SUBMERSIBLE PUMP EVALUATION OF SELECTION SYSTEM OF PDAM TIRTAULI IN SIANTAR SELATAN DISTRICT, PEMATANGSIANTAR CITY IN 2018

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Abstract

In this Final Project a submersible pump type pump has been applied. From the data pump the capacity is 27.10 l / sec. The pump head is 14.62 m based on calculations in the field. By using empirical equations, we can determine the main parameters of pump planning, namely specific speed, pressure loss on the pipe wall, length, diameter and type of pipe, the number and type of pipe accessories used.By conducting research and measurements on the field obtained a 6 inch pipe diameter, Ci type and 1260 meter pipe length using Hazen William formula and continuity of flow and pressure loss along the pipe (loss head friction) and pressure loss (minor loss head) is 20.50 meters.

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Keywords:submersible pump, head loss, pipe length, pipe type and pipe size

INTRODUCTION

Pumps have been used by many people for a long time, from the smallest units in households to large industries. The use of pumps that are increasingly widespread over time causes the type and shape of the pump to develop very rapidly. In the current era, many pump manufacturers offer various forms of pumps with various advantages. In fact, often a company makes certain pumps that are only used for special applications. Considering the many types of pumps on the market, foresight in choosing a pump is the main requirement in order to obtain optimum pump work according to the system served.

In the household pumps are widely used to pump water from wells for use in various activities of daily life. In agriculture, pumps are widely used in irrigation systems to irrigate rice fields. In supplying drinking water to the community, pumps are used to distribute raw water to the IPA (Water Treatment Plant) and then distribute it to people's homes.

In the oil industry, pumps are not only used in refineries but are also used in distributing oil to distribution centers. In power service centers, especially PLTU (Steam Power Plant), pumps are used as boiler feed pumps. In addition, it is also used to pump condensate (water condensed in the condenser) to the boiler feed pump and to circulate cold water to the condenser. In buildings, pumps are used to circulate cooled water to rooms in a central air conditioning system.

In the food industry in general, cleanliness in the production process is a major requirement to maintain product quality. Therefore the pumps used in the food industry must be corrosion resistant without any leakage of lubricating oil into the food. The cleaning process should also be made as easy as possible. In the food industry, sanitary pumps are widely used which meet hygiene and health requirements. This pump is used to convey liquid raw materials (have not yet undergone a production process) and also liquid food products prior to packing. In addition, it is also used to supply clean water as a mixture of other ingredients in the factory process.

The pipes used in the food/beverage production process must also meet hygiene requirements. Therefore the pipe material must be resistant to rust. The material that is often used is stainless steel because apart from being rust-resistant, the pipe also has a smooth surface and easy cleaning.

LITERATURE REVIEWS

In the application of a water distribution installation system, both waste water and clean water, the role of the pump is never separated. This has been clearly felt by those working in the field of environmental engineering, especially PDAMs in Indonesia.

In accordance with the role of the pump which is used as a tool to increase the pressure (head) of liquid so that the liquid can be raised from a low surface level to a high surface level, especially in underground water distribution systems from deep wells, the role of the pump is absolutely necessary (required).

To achieve maximum results according to the plan used as a reference, it is not enough to only be guided by the operating system, maintenance and repair, but the selection of pump specifications according to their use must also be understood.

In terms of selecting pump specifications to anticipate the possibility of various forms of waste, we must first know the steps and calculations that can affect the operation of a pump unit, in this case a submersible pump.

In its application according to existing systems and procedures, to choose the right pump specifications, during the initial planning we know what type of liquid will be pumped, the value of the static head of the pump, the driving power of the electric motor (electricity), the length and size of the suction and pressure pipes, the required amount of liquid discharge, as well as calculating how much pressure loss and water loss occurs along the pipe, so that in determining the proper pump specifications that are carried out and function properly.

Raw Water Source

Sources of raw water for drinking water are generally categorized as consisting of:

a. Rainwater, namely the precipitation of water vapor that collects into clouds and falls to the surface of the earth as water droplets

b. Surface water, namely water that is on the surface of the ground. It is divided into 3 (three) namely: lake water, sea water, and river water

c. Groundwater, namely water that is in the layers of soil or rock below the surface of the soil

Water Tapping Facility

The tapping facility is the most important part of the whole clean water supply system because if it doesn't work, the whole system can't function

The function of the water tapper is to provide raw water continuously to meet 3 (three) important factors that must be met by the water supply system, namely quality, quantity and continuity.

