Performance Analysis of Electrical Submersible Pumps Type 95-4 Using Nodal Method

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Abstract. Research this aim for analyze performance *Electrical Submersible Pumps* (ESP) Type 95-4 at PDAM Tirta Taman Sari, Madiun City. Method study conducted with Nodal Method. Specification data along with ESP performance obtained directly with method ask answer to operators as well to do experiment by straight away. One ESP components in acquisition capacity fluid is *impeller* contained in each *stage* will Keep going give addition pressure and accelerate movement flowing fluid through with style centrifugal. For evaluate operation production could use Analysis Nodal System with connect curve pressure *tubing intake stages* pump with curve *inflow performance relationship*. In trial the use type pump ESP 95-4 with power pump (P) 15 kW, discharge (Q) 95 m^3/h or 0.0263 m^3/s, rev maximum pump (n) 2900 rpm. Use *submersible motor* with frequency (F) 50 Hz, power (P) 22 Kw, voltage (V) 380 / Δ415 V, strong current (I) 47,0/45,3 A, motor rotation (n) 2855–2880 rpm. Then searching for score strong current (I) 3 wires (AI, AII, AIII), time (T), and discharge (Q) with pay attention regulated water pressure through valve *butterfly*. From result calculation obtained at a pressure of 45 kg/cm^2 get score strong current (I) AI 41.1 A, AII 46.9 A, AIII 44.2 A, time (T) 41.88 s, discharge (Q) 23.87 m^3/s. It means results from ESP performance still in condition good and still can used.

Keywords: Electrical Sumbersible Pumps · Strong Current · Water Discharge · Lap Time · Analysis Nodal System

1 Introduction

Pump is a machine that is used to move liquid water or oil through the piping system and to increase the pressure of the liquid. A further definition of a pump is a machine that uses energy transformations to increase the pressure of a liquid. The energy input into the pump is usually the energy source used to power the drive. Most commonly, electric motors are most often used as propulsion by using electric power [1].

The energy conversion in a centrifugal pump is governed by a general energy equation that describes the conservation of energy between two points in a flowing stream. State that the change in the energy content of a fluid is equal to the work done on the fluid.

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Fluid flowing in a pump can have three forms of energy: potential, kinetic and pressure energy, where the change in potential energy due to a change in altitude is negligible because the vertical distance in the pump stage is negligible. So that the amount of pressure and kinetic energy must be constant, the energy input from the prime mover will be converted into an increase in fluid pressure [2].

Electrical Submersible Pumps (ESP) are a Suite pump consisting of from a number of levels (*stages*) with a motor embedded in fluid and use Genre electricity from surface [3]. ESP is type from pump centrifuge used for lift fluid from reservoir to surface at speed production certain [4].

The head will be developed by the impeller under ideal operating conditions (ignoring friction and other losses), obtained by increasing the centrifugal force acting on the fluid between the two successive blades, assuming an infinite number of blades. The result of this reduction is the famous Euler equation, which is expressed as a function of the rate of liquid passing through the pump as a straight line [5].

Conventional ESP installations run on AC power with a constant frequency of 60 Hz or 50 Hz. The ESP motor in a 60 Hz electrical system rotates at about 3.500 RPM, whereas in the case of a 50 Hz power supply, the motor speed is around 2.900 RPM. For constant speed applications, the most important factor is the size of the impeller which is of course limited by the ID of the well casing. Pumps with larger sizes can produce higher rates although the impeller design also has a large impact on pump capacity [6].

Principle base ESP work that is with stream fluid from *stage* one to next *stage*, where in pump there is rotating part (*impeller*) and place the fluid (*diffuser*). *Impeller* is working to do suction fluid from below then continue *diffuser* and the fluid in the *diffuser* will continue again to part top (*impeller*). If used *stage* a lot, then house *stage* will be higher. This process in progress repeated several times and depending on the quantity *stage*. Every stage used determine the volume of fluid transferred [7].

