parameter | Symbol | Value | Unit |
|---|---|---|---|---|
| 1. | SG Oil | - | 0,7759 | - |
| 2. | SG Water | - | 1,04 | - |
| 3. | $^0$ API | - | 50,9 | - |

Production Data

| No | Parameter | Symbol | Value | Unit |
|---|---|---|---|---|
| 1. | Flow Rate | Qo | 164, 211 | BOPD |
| 2. | Total Flow Rate | Qt | 254, 663 | BFPD |
| 3. | Water Cut | WC | 34,2 | % |
| 4. | Static of Fluid Level | SFL | 1025 | Ft |
| 5. | Dynamic of Fluid Level | DFL | 1125 | Ft |

Pump Data

| No | Parameter | Symbol | Value | Unit |
|---|---|---|---|---|
| 1. | Stepping Speed | SPM | 5 | SPM |
| 2. | Step Length | SL | 120 | Inch |
| 3. | Pump Type | Hidrolik | - | - |
| 4. | Depth of Pump | L | 1476 | Ft |
| 5. | Diameter of Tubing | OD Tubing | $2\frac{7}{8}$ | Inch |
| 6. | Diameter of Rod | R | $2\frac{7}{8}$ | Inch |
| 7. | Diameter of Plunger | | 2 | Inch |
| 8. | Sevice Factors | SF | 0,65 | - |
| 9. | Crank Pitman Ratio | C/P | 0,33 | - |
| 10. | Minimum of Tensile Strength | T | 115000 | Psi |
| 11. | Modulus Elastic | E | 30000000 | - |

### Evaluation Calculation

In calculating the evaluation of the pump in the installed condition, the following calculation steps are required :

a. Determine the SG of mixed fluid ($SG_{mix}$)

$SG_{mix}$ = (1,04 x WC) + ((1 - WC) x SGo)
= (1,04 x 0,342) + ((1 – 0,342) x 0,7759)
= 0,866.

Fluid Gradient = SGmix x 0,433

= 0,866 x 0,433
= 0,375 psi/ft.

b. Static pressure determination (Ps)
Ps = (mid perforasi – SFL) x 0,433 x $SG_{mix}$
= (1583,42 – 1025) x 0,433 x 0,866
= 209,449 psi.

c. Determination of well bottom flow pressure (Pwf)
Pwf = (mid perforasi – DFL) x 0.433 x SGmix
= (1583,42 –1125) x 0,433 x 0,866
= 171,942 psi.

d. Determination of productivity index (PI)
$PI = \frac{Q}{PS-Pwf}$
= 6,790 STB/day/psi

e. Determination of Ar, M, At, Ap, dan K
- Rod diameter $\frac{7}{8}$ inch get the price :

Rod area (Ar) = 0,601 $inch^2$
Rod weight per foot (M) = 2,22 lb/ft
- Meter $2\frac{7}{8}$ inch get the price :

Tubing area (At) = 1,812 $inch^2$
- Plunger diameter 2 inch get the price :

Plunger area (Ap) = 3,142 inch
Konstanta (K) = 0,466 bpd/in/spm

f. Determine the weight of the rod (Wr)
Wr = rod length (L) x rod weight / feet (M)
= 1476 x 2,22.
= 3276,72 lb

g. Determine the acceleration factor (α)
$\alpha = \frac{S \,.\, N}{70500}$
α = 0,043

h. Determine the maximum polished rod load (Wmax)
Wmax = (1 + α) Wr + Wf
= (1 + 0,043 ) 3276,72 + 1378,111
= 4794,266 lb.

i. Determine of minimum polished rod load (Wmin)
Wmin = Wr (1 – α – (0,107 x SGmix))
= 3276,72 (1 – 0,043 – ( 0,107 x 0,866))
= 2833,580 lb.

j. Determine of maximum stress (Smax)
$Smax = \frac{Wmax}{Ar}$

$Smax = \frac{4794,266}{0,601}$
= 7977,148 psi

k. Determine of minimum stress (Smin)
$Smin = \frac{Wmin}{Ar}$

$Smin = \frac{2833,580}{0,601}$
= 4714,775 Psi

l. Determine of allowable stress (SA) :
$SA = (\frac{T}{4} + 0{,}5625\ x\ Smin)\ x\ Sf$
= ($\frac{115000}{4}$ + 0,5625 x 4714,775) x 0,65
= 20408,275 psi.

m. Determine of rod length + stretch of tubing (er + et)
- $er = \frac{5{,}2\ x\ SGMix\ x\ DFl\ x\ Ap\ x\ L}{E\ x\ Ar}$

$er = \frac{5{,}2\ x\ 0{,}866\ x\ 1125\ x\ 3{,}142\ x\ 1{,}476}{30000000\ x\ 0{,}601}$
er = 1,303 inch
- $et = \frac{5{,}2\ x\ SGMix\ x\ DFl\ x\ Ap\ x\ L}{E\ x\ At}$

$et = \frac{5{,}2\ x\ 0{,}866\ x\ 1125\ x\ 3{,}142\ x\ 1{,}476}{30000000\ x\ 0{,}812}$
et = 0,432 inch.

