Optimization Of Electrical Submersible Pump Size To Increase Dr-01 Well Production Rate Of Field Puyuh

Optimasi Electrical Submersible Pump Untuk Meningkatkan Laju Produksi Sumur Dr-01 Lapangan Puyuh

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Abstract. *The "DR-01" well is installed with an electrical submersible pump with the problem of decreasing production and based on tests conducted on December 13, 2014 the production of the "DR-01" well produced 171 bfpd with a water content of 96%. The electrical submersible pump operates with the Allen C1000ARC pump type and pump setting depth of 4592 ft, TDH 4268.58 ft, number of stages 94, frequency 50 Hz, HP 28, head/stage 24 with a pump efficiency of 20%. In planning the optimization of a good and correct electrical submersible pump it will produce a pump efficiency value of above 35%. To overcome these problems, it is necessary to perform optimization calculations on electrical submersible pumps by calculating IPR (Inflow Performance Relationship) values using the Wiggins method, calculating SGf and Gf values, calculating SBHP (Static Bottom Hole Pressure) and FBHP (Flow Bottom Hole Pressure) values, calculating PIP (pump intake pressure), calculating TDH (Total Dynamic Head) and pump performance curves. After optimizing the DR-01 well, the results obtained are the type of pump Allen C680AR, the pump setting depth value is 4653.92 ft, the total dynamic head value is 4202.74 ft, the number of stages is 145 stages, pump frequency is 60 Hz, Qgross value is 500 bfpd, horse power is 19 HP , head stage 29, and a pump efficiency value of 57%. Where the value of the pump efficiency is considered optimum.*

Keywords: *artificial lift, ESP, IPR, pump setting depth, type of pump, .*

Abstrak. Sumur “DR-01” dipasangi *electrical submersible pump* dengan permasalahan penurunan produksi dan berdasarkan pengujian yang dilakukan pada tanggal 13 Desember 2014 produksi sumur “DR-01” menghasilkan 171 bfpd dengan kadar air 96%. *Electrical submersible pump* beroperasi dengan tipe pompa Allen C1000ARC dan setting kedalaman pompa 4592 ft, TDH 4268,58 ft, jumlah *stage* 94, frekuensi 50 Hz, HP 28, *head/stage* 24 dengan efisiensi pompa 20%. Dalam perencanaan optimasi *electrical submersible pump* yang baik dan benar akan menghasilkan nilai efisiensi pompa di atas 35%. Untuk mengatasi permasalahan tersebut, maka perlu dilakukan perhitungan optimasi pada *electrical submersible pump* dengan cara menghitung nilai IPR (*Inflow Performance Relationship*) metode Wiggins, menghitung nilai SGf dan Gf, menghitung nilai SBHP (*Static Bottom Hole Pressure*) dan FBHP (*Flow Bottom Hole Pressure*), menghitung PIP (*Pump Intake Pressure*), menghitung TDH (*Total Dynamic Head*) dan kurva kinerja pompa. Setelah dilakukan optimasi pada sumur DR-01, maka diperoleh hasil yaitu jenis pompa Allen C680AR, nilai setting *depth* pompa sebesar 4653,92 ft, nilai *total dynamic head* sebesar 4202,74 ft, jumlah *stage* sebanyak 145 *stage*, frekuensi pompa sebesar 60 Hz, nilai Qgross sebesar 500 bfpd, *horse power* sebesar 19 HP, *head stage* 29, dan nilai efisiensi pompa sebesar 57%. Dimana nilai efisiensi pompa tersebut sudah dianggap optimum.

Kata kunci: *artificial lift, ESP, IPR, pump setting depth*, tipe pompa

INTRODUCTION

The process of lifting fluid from the well to the surface consists of several methods, including natural flow wells and artificial lift wells [1]. Oil and natural gas in the first stage of acquisition use natural power from the reservoir so that it is able to flow fluids to the surface. However, over time the reservoir pressure decreases so that the pressure is unable to flow fluids to the surface. On the other hand, it is estimated that oil reserves are still substantial and remain profitable enough to be produced [2]. When the formation pressure is no longer able to raise the reservoir fluid to the surface artificial lift is used, one of which is by using an electric submersible pump (ESP) artificial lift.