Efficiency pump defined as ratio the power exerted on the fluid by the pump in relation with supplied power for move pump. Value no permanent for pump certain, efficiency is function from debit and because it's also surgery head. For pump centrifuge, efficiency tend increase with rate genre until point middle through range operation (efficiency peak) and then decrease moment rate Genre increase more continued. Performance data pump like this usually provided by the manufacturer before election pump. Efficiency pump tend decrease from time to time because wear (e.g. increase distance free because size impeller reduced) [8].

ESP motors are electric motors type induction cage squirrel three phase, two pole. The construction of the squirrel cage induction motor is the simplest among electric motor. It is also the most reliable of the motors due to the fact that the rotor is not directly connected to the mains. In use this motorbike is the most efficient [9].

electric motor working move pump with method change energy electricity sent to the motorbike via changed cable becomes energy mechanic. Energy this will be move pump through *shafts* in each unit and between *shaft* will be in relationship with *coupling*. Basically, an electric motor consists of 2 parts main that is rotating *rotor* and non-rotating *stator* rotating [10].

If supplied with frequency 50 Hz, speed synchronous motor to 3.000 RPM and curve performance shifted horizontally. Form curve no changed because feature motor construction not changes, so that at the same load must a similar slip occurs. That's why an operational speed of around 2.900 RPM can be expected if the motor is supplied with mains at 50 Hz where the sync speed is 3.000 RPM [11].

To ensure that the ESP motor can be turned on, it is necessary to check the voltage at the motor terminals at startup. The precise calculation model considers the performance of a series-connected electrical system consisting of a power cable, surface transformer, and ESP motor. The procedure used is simple, it is thought to allow quick checks of wiring and motor co-operation in starting conditions [12].

During period short ignition, decrease voltage on cable electricity greatly increased because the instantaneous very high current, therefore, the voltage reaching the motor terminals is significantly reduced. Under unfavorable conditions, the motor cannot generate sufficient torque to start or reach operating speed. The general rule for normal starting is that about 50% of the voltage plate names must be available at the motor terminals [13, 14].

In election ESP size must be customized with big rate expected production (Q) at the appropriate *head*. Besides Q, size *casing* is also decisive factor in election effective ESP measure [15].

2 Method

This research was conducted using the nodal method directly to PDAM Tirta Taman Sari, Madiun City. Broadly speaking nodal analysis depicted as reservoir, well and choke head interactions wells, and solutions-oriented system for determine level production flowing well. Nodal analysis was used to investigate the effect of changes in operating parameters on well performance [16]. System production of well water produced by the ESP pump as shown Fig. 1.

Activity experiment held by direct together with related operators. The ESP performance specification data collection process includes Strong 3 Wire Current (AI, AII, AIII), Lap Time, and Water Flutter.

In addition to conducting surveys and questions and answers, work steps were also carried out to obtain supporting data in this study, including:

1. Know how to operate and installation *Electrical Submersible Pumps.*
2. Search and collect references on *Electrical Submersible Pumps.*
3. Analyze *Electrical performance Submersible Pumps Type 95- 4.*

3 Results and Discussion

In study performance *Electrical Submersible Pumps* use pump with specification as following:

From specification data pump on with type SP95-4 as on Table 1 has rate production 95 m^3/h with a torque of 25HP, has range *head* between 48 m–84 m signifies that pump capable lift fluid depth of 48 m–84 m and loop pump maximum reach 2900 Rpm.

For move pump need a driving motor, the following is specifications of the driving motor used.

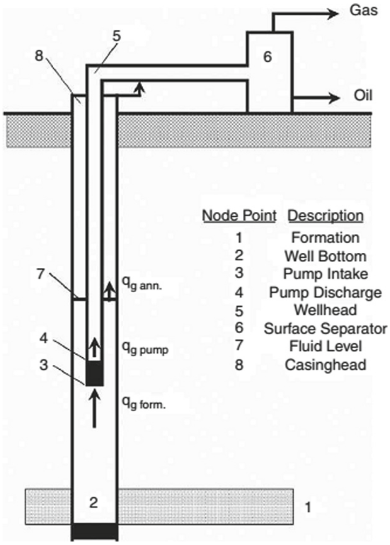

Fig. 1. System production of well water produced by the ESP pump.

