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Design Electric Submersible Pump based on Simulation of Reservoir Pressure Drop to Tubing Performance Relationship

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ABSTRACT

Electric submersible pump (ESP) is one of the artificial lift methods used to increase the production rate. The purpose of the simulation of the reservoir pressure drop to tubing performance using software pipesim is to be able to project the production limits of the natural flow well and continue using the artificial lift. Natural flow wells produce at a rate of 400 bbl/d, reservoir pressure 1250 psi, pwf 882 psi, and AOFP 868 bbl/d. Based on the production data, a simulation of the decrease in reservoir pressure was made to the production rate and the results showed that at a reservoir pressure of 950 psi, pwf 642 psi, and AOFP 380 bbl/d the well could not produce natural flow. Based on the simulation analysis, an artificial lift well plan is made with a production rate of 50% of AOFP, which is 190 bbl/d. The selected ESP is Reda model DN280, diameter 4 inc, Qmin 100 bbl/d, Qmax 500 bbl/d, pump intake production rate 206 bbl/d, efficiency 34.77%, speed 60 Hz, stage required 201, pump power required 12.95 hp with tubing diameter 2.375 inc.

Keywords: Gas-oil ratio, nodal analysis, tubing, production rate.

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1. Introduction

Optimum field development strategy requires good knowledge of anticipated well performance and future flowing condition variation, which can be accomplished by continuous monitoring of the surface facility network, wells, and reservoirs (Qasem et al., 2012). IPR and OPR play an important part in well completion, nodal analysis calculations, and artificial lift design (Feng et al., 2012).

Electric submersible pump (ESP) with excellent lift rate, high energy efficiency, and low maintenance costs account for about 10% of world oil production (Popaleny et al., 2018). ESP used for deep reservoirs, and high production volumes, and is in offshore applications so ESP is considered to be the best choice (Liang et al., 2012).

The purpose of this research is to projecting boundaries natural flow well production using simulation method. The tool used is software pipesim, which simulates the reservoir pressure drop on tubing performance. Simulation results at reservoir pressure of 950 psi, Pwf 642 psi, and absolute open flow potential (AOFP) 380 bbl/d the well can no longer produce natural flow, and then the simulation data can be used as future IPR data for artificial lift plans.

2. Literature review

2.1. Inflow performance relationship (IPR)

The inflow performance relationship (IPR) of a well describes the relationship between production rate and bottom-hole pressure, which serves as an important tool for understanding and predicting well performance (Lu et al., 2019). For oil wells, it is often assumed that the fluid flow rate is proportional to the difference between reservoir pressure and wellbore pressure (Jahanbani et al., 2009).

Conventional IPR assumes stable (i.e. boundary-dominated) flow conditions (Shahamad et al., 2015). The parameters used to make the IPR curve include the thickness of the payment zone, rock permeability, fluid viscosity, wellbore radius, drainage area, and skin factor. Without knowing all the values of these parameters, well IPR curves are usually constructed using various empirical models (Guo, 2007). Common models used in designing IPR include Vogel, Fetkovitch, Wiggins, and Sukarno. Each model has advantages and disadvantages (Elias et al., 2009).

2.2. Tubing

Tubing performance relationship (TPR) represents the ability of tubing to flow fluid. The selection of tubing can be determined by finding the optimum flow rate for each well-using sensitivity analysis between the TPR curve with various tubing sizes and the IPR curve (Guo et al., 2015).
Three analyzes can be performed to determine the optimum tubing size:

a) Optimum Flow Rate

The percentage of the most optimum flow rate of a well is 40% – 60% of the AOFP value of a well. This range is used with the assumption that if the flow rate is too large (Q > 60%) it can cause production problems such as sand and water cut problems. If the production rate is too small (Q < 40%) it will cause well production to become uneconomical (Brown., 1984).

b) Selection of Tubing Diameter

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In selecting the optimum tubing diameter, it is also necessary to pay attention to the impacts of multiphase flow and the wrong tubing size used. The tubing size can be too big or too small. Proper tubing size will extend well flow life and minimize the need for injection gas for gas lift installations (Winkler, 1994).

c) Usage Time

Tubing usage time can be analyzed based on the TPR curve against the IPR curve by simulating different reservoir pressures. Optimum tubing is tubing that can drain fluid when the reservoir pressure is low (Rolovic et al., 2016).