Electric submersible pump have indeed become a cornerstone of artificial lift technology in the petroleum industry since their introduction in 1927. Their ability to efficiently lift large volumes of fluids from wells has made them a popular choice for oil production, particularly in wells with high flow rates or those requiring significant artificial lift support. Electric submersible pump (ESP), installed in approximately 150,000 to 200,000 wells worldwide, comprise multiple centrifugal pump stages arranged in series within a housing and integrated with a submersible electric motor [12].

Electric submersible pump (ESP) represent one of the most widely implemented artificial lift techniques, accounting for over 60% of total global oil production [4]. Recognized for their high adaptability, ESP systems can be deployed across diverse oil and gas applications, ranging from onshore operations to complex offshore, deepwater, and subsea environments [5]. Conventional approaches to ESP monitoring such as collecting operational parameters, conducting onsite well visits, or manually interpreting amperage charts often constrain the ability to fully optimize pump performance [4].

Electric submersible pump (ESP) units provide an efficient and cost effective solution for lifting large fluid volumes from significant depths under diverse well conditions. Modern ESP systems are capable of handling production rates as low as 375 BPD to over 8,500 BPD, from depths exceeding 15,000 ft [6]. Over the years, ESP manufacturers in collaboration with major oil companies have accumulated extensive expertise in producing high viscosity fluids, managing gassy wells, and operating under high temperature environments [7]. An ESP system comprises several key components, including a three phase electric motor, seal section, rotary gas separator, multi stage centrifugal pump, power cable, motor controller, and transformer. Ancillary components typically include the wellhead, cable bands, check valve and drain valve, while optional equipment may integrate downhole pressure and temperature sensors for real time wellbore condition monitoring. In operational configuration, the downhole assembly is suspended from the production tubing and remains fully submerged in the well fluid [7].

Changes in reservoir conditions such as sands coming to the surface, or other problems with the electric submersible pump can be identified using ammeter charts that record the pump performance of each well on a continuous basis. An ammeter chart, like an electrocardiogram is a recording of the heartbeat of a submersible electric motor. Proper, timely and thorough analysis of the ammeter chart can provide valuable information for the detection and correction of minor operational problems before they become major costly problems [7].