Table 1. Specifications of ESP Type 95-4.

ISO09001 Pump Data	
Type: SP95-4	HP: 25
Q: 95 m^3/h	H: 48m
Hmax: 84m	Rpm: 2900
Date: 13J	NO: P13070900030914

Table 2. Specifications Sumbersible Pumps.

Submersible Motor	
Model	2367169020
Rated power	22 kW
Frequency	50 Hz
Voltage rated	3 × 380 – 400 – 415 V
Current value	47.0 – 45.3 – 45.5 A
Rated speed	2855 – 2865 – 2880 Rpm

Specification data submersible *motor* as on Table 2 have power of 22 kW with frequency 50 Hz, has 3 values voltage as big as 380, 400 and 415 V with 3 grades current of 47.0, 45.3, and 45.5 A, and has 3 values rounds 2855, 2865, and 2880 Rpm.

Table 3. Testing Voltage and Current Delta Circuit.

Voltage (V)	Current (I)	Initial Current	Delta Current	Tech
(R) 380 V	(AI) 47.0 A	22.1 A	49.5 A	45 kg/cm2
(S) 400 V	(AII)45.5 A			
(T) 415 V	(AIII)45.3 A			

3.1 Calculation Power, Current and Voltage

In performance data *submersible motor* available big current and voltage as on Table 3.

3.1.1 Calculation Power Connect Delta Perfasa

- Measured process phase (R)

$$\begin{aligned} \mathrm{P(R)} &= 3 \cdot \mathrm{V} \cdot \mathrm{I} \cdot \cos \\ &= 1.73\,.\,380\,.\,47\,.\,0.8 \\ &= 24,718.24 \ \text{Watts} \end{aligned} \tag{1}$$

- Measured process phase (S)

$$\begin{aligned} \mathrm{P(S)} &= 3 \cdot \mathrm{V} \cdot \mathrm{I} \cdot \cos \\ &= 1.73\,.\,400\,.\,45,\ 5\,.\,0.8 \\ &= 25,188,80 \ \text{Watt} \end{aligned}$$

- Measured process phase (T)

$$\begin{aligned} \mathrm{P(T)} &= 3 \cdot \mathrm{V} \cdot \mathrm{I} \cdot \cos \\ &= 1.73\,.\,415\,.\,45,\ 3\,.\,0.8 \\ &= 26,018.51 \ \text{Watts} \end{aligned}$$

3.1.2 Connection Current Connect Delta Perfasa

- Measured process phase (R)

$$\begin{aligned} \mathrm{I(R)} &= \frac{P}{\sqrt{3} \cdot V \cdot cos\varphi} \\ &= \frac{25.188,80}{1,73.400.0,8} \\ &= 45.5 \ \text{Ampere} \end{aligned} \tag{2}$$

- Measured process phase (S)

$$\mathrm{I(S)} = \frac{P}{\sqrt{3} \cdot V \cdot cos\,\varphi}$$

$$= \frac{25.188,80}{1,73.400.0,8}$$
$$= 45.5 \text{ Ampere}$$

- Measured process phase (T)

$$\mathrm{I(T)} = \frac{P}{\sqrt{3} \bullet V \bullet cos\varphi}$$
$$= \frac{26.018,51}{1,73.415.0,8}$$
$$= 45.3 \text{ Ampere}$$

3.1.3 Connection Voltage Connect Delta Per-Phase

- Measured process phase (R)

$$\mathrm{V(R)} = \frac{P}{\sqrt{3} \cdot I \cdot cos\,\varphi}$$
$$= \frac{24.718,24}{1,73.47.0,8}$$
$$= 380 \text{ Volts} \tag{3}$$

- Measured process phase (S)

$$\mathrm{V(S)} = \frac{P}{\sqrt{3} \cdot I \cdot cos\,\varphi}$$
$$= \frac{25.188,80}{1,73.45,5.0,8}$$
$$= 400 \text{ Volts}$$

- Measured process phase (T)

$$\mathrm{V(S)} = \frac{P}{\sqrt{3} \cdot I \cdot cos\,\varphi}$$
$$= \frac{26.018,51}{1,73.45,3.0,8}$$
$$= 415 \text{ Volts}$$

3.2 Lap Time Calculation

Based on results Interview as well as observation at PDAM Tirta Taman Sari, Madiun City. Calculation of time in a water meter as shown Fig. 2 by manual counting using a *stopwatch* by counting one round on the red needle index.