2.3 Electrical submersible pump (ESP)

The electric submersible pump is composed of surface equipment and downhole equipment. Surface equipment consists of transformers, switchboards, junction boxes, and variable speed drives. Another function of surface equipment is to generate electricity to drive motors. Downhole equipment consists of a motor, protector, pump intake, centrifugal pump, and cable (Beggs, 2003). ESP has very high flexibility so that it can be designed according to the desired flow rate while taking into account reservoir characteristics, well characterized, and considerations of geographical and environmental factors (Lea et al., 1999). This is done to avoid problems such as sand problems and gas locks that can reduce pump efficiency (Mendonca, 1997). The performance of the electrical submersible pumping (ESP) system is affected by the amount of free gas (gas-locking). Gas-locking can cause the pump to be unable to lift fluid and not optimally maintain excess heat in the ESP during normal operation. The way to control gas-locking is at the pump inlet, the pump pressure remains above the bubble point pressure of the produced liquid (Rooks et al., 2012). If the fluid pressure is below the bubble point, it is recommended that the pump be installed just above the perforation. The aim is to maintain a high intake pressure and thereby reduce the disturbance of free gas in the fluid flow. Whenever the unit is to be installed below or even in a perforated zone, it is recommended that a motor shroud be used to direct fluid flow over the motor. Producing from below the perforation will also allow the system to use natural annular gas separation. When the pump intake is above the perforation, gas and liquid flow in the same direction through the narrow annular area between the ESP and the casing wall (Wilson, 1998).

3. Methodology

3.1. Research data

The main data used in this study are as follows:

a) Well data include: well type, total depth, perforation depth, outside diameter casing (ODC) and inside diameter casing (IDC)
b) Reservoir and production data include water cut, gas liquid ratio (GLR), gas specific gravity (Gsg), water specific gravity (Wsg), type of oil, pressure reservoir (Pr), pressure well flowing (Pwf), pressure well head (Pwh), production test, absolute open flow potential (AOFP), surface temperature, bottom hole temperature and tubing diameter.

3.2. Data processing and analysis

The data obtained were then processed and analyzed using Pipesim software. The steps taken are to simulate the reservoir pressure drop on tubing performance. The simulation results are used as a future inflow performance relationship (IPR) in selecting the manufacturing and model of the electric submersible pump (ESP). An important aspect in designing an ESP using Pipesim software is the suitability of pump selection, motor selection and cable selection.

3.3. Research Diagram

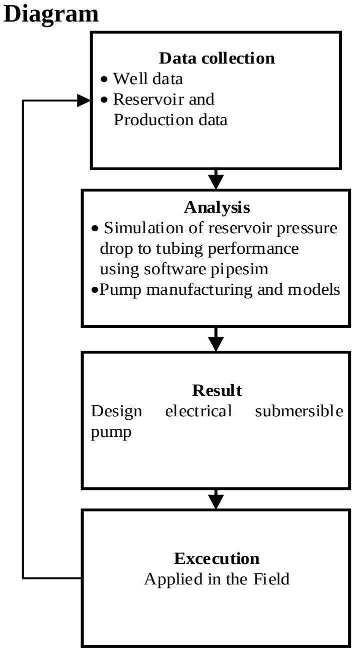

Figure 1. Diagram reseach ESP design

4. Result and Discussion

4.1. Result Simulation of the Reservoir Pressure Drop to Tubing Performance

Based on the well production data, the reservoir pressure (Pr) is 1250 psi, pressure well flowing (Pwf) is 882 psi, well head pressure (Pwh) is 100 psi, Q max is 868.46 bbl, production test (Qt) is 400 bbl, gas-liquid ratio (GLR)) 700 scf/stb and tubing with a diameter of 2,375 inc (Fig. 1), then a reservoir pressure drop simulation for tubing performance was made using software pipsim with the aim of knowing when the well could not produce itself and continued using artificial methods. Inflow performance relationship (IPR) and outflow performance relationship (OPR) curves can be used to effectively assess well performance (Hakiki et al., 2017). The simulation results show that at reservoir pressure (Pr) = 950 psi, pressure well flowing (Pwf) = 642 psi, pressure wellhead (Pwh) = 100

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psi, Q max = 380 bbl, production test (Qt) = 190 bbl, gas-liquid ratio (GLR) = 700 scf/stb and tubing diameter = 2,375 inc , the well cannot produce natural flow which can be seen through the IPR curve that does not intersect with the tubing (Figure 3). IPR and OPR are also used to determine the optimization scheme and profitability of oil and gas production (Tariq et al., 2018).