n. Determine of overtravel plunger (ep)
$ep = \frac{40{,}8\ x\ L^2\ x\ a}{E}$
$ep = \frac{40{,}8\ x\ 1476^2\ x\ 0{,}043}{30000000}$
ep = 0,126 inch

o. Determine of effect counter balance ideal (Ci)
$Ci = \frac{W_{max+W_{min}}}{2}$
$= \frac{9794{,}266+2833{,}50}{2}$
= 3813, 923 lb

p. Determine of maximum torch (Tp)
$Tp = (W_{max} - 0{,}95\ x\ Ci\ )\ x\ S\ x\ 0{,}5$
= (9794,266 – 0,95 x 3813,923) x 120 x 0,5
= 70262,361 in/lb

q. Determine of Net Lift Pump (LN)
$LN = L - \frac{Pwf}{0{,}433\ x\ SGMix}$
$= 1476 - \frac{171{,}492}{0{,}433\ x\ 0{,}866}$
= 1132, 03 ft

r. Determine of stroke plunger effective (Sp)
Sp = S + ep – (et + er)
= 120 + 0,126 – (0,432 + 1,303)
= 118,390 inch

s. Determine of displacement pump (V)
V = K x Sp x N
= 0,466 x 118,390 x 5
= 275,850 BFPD

t. Determine of pump volumetric efficiency (Ev)
$Ev = \frac{Qt}{V}\ x\ 100\ \%$
$= \frac{254{,}663}{275{,}850}\ x\ 100\ \%$
= 92,32 %

u. Determine of prime mover horsepower
- Hydraulic horse power (Hh)

Hh = (7,36 x$10^{-6}$) x Q x SGMix x LN
= (7,36 x $10^{-6}$) x 254,663 x 0,866 x 1132, 03
= 1,838 HP
- Friction horse power (Hf)

Hf = (6,31 x $10^{-7}$) x Wr x S x N
= (6,31 x $10^{-7}$) x 3.276, 72 x 120 x 5

= 1,241 HP

- Break horse power (Hb)

  Hb = 1,5 x ( Hh + Hf )

  = 1,5 x ( 1,838 + 1,241)

  = 4,618 HP

Table 1. Calculation Results of Hydraulic Pumping Unit Evaluation at Wells Budi#04

| No | Parameter | Symbol | Value | Unit |
|---|---|---|---|---|
| 1. | SG Mix | SGmix | 0,866 | - |
| 2. | Fluid Gradient | GF | 0,375 | psi/ft |
| 3. | Static Pressure | Ps | 209,449 | psi |
| 4. | Well Bottom Flow Pressure | Pwf | 171,942 | psi |
| 5. | Productivity Index | PI | 6,790 | STB/day/psi |
| 6. | Rod Area | Ar | 0,601 | $Inch^2$ |
| 7. | Rod Weight Per Foot | M | 2,22 | lb/ft |
| 8. | Tubing Area | At | 1,812 | $Inch^2$ |
| 9. | Plunger Area | Ap | 3,142 | $Inch^2$ |
| 10. | Konstanta | K | 0,466 | Bpd/in/spm |
| 11. | Weight of Rod | Wr | 3276,72 | lb |
| 12. | Fluid of Weight | Wf | 1378,111 | lb |
| 13. | Acceleration Factor | *a* | 0,043 | - |
| 14. | Maximum Polished Rod Load | Wmax | 4794,266 | lb |
| 15. | Minimum Polished Rod Load | Wmin | 2833,580 | lb |
| 16. | Maximum Stress | Smax | 7977,148 | psi |
| 17. | Minimum Stress | Smin | 4714,775 | Psi |
| 18. | Strees Allowable | SA | 20408,275 | psi |
| 19. | Rod Strecth | er | 1,303 | Inch |
| 20. | Tubing Strech | et | 0,432 | Inch |
| 21. | Rod Long + *Tubing strech* | er + et | 1,736 | Inch |
| 22. | Plunger Overtravel | ep | 0,126 | Inch |
| 23. | Counter Balance Efect Ideal | Ci | 3813,923 | lb |
| 24. | Maximum of Torch | Tp | 70262,361 | In-lb |
| 25. | Net Lift of Pump | LN | 1132,03 | ft |
| 26. | Stroke Plunger Effective | Sp | 118,390 | Inch |
| 27. | Pump Displacement | V | 275,850 | BPD |
| 28. | Pump Volumetric Efficiency | Ev | 92,32 | % |
| 29. | Hidrolik Horse Power | Hh | 1,838 | HP |
| 30. | Friction Horse Power | Hf | 1,241 | HP |
| 31. | Break Horse Power | Hb | 4,618 | HP |

## DISCUSSION

With the pump specification data installed in the BUDI#04 well in the Budi Tately N.V. field, it is known that the type of pump used is hydraulic type with tubing size 2 7/8 inch, sucker rod diameter 7/8 inch, plunger diameter 2 inch, pump depth 1476 ft.

The evaluation stage includes calculating the volumetric efficiency of the pump using reservoir data, well data, production data and pump data. The results of the pump efficiency calculation show that the pump settings (N value of 5 SPM and S value of 120 inch) can produce a production rate of 164.211 BOPD. After analysis, it is known that Well BUDI#04 does not need to be optimized because based on calculations it has a volumetric efficiency of 92.32%, meaning that it has exceeded the minimum volumetric efficiency of the pump to work optimally, which is 70%.

## CONCLUSION

Based on the results of the calculation of the Hydraulic Pumping Unit at Well BUDI #04 Budi Field which has been carried out at Tately N.V, it can be concluded :

1. After the comparison between the condition of the well when it was still natural flow which was initially able to produce (150 BOPD and 230 BLPD with water cut around 0.2%) decreased to (11 BOPD and 19 BLPD) and after the well was installed HPU, the well production increased again to (100 - 190 BOPD and 250-300 BLPD with water cut around 0.3%).
2. Production at Well BUDI#04 can be said to be optimal because based on the results of the evaluation carried out on the sucker rod pump installed conditions, the volumetric efficiency is above 70%, namely 92.32%.

3. The production of Well BUDI#04 successfully increased after installing the HPU pump with a percentage of 59%.

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