Pump

A pump is a device used to move a liquid from one place to another by increasing the pressure of the liquid. The increase in liquid pressure is used to overcome flow resistance. These flow barriers can be in the form of pressure differences, height differences or frictional resistance, and according to their function, the pump is a tool used to:

a. Transferring fluids from one place to another (eg water from an underground aquifer to a water storage tank).
b. Circulating fluids around the system (e.g. cooling or lubricating water passing through machinery and equipment).

Pump Capacity

Pump capacityis the volume of liquid pumped per unit of time which is usually measured in liters/second or m3/second, this capacity is usually called the actual capacity of the pump.

Pump internal capacityis the amount of liquid flowing through the pump, equal to the actual capacity plus the leakage that occurs in the pump itself. Therefore there must be a correction factor in determining the pump capacity.

Pump Characteristics

Pump characteristics can be described in the characteristic curve which states the relationship between capacity and head, shaft power (Bhp) and pump efficiency (). The pump characteristic curve is generally drawn at a constant speed.ŋ

Characteristics of Series and Parallel Pumps

If the required head and capacity cannot be achieved with just 1 (one) pump, then 2 (two) or more pumps arranged in series or parallel are required. To get a higher head, several pumps are arranged in series and to get a larger capacity, several pumps are arranged in parallel.

Submersible Pump

A submersible pump is a multistage centrifugal pump, in which the entire pump and motor are submerged in liquid. This pump is driven by an electric motor below the surface of the liquid through a motor shaft (shaft) that rotates the pump, and will rotate the impellers of the pump. The rotation of the blades creates a centrifugal force which is used to push the fluid towards the ground surface.

Submersible Pump Performance Characteristics

The electric motor rotates at a relatively constant speed, turning the pump (impeller) through the shaft which is connected to the protector section. Power is channeled to the pump motor via a conductor electrical cable clamped on the tubing. Fluid enters the pump at the intake and is discharged into the tubing when the pump is operating.

***Pump Head (*System Resistance)**

*heads*denotes the energy or ability to perform per unit mass. From the point of view of the pump, head is a measure of the energy given to the liquid at a certain capacity and operating speed, so that the liquid can flow from a low place to a high place.

Pump Operation System

Submersible pumps use electrical power to drive a motor. The motor has a shaft perpendicular to the impeller and one shaft perpendicular to the impeller. Because the position of the impeller is on the same axis as the motor, when the motor is running the impeller will rotate and the water in the suction cup will be lifted by the blades in the impeller.

To keep the water that has been sucked in (lifted) by the impeller so that it doesn't leak back into the suction cup, the water is held back by the lower diffuser which is at the bottom of the pump. The sucked water will first circulate in the Motor Housing to cool the motor before flowing into the exhaust. (exhaust pipe)

To turn off the pump we disconnect the electric current that goes to the terminal board. If the current is cut off, the motor will stop automatically and the impeller will stop sucking water.

METHODS

Data collection technique

Data collection techniques are carried out by:

A. **Observation (Observation)**

Direct observations made in the field directly during research are aimed at obtaining direct data and information and preventing any misunderstandings about the system for selecting specifications, operation, maintenance and repair of pumps, especially deep well pumps and the systems applied.

B. **Interview**

This activity was carried out to inventory data that was not obtained directly from the field and then used as a complement to field data and analyzed to serve as a reference and guide in data collection techniques and efforts were made to conduct interviews with personnel (officers) whose information could be trusted.

C. **Study of literature**

Activities carried out throughout the research to obtain materials or data for comparison between practice in the field and theory learned during education. From the system data for selecting specifications, operation, maintenance and repair of pumps obtained, it will be known whether the application of the existing system is in accordance with the theory obtained during education and meets the required criteria.

D. Field research.

Activities that are carried out directly at the practice location and help with the work carried out. From this activity it is hoped that actual data will be obtained from the condition of the system for selecting specifications, operation, maintenance and repair of the pumps applied so that an evaluation of the system can be carried out.

Data source.

The data sources that will be collected from the research location to be analyzed include:

Primary data.

Direct data collection was carried out during field observations assisted by previously appointed officers. The data that will be taken are:

1. Pump operating capacity
2. Fluctuation of water level
3. Spring elevation
4. Pump elevation - reservoir
5. Pipeline length, diameter and accessories
6. Panel diagrams
7. *Directions/booklets*

Secondary Data.