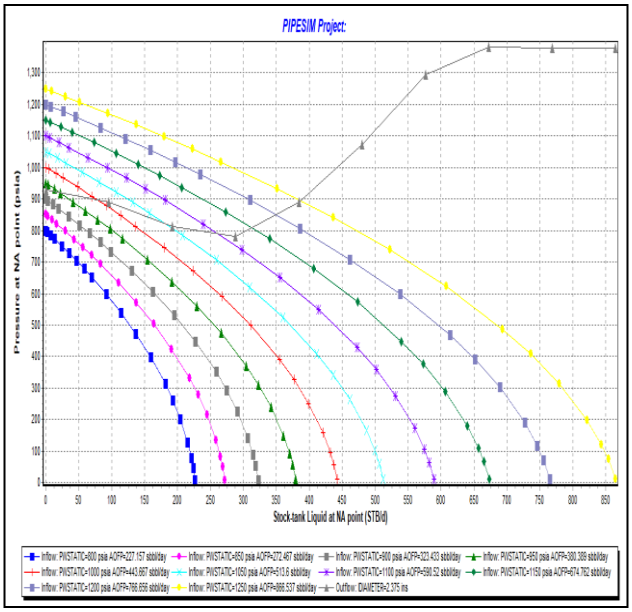


Figure 2. Inflow Performance Relationship vs Tubing Performance Relationship

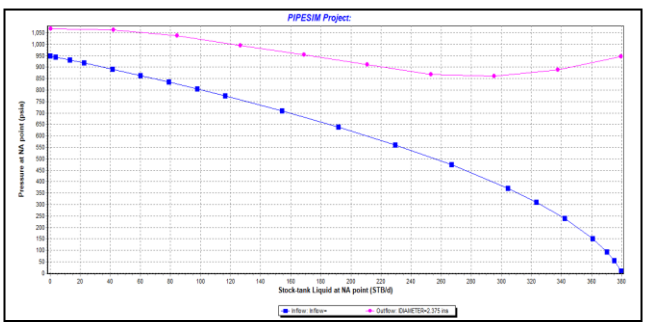
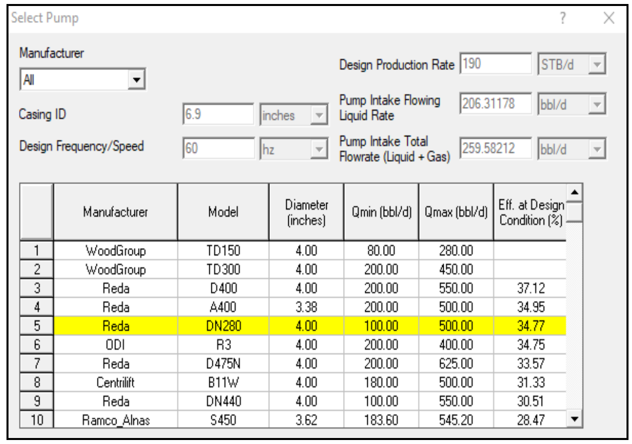


Figure 3. Future Inflow Performance Relationship

4.2. Pump Selection

ESP selection can be done by considering several things such as the percentage of the production rate from the well's AOFP value, the selected ESP has the highest pump efficiency and is connected to the desired production rate, and the pump diameter must be smaller than the ID casing used. In this study, the scenarios to be analyzed are the use of ESP with an anchor gas efficiency of 90% (GIP = 10%), and the pump placed at the bottom of the well. (Bagci et al., 2010) The selection of ESP pumps is carried out using software pipesim, where in this software there is already a database of various types of pumps from various manufacturers