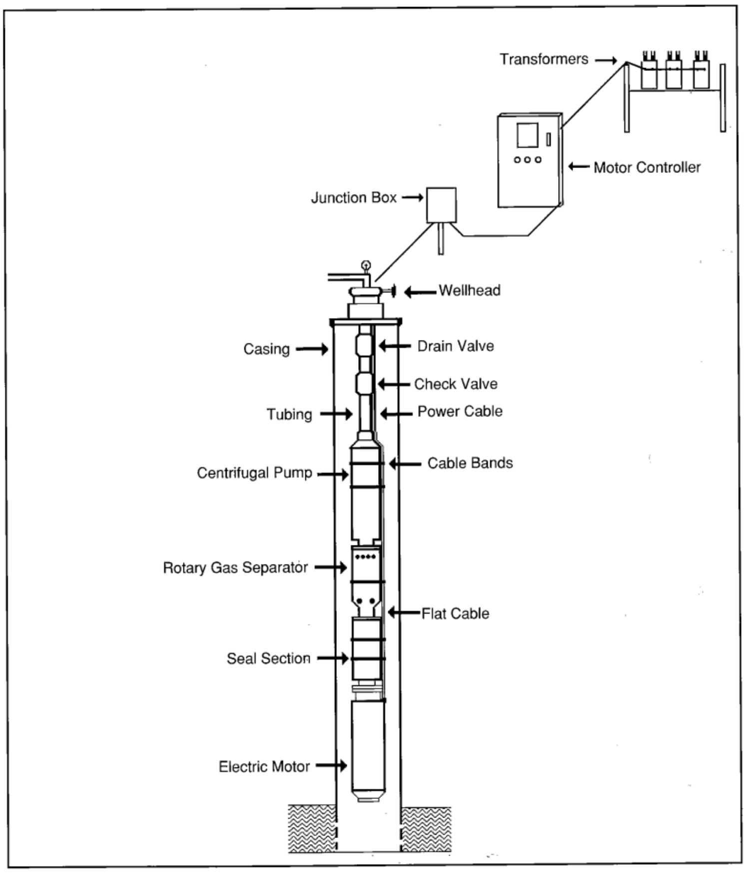

Figure 1. Typical ESP Installation [7]

The electric submersible pump (ESP) is composed of a series of dynamic or centrifugal pump stages, directly driven by a submersible electric motor through a rigid shaft coupling. This direct mechanical linkage ensures synchronous rotational speed between the motor and pump shafts, minimizing power transmission losses and enhancing operational efficiency [8]. ESP systems are designed to function across wide operating envelopes, with deployment capabilities exceeding 12,000 ft in depth and handling flow rates up to 45,000 bbl/day. Nevertheless, performance and operational lifespan can be constrained by adverse downhole conditions, including high free gas content in produced fluids, elevated temperatures, increased oil viscosity, sand production, and paraffin deposition [8].

Excessive free gas can induce pump cavitation, resulting in motor instability and ultimately reducing pump service life and reliability. Elevated downhole temperatures may degrade thrust bearing performance, epoxy encapsulation of electronic components, insulation integrity, and elastomer resilience. Increased viscosity of the produced fluid decreases the total dynamic head achievable by the pump system, necessitating additional pump stages and higher horsepower requirements. Furthermore, the presence of sand and paraffin in the fluid stream can accelerate wear and cause internal blockages within the pump [8].

In electric submersible pump (ESP) service, the pump operates with its shaft in a vertical orientation and functions as a centrifugal pump with the following primary characteristics [9]:

1. A multistage configuration comprising several tens to hundreds of stages connected in series.
2. Closed vane design for impeller.
3. Single suction inlet arrangement.
4. Self-priming capability.
5. Flow configuration in either radial or mixed-flow design.

An oil well that is produced continuously will certainly experience a decrease in production due to reduced fluid reserves in the well, decreased driving pressure in the well and decreased pump efficiency. To maintain a stable production rate and high pump efficiency, an evaluation needs to be carried out to determine whether the pump used is appropriate to the well's capabilities [10]. To optimize production from a well's potential technically, it is necessary to know the limitations of the well and the facilities used on the surface so that the goal of optimizing production can be achieved. When planning a redesign of an electric submersible pump that has been installed, current production flow rate data and well performance estimates can be determined, so that a redesign can be determined for the well in order to achieve production targets and prevent overdesign [11].

In this study, researchers identified the causes of the decline in production rates in the DR-01 well using an artificial lift electric submersible pump. The results of the identification will be used in determining the appropriate pump size for the electrical submersible pump. The appropriate pump size is expected to optimize the increase in production rates in the DR-01 well.

METHODOLOGY

The research location is in Musi Banyuasin Regency and Banyuasin Regency, South Sumatra Province. WK BPP is approximately 50 km from Palembang City. The area of WK is 267 km^2 with 3 Existing Fields (Puyuh Oil Field, Bertak Oil Field and Pijar Oil and Gas Field). The research location is in the South Sumatra Basin in the North Palembang Sub-Basin, where the production layer is in the Lemat Formation. The research method used is to study literature, collect data and process data. The available data are well data, fluid data and reservoir data. After collecting and processing the data, then identifying the causes of the decrease in the production rate at “DR-01 Well”. After identification, the next step is to evaluate starting from drawing the IPR curve, calculating specific gravity and fluid gradient, calculating pump intake pressure, PSD, TDH and calculating % EP followed by optimizing the size of the electric submersible pump by finding the optimum PSD, total dynamic head and determining the type of pump. The last is to produce pump size results that are in accordance with the needs for increasing production rates.