The data obtained from the literature studies conducted, coupled with existing data in the PDAM or any existing data used by the PDAM concerned. The data that will be taken are:

1. Description of PDAM Tirtauli City of Pematangsiantar
2. *As built drawing*pump installation
3. *Specification*pumps from pump manufacturers in the form of curves, types and brands of pumps
4. Pump operating system
5. Power consumption for pump operation

RESULTS AND DISCUSSION

Results And Discussion

System analysis

A. Pump Head Calculation

1. Calculation of the Pump Head According to the Planned Data of PDAM Tirtauli, Pematangsiantar City

a. Overview of the speed with the pipe used in the pumping system is a 150 mm GIP pipe with Q = 0.0271 m3/second:

Flow Continuity Formula: Q = V x A

$\frac{1}{4}$ xΠx D2 x V = 0.0271 m3/sec

$$V = \frac{4\,x\,Q}{\Pi\,x\,D^2}$$

$$V = \frac{(4)(0{,}0271)}{(3{,}14)(0{,}15)^2} = \mathbf{1.53 m/s}$$

Speed Energy (Ek)

From the data on flow velocity, we can determine the Velocity Energy with the formula $\frac{V2}{2g}$

$$\text{Speed energy (Ek)} = \frac{V2}{2g} = \frac{(1{,}53)^2}{2\,x\,9{,}81} = 0.12 \text{ m}$$

b. Calculation of Minor Head Losses in Suction and Discharge Pipeline Networks

Table Pump network fittings

No	Name of goods	Size	Total	Unit	K value	CHW	Total Value of "K"
I.	Suction network (suction):						
1	Galvanized Pipe	150mm	2	m		135	
2	Strainers	150mm	1	units	1.97		1.97
						Qty Ks:	**1.97**
II.	NetworkPress (Discharge):						
1	Galvanized Pipe	150mm	1260	m		135	
2	Gate Valves	150mm	1	units	0.140		0.14
4	Bend 90o GIP	150mm	7	units	0.26		1.82
5	Bend 45o GIP	150mm	6	units	0.14		0.84
6	Reservoir Inlets	150mm	1	units	1,000		1
						Jl. Kd	**3,8**
						Total Total Ks + Kd	5,77

In the table above, the values obtained are:

∑Ks = 1.97

∑Kd =3.80

From the above data, minor head loss can be calculated using the formula hmm $= \sum Ks \text{ x } \frac{V^2}{2xg}$

hms $= 1.970x \frac{(1{,}53)^2}{2\,x\,9{,}81}$ =**0.24 meters**

hmd $= 3{,}80x \frac{(1{,}53)^2}{2\,x\,9{,}81}$ = 0.46 meters

Total head minor

∑hm = hms + hmd

= 0,24 meters + 0.46 meters

=**0.70 meters**

c. Calculation of Head Loss Friction in Transmission Pipeline Networks from Springs to Reservoirs

Known data:

Q pump = 0.0271 m3/sec
D = 100mm = 0.150 meters
GIP pipe→Chw = 135
L suction pipe =2 meters
L discharge pipe =1260 mtrs

Calculation of Major Head Loss in Suction Pipeline Networks

$$hfs = \left[\frac{Q}{0{,}2785\,xCHWxD^{2,63}}\right]^{1,85} x\,L$$

$$= \left[\frac{0{,}0271}{0{,}2785\,x135\,x\,0{,}15^{2,63}}\right]^{1,85} x\,2\,meter$$

= 0.03 meters

Calculation of Major Head Loss in Discharge Pipelines

$$hfd = \left[\frac{0{,}0271}{0{,}2785\,x135\,x\,0{,}15^{2,63}}\right]^{1,85} x1260\,meter$$

= 19.77 meters

So :

∑hf =hfs + hfD

= 0.03 meters + 19.77 meters

= 19.80 meters

$\sum hl = \sum hf + \sum hm$

= 19.80 meters + 0.70 meters
= 20.50 meters

d. Calculation of Head Static (ht)

*Head statics*in this case is the height between the deep well water level and the highest pump outlet pipe

ht =- 6 meters

e. Pump Head Calculation (Hp)

Calculation of pump head can be determined by using the following theorem:

Mobile phone =∑hl + ht + Speed energy (Ek)
= 20.50 meters + (-6 meters) + 0.12 meters
= 14.62 meters

Then the coordinate point of the pump requirement can be known:

Q = 0.0271 m3/s = 97.56 m3/hour

H = 14.62 meters

Pump Analysis

a. Pump Specific Speeds.

- Pump Specific Cycle at the location of the Simarito spring, Aek Nauli Village, South Siantar District, Pematangsiantar City.

The specific rotation of the pump can be determined based on the working point at the best efficiency by looking at the initial characteristic curve. The pump used is a Submersible Pump.