	Manufacturer	Model	Diameter (inches)	Qmin (bbl/d)	Qmax (bbl/d)	Eff. at Design Condition (%)
1	WoodGroup	TD150	4.00	80.00	280.00	
2	WoodGroup	TD300	4.00	200.00	450.00	
3	Reda	D400	4.00	200.00	550.00	37.12
4	Reda	A400	3.38	200.00	500.00	34.95
5	Reda	DN280	4.00	100.00	500.00	34.77
6	ODI	R3	4.00	200.00	400.00	34.75
7	Reda	D475N	4.00	200.00	625.00	33.57
8	Centrilift	B11W	4.00	180.00	500.00	31.33
9	Reda	DN440	4.00	100.00	550.00	30.51
10	Ramco_Alnas	S450	3.62	183.60	545.20	28.47

Figure 4. Select Pump

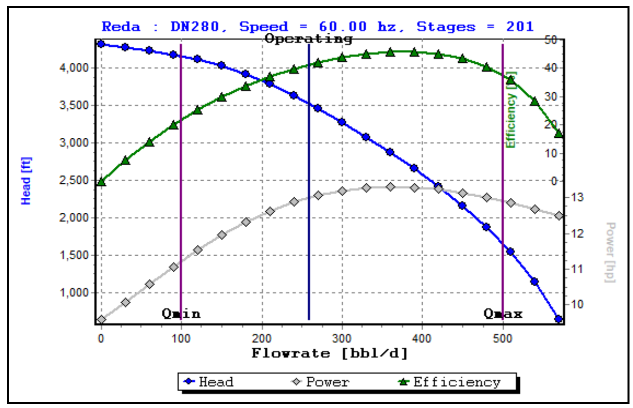


Figure 5. Select Pump

Based on input production simulation data using the pipesim software, it can be seen that the ESP used based on the manufacture and model include:

- Manufacturing ODI models R1 and R2
- Manufacturing Centrilift model B11W
- Manufacturing Ramco_Alnas model S450
- Woods Group Manufacturing TD 150 and TD 300
- Trico model T4-300.
- Manufacturing Reda models D400, A400, DN280, D475N, and DN440 6 manufacturing types and 12 pump models are available.

Manufacturing Reda model DN280, diameter 4 inc, Qmin 100 bbl/d, Qmax 500 bbl/d, pump intake production rate 206 bbl/d, efficiency 34.77%, speed = 60 Hz, stage required 201, pump power required = 12.95 hp (Figure 4), recommended as a manufacturer and the right model is used based on the parameters Qmin and Qmax to the planned production rate of 190 bbl/d from Qmax 380 bbl/d.

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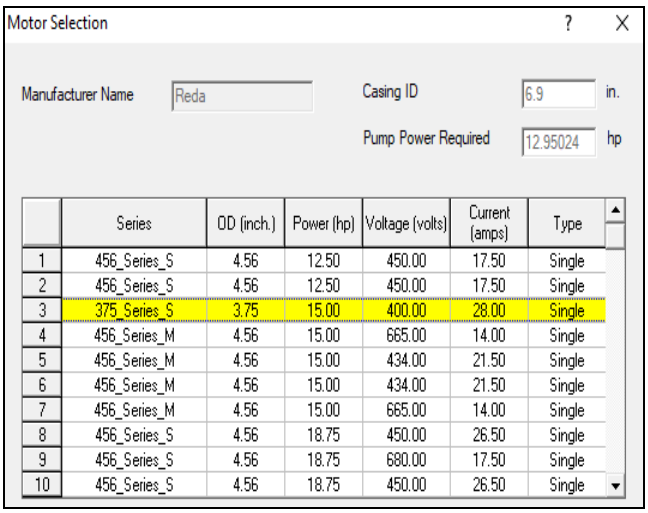
4.3. Motor Selection

Reda DN280 as the basis for selecting the type of motor. Each type of motor can be classified by series, outside diameter (OD), power (hp), voltage (volt), current (amperes), and type. The recommended types of DN280 reda motors are 43 series with each outside diameter (OD), power (hp), voltage (volt), current (amperes), and type. The selected motor is limited by the inside diameter of the casing between 3 inches to 10 inches, and the motor can work at high pressures and temperatures (Rabbi, et.al., 2017). Motor classification 375_Series_S, outside diameter 3.75 inc, power 15 hp, voltage 400 volts, current 28 amperes and single type is selected based on the motor power required 15 hp is greater than the pump power required value of 12.95 hp, so it is safe to use in operation (Figure 6). Specific technical relations are important for the inductor volt-amps and the relation between magnetic induction and magnetic field (Quintaes et al., 2011).