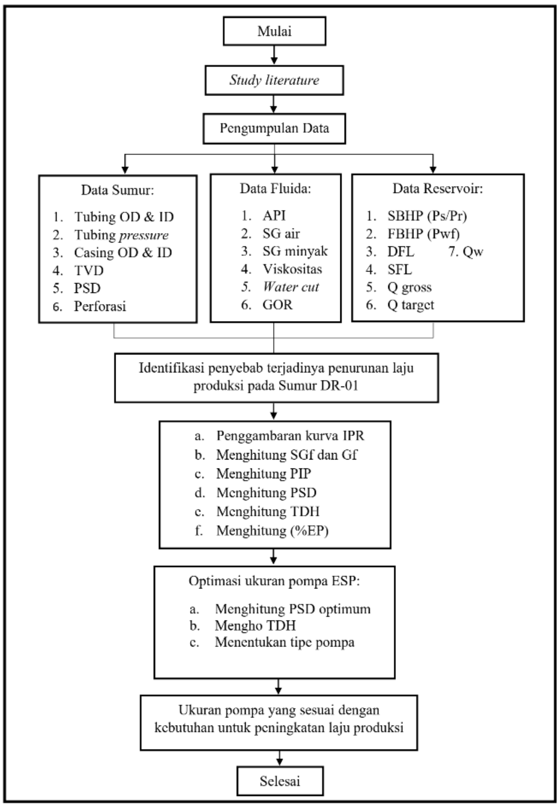

Figure 2. Research process flowchart

RESULT AND DISCUSSION

The DR-01 well is a vertical oil well located in Puyuh Field and has been carrying out oil production activities since the year 1993, cross-section of the DR-01 Well (figure 4). The DR-01 Well in Puyuh Field was originally a natural flow well, then replaced with an artificial lift well using a sucker rod pump in 1996. In 2002, the sucker rod pump (SRP) in the Well DR-01 is replaced with an artificial lift type electrical submersible pump because there is a decrease in the production rate, as can be seen in figure 3. The DR-01 well experienced ups and downs in oil production from year to year, until 2014 oil production was temporarily stopped. From figure 3, a comparison can be seen between oil flow rate, water flow rate, gas flow rate and water cut at Well DR-01. Researchers can conclude that the cause of the decrease in the rate of Production on the ESP Well DR-01 pump occurs due to several factors, namely:

1. Zero-meg (Motor Burn). The motor burn or zero-meg on the ESP Well DR-01 pump occurred in 2002 and 2011.
2. Tubing Problems. The ESP pump on the DR-01 well experienced many problems disruption to the tubing causing a decrease in flow rate production.
3. Cable Problems.
4. Impeller Problems.
5. The ESP pump bearings experience corrosion caused by sand that is produced together with the fluid.

The significant problem that occurred in the electrical submersible pump unit of the DR-01 Well in Puyuh Field was a problem with the impeller and bearing, where this problem caused the fluid production rate to decrease.

The optimization is done by using the Wiggins IPR method. The Wiggins method is an extension of the Vogel method in which Wiggins 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-phase method.