With pump rotation (n) = 2900 rpm and the pump coordinates are:
Capacity (Q) =27.10 l/sec
H (heads) =14.62 meters

Then the specific rotation of the pump can be found using the following equation 2.16:

By knowing the operating capacity of the pump = 27.10 l/s, then:

$$\frac{27{,}10 \frac{l}{det} x60 \, \det/menit}{1000 \; l/m^3} = 1{,}626 \frac{m^3}{menit}$$

Ns $= nx\frac{Q^{1/2}}{H^{3/4}}$

$=2900x\left(\frac{1{,}626^{0{,}5}}{14{,}62^{0{,}75}}\right)$

= 494.59

b. Pump Characteristics.

Based on the performance curve from the pump manufacturer, the pump operating capacity and pump head at the Simarito spring location, Aek Nauli

Village, Siantar Selatan District, Pematangsiantar City are compared with the performance curve graph from the pump manufacturer

TableComparison of operating capacity (Q) with capacity (Q) on the Performance Curve Graph of Pump Manufacturers at the same head.

Simarito spring pump, Aek Nauli Village, South Siantar District, Pematangsiantar City		Based on the Performance Curve (Simarito spring pump, Aek Nauli Village, South Siantar District, Pematangsiantar City)	
Capacity (Q) l/sec	heads (H)m	Capacity (Q) l/sec	heads (H)m
27,10	**14,62**	**30**	**35**

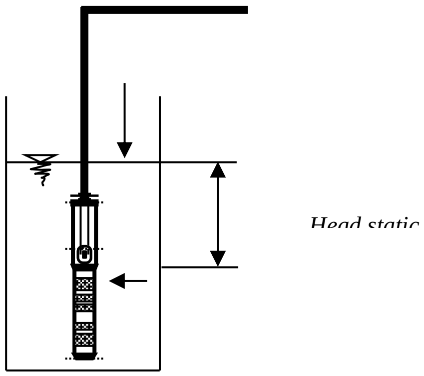
Source: Calculation results and performance

c. *Net Positive Suction Head Available (NPSHAV)*

In general, for submersible pumps there is no need to calculate NPSH, because in principle the NPSH value is used to review the suction capacity of the suction network or as a head that causes liquid to flow through the suction pipe and finally into the pump. As it is known that the pump is submersible as long as the inlet mouth of the pump is still submerged in liquid, then NPSHAV > NPSH REG.

Cavitation can still occur if the targeted head height cannot be reached by the pump, as a result the pump continues to rotate, but the water cannot reach the desired destination.

But on this occasion, writing calculates the NPSHAV value as follows:



Drawing of the head principle on the submersible pump suction pipe

The figure above shows that the pressure acting on the surface of the liquid (Pa) will help push the liquid into the pump at that pressure, supported by the height of the liquid against the pump shaft (hs), while the saturated vapor pressure (Pv) that occurs at the pump when the pump is operating it gives negative energy to the two powers earlier, so from these events the NPSH AV value for submersible pumps can be calculated by the equation:

$NPSH\ AV = + hs \frac{Pa - Pv}{\gamma}$

It is known that the pump operates under the following conditions:

- Calculation of NPSHAV Pump for the location of the Simarito spring water pump, Aek Nauli Village, South Siantar District, Pematangsiantar City.

Water temperature T 25.5 oC =

$$998.3+\left(\left(\frac{25,5-20}{30-20}\right)\ x\ (995,7-998,3)\right)$$

= 998.3 + (0.55 x (-2.6))
= 998.3 + (-1.43)
= 996.87

So at T = 25.5 oC the value γ = 996.87 kg/m3 is obtained
Atmospheric pressure (Pa) = 10.33 mka
Saturated vapor pressure (Pv) at 25.5 oC must also be interpolated as follows:

Water temperature T 25.5 oC = $238.3+\left(\left(\frac{25,5-20}{30-20}\right)\ x\ (432,5-238,3)\right)$

= 238.3 + (0.55 x 194.2)
= 238.3 + (106.81)
= 345.11

So at T = 25.5 oC the value of Pv = 345.11 kg/m2 is obtained
Head suction(hs) = 2 meters

NPSH AV $=\frac{Pa-Pv}{\gamma}+$ hs

$=+2\frac{10330-345,11}{996,87}$

= 12.016 meters

d. Calculation of Pump Power

In calculating the pump power used at the pump working point, it can be seen in the voltage (volts), electric current (amperes) and cos φ on the control panel, while the efficiency of the pump can be seen in the display of the performance characteristics of the curve.

Is known :

Pump power at