	Series	OD (inch.)	Power (hp)	Voltage (volts)	Current (amps)	Type
1	456_Series_S	4.56	12.50	450.00	17.50	Single
2	456_Series_S	4.56	12.50	450.00	17.50	Single
3	375_Series_S	3.75	15.00	400.00	28.00	Single
4	456_Series_M	4.56	15.00	665.00	14.00	Single
5	456_Series_M	4.56	15.00	434.00	21.50	Single
6	456_Series_M	4.56	15.00	434.00	21.50	Single
7	456_Series_M	4.56	15.00	665.00	14.00	Single
8	456_Series_S	4.56	18.75	450.00	26.50	Single
9	456_Series_S	4.56	18.75	680.00	17.50	Single
10	456_Series_S	4.56	18.75	450.00	26.50	Single

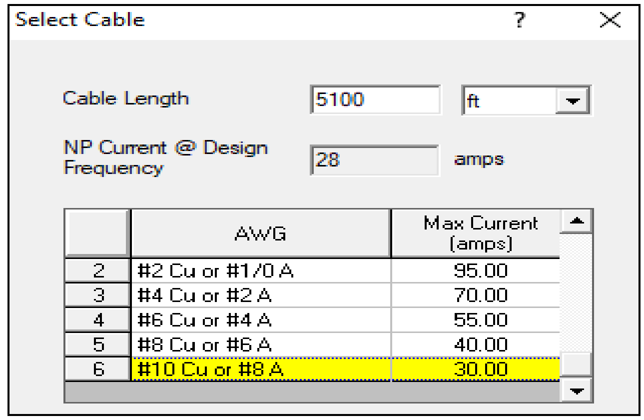
Figure 6. Motor Selection

4.4. Cable Selection

Reda DN280 and motor 375_Series_S as the basis for selecting the cable. There are 6 AWG cables based on the maximum current value (amperes)

a) AWG #10Cu or #8A = 30 amps
b) AWG #8Cu or #6A = 40 amps
c) AWG #6Cu or #4A = 55 amps
d) AWG #4Cu or #2A = 70 amps
e) AWG #2Cu or #1/0A = 95 amps
f) AWG #1Cu or #2/0Al = 110 amps

Reda DN280 and motor 375_Series_S current are 28 amperes, then AWG #10Cu or #8A = 30 amps can be used because the cable ampere is greater than the motor ampere. The total cable length from the subsurface to the surface is 5100 ft, voltage drop 361.8 volts, downhole voltage 400 volts, surface voltage 761.8 volts, and total system KVA 36.9 (Figure 7). The cable is used to transmit electric current from the transformer to the motor, it is necessary to test the electrical system configuration for long distance energy transmitting (Ribeiro et al., 2005).



	AWG	Max Current (amps)
2	#2 Cu or #1/0 A	95.00
3	#4 Cu or #2 A	70.00
4	#6 Cu or #4 A	55.00
5	#8 Cu or #6 A	40.00
6	#10 Cu or #8 A	30.00

Figure 7. Select Cable

5. Conclusion and Recommendation

5.1 Conclusion

The simulation results of reservoir pressure drop on tubing performance show that the well cannot produce natural flow at reservoir pressure (Pr) 950 psi, well flow pressure (Pwf) 642 psi, AOFP 380 bbl, and tubing diameter 2,375 inc. An important aspect in designing an ESP DN280 type REDA model is the suitability of pump selection, motor selection, and cable selection.

5.2 Recommendation

The ESP DN280 type REDA model is an artificial lift that is prepared after the well cannot produce natural flow.

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