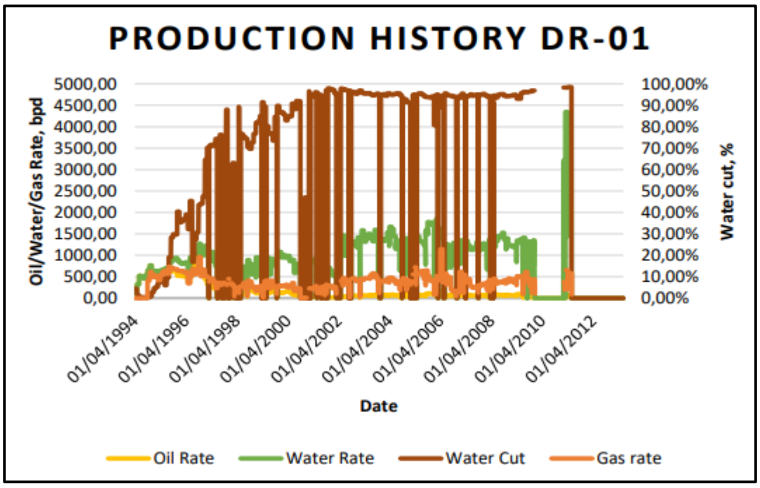

Figure 3. Production History of DR-01 Well

Table 3. DR-01 Reservoir Data

Reservoir Data		
SBHP (P_s/P_r)	1900	psi
FBHP (P_{wf})	450	psi
DFL	1237	ft
SFL	753	ft
Q_{Gross}	171	bpd
Q_w	884	bpd
Q_{target}	500	bpd

Table 4. DR-01 Fluid Data

Fluid Data		
API	29.3	°API
SG_{water}	1.00	
SG_{oil}	0.88	
GOR	250	scf/bbl
μ	1.95	cp
W_c	96	%

Evaluation of DR-01 Well

Evaluation of the electrical submersible pump (ESP) at the DR-01 well was carried out to determine the comparison between the productivity of the study well formation and the capacity of the pump being used, with the aim of increasing pump efficiency in order to obtain an optimum production rate that is in accordance with the productivity of the formation.

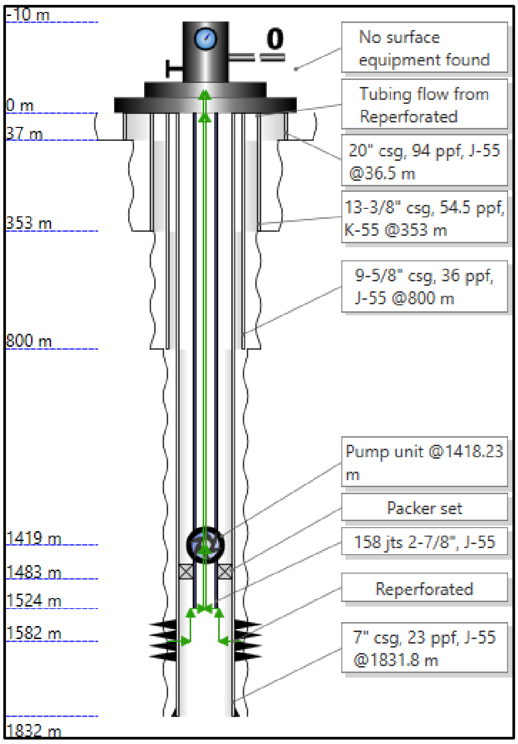

Figure 4. Well Profile Before Optimization

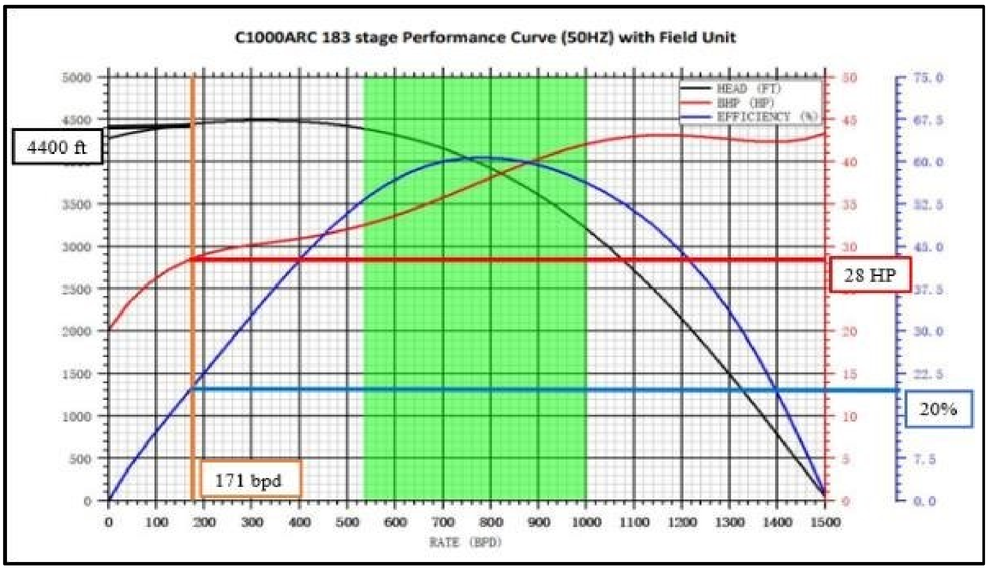

Figure 5. Pump Performance Curve C1000ARC

The results of the evaluation of the electrical submersible pump C1000ARC 50 Hz pump can be seen in table 5 below:

Table 5. DR-01 Well ESP Pump Evaluation Result

Pump Performance Curve	
ESP Type	C1000ARC
Pump Setting Depth	4592 ft
Stage Amount	183 stages
Pump Intake Pressure	155.57 psi
Dynamic Head Amount	4268.58 ft
Head/Stage	4400 ft
Frequency	50 Hz
Efficiency Pump	20 %
Horse Power	28 HP/stage

Optimization of Electrical Submersible Pump Size at DR-01 Well Field Puyuh

Based on the analysis above, the pump installed in the DR-01 Well cannot continue to be used because if it is used continuously, it will damage the pump components and equipment others. Then the next step is to optimize the pump to get a new pump setting as a design pump that is in accordance with the productivity of the formation and the operating rate of the pump so that it produces optimally. Optimization of the pump size in DR-01 Well is done because this well has an actual production rate outside the recommended operating range, while at the optimum rate it is necessary to replace the new pump size because it is outside the recommended operating range. The stages of optimizing the ESP pump in DR-01 Well are carried out with the following calculations:

1. Calculation of optimum pump setting depth (PSD)
2. Total dynamic head (TDH) calculation
3. Determining the type of pump

Table 6. DR-01 Well ESP Pump Optimization Results

ESP Type	Allen C 680 AR
Pump Setting Depth	4653.92 ft
Stage Amount	152.8 stages
Pump Intake Pressure	215.5 psi
Dynamic Head Amount	4202.74 ft
Head/Stage	29 ft
Frequency	60 Hz
Efficiency Pump	57%
Horse Power	27.5 HP/stage

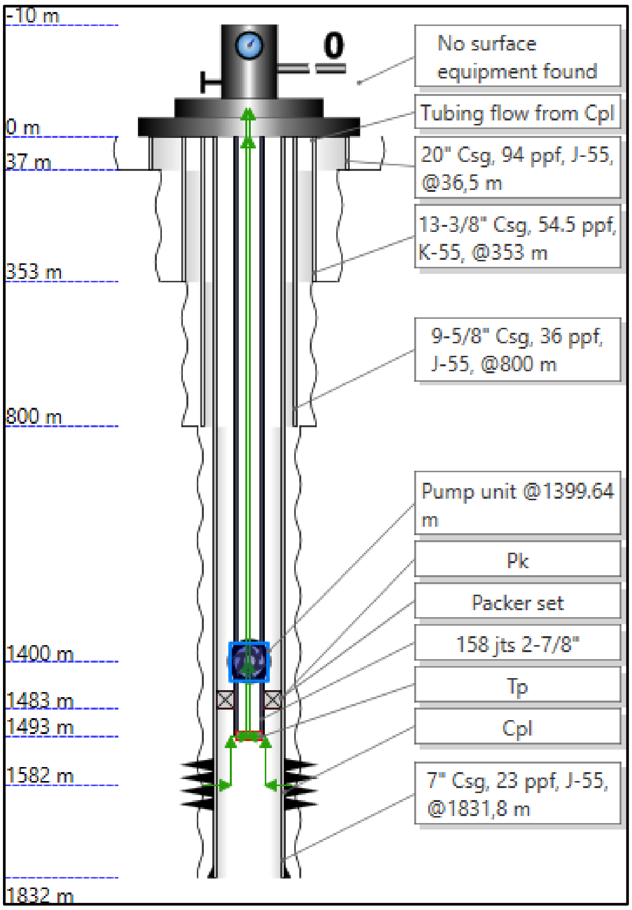

Figure 6. Well Profile After Optimization

Discussion

Based on the results of optimizing the ESP pump that has been carried out, the results of the pump parameters in the DR-01 Well can be seen in the following table:

Table 7. Comparison of ESP Pump in DR-01 Well

Parameter	Before Optimization	After Optimization
Pump Type	Allen C1000ARC	Allen C680AR
Pump Setting Depth, ft	4592	4653.92
Total Dynamic Head, Ft	4268.58	4202.74
Amount Stage, stages	94	152.8
Frequency, Hz	50	60
Q Gross, bfpd	171	500
Horse Power, HP/stage	28	27.5
Head/stage	24	29
Efficiency Pump, %	20	57

The results of the evaluation of the ESP installed on the DR-01 Well, it can be seen that the actual production rate is 171 bfpd and the rate is below the ROR of the C1000ARC pump. Judging from this, the pump works in a downthrust condition where the impeller is part of the pump bottom contact with the diffuser thereby damaging the impeller. Ideally in operating range conditions, the impeller will rotate in the middle of the diffuser. The desired optimal production rate is 74% of the maximum production rate of 1287 bfpd. The pump installed with type C1000ARC 50 Hz is less than the desired rate, if the pump is still used then downthrust will occur. Based on the results of optimizing the electrical submersible pump above, a bottom well pressure of 450 psi is obtained with a pump intake pressure (PIP) of 215.5 psi, while the optimum total dynamic head (TDH) for the pump to operate properly is 4202.74 ft. From the results of the optimization calculation, a flow rate of 869 bfpd is obtained with an increase in flow rate of 689 bfpd to the actual flow rate, so that it can be seen from the pump performance curve graph for the C680AR pump type, where the optimum production rate can be pulled up to be cut with the pump efficiency curve then obtained efficiency value of 57%.

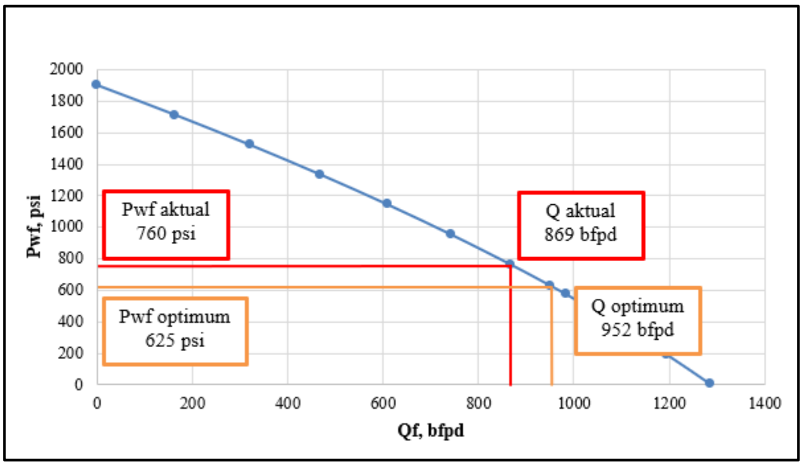

Figure 7. IPR Curve DR-01 Well

CONCLUSION

1. Factors causing the most significant decrease in production rate of the Sumur DR-01 Han Field electric submersible pump are problems with corrosive impellers and bearings.
2. After optimization calculations have been carried out on the DR-01 Well, the results obtained are the Allen C680AR pump type, the pump setting depth value is 4653.92 ft, the total dynamic head value is 4202.74 ft, the number of stages is 145 stages, pump frequency is 60 Hz, Qgross value is 500 bfpd, horse power 27.5 HP/stage, head/stage 29 and a pump efficiency value of 57%. Where the pump efficiency value has been considered optimum from the previous pump.

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