Fig. 2. Water Meter.

3.3 Water Discharge Calculation

The rate of water flowing per unit time in a pipe or channel is called velocity, which is expressed in m/second. Discharge is the volume of water flowing in a pipe or channel per unit time expressed in m^3/s.

In debit calculation using formula:

$$Q = \frac{1000}{T}\, m^3/s \tag{4}$$

In trial ESP type 95-4 performance, discharge measurement using water pressure of 45 kg/cm^2 with time round for 41.88 s, so that the resulting discharge is:

$$\begin{aligned} Q &= \frac{1000}{T}\, m^3/s \\ &= \frac{1000}{41,88}\, m^3/s \\ &= 23.87\, m^3/s \end{aligned}$$

3.4 Nodal Analysis of ESP Performance Data Results Type 95-4

Based on the analysis that has been carried out, the researchers obtained the following data as shown Table 4.

Table as well as the graph on Fig. 3 showing that the bigger current electricity AI, AII, AII cause the longer the time (T) required. Whereas the faster time (T) is getting many rate production / discharge (Q) generated, compared to backwards when the longer the time (T) then the more a little rate production / discharge (Q) generated.

Table 4. Performance of ESP Type 95-4.

Pressure (Kg/cm^2)	**Current I (A)**	**Current II (A)**	**Current III (A)**	**Time (s)**	**Debit (m^3/s)**
10	36.6	32.5	31.7	26.53	37.69
15	37.7	33.3	33.3	27.38	36.52
20	39.3	34.4	34.5	32.54	30.73
25	39.3	36	35.4	38.97	25.66
30	41	36.1	36.6	40.36	24.78
35	41.1	39.3	36.7	46.25	21.62
40	43.1	42.2	39.4	39.35	25.41
45	46.9	44.2	41.1	41.88	23.88
36	41.9	38.9	37	35,12	28.47
38	41.3	38.4	37.1	36.85	27.14
42	45.2	41.2	39.9	40.32	24.80
50	47.5	45.3	42.9	50,17	19.93
28	39.7	38.2	37.4	32.17	31.08
23	38.5	36.2	34.4	29.01	34.47
32	38.8	36	35.7	35.15	28.45
22	35.7	34.2	31.5	28.44	35.16

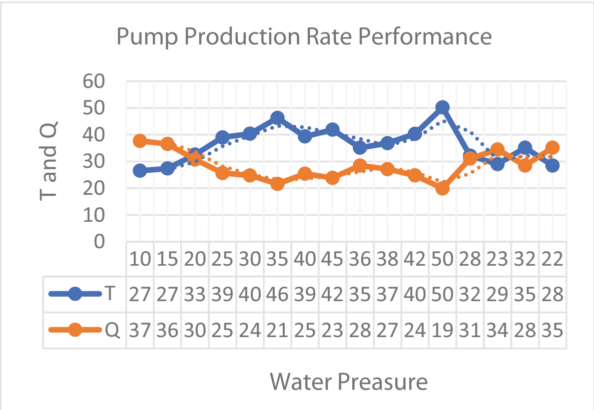

Fig. 3. Curves *Pumps Performance* SP95-4.

4 Conclusion

From the results of the analysis and calculation of the performance of the ESP Type 95-4 carried out at the Tirta Taman Sari PDAM, Madiun City, the conclusions that can be conveyed are as follows: Measurement result cable *Submersible Motors* get value 46.9 A - 44.2 A - 41.1 A at a pressure of 45 kg/cm^2, which shows that the driving motor in condition good and worthy because no not enough from current beginning of 22.1 A and not exceed delta current of 49.5 A. Calculation result performance *electrical submersible pumps* at a pressure of 45 kg/cm^2 show big rate of 23.88 m^3 /s with time 44.88 s. So that can be rated pump still good and worthy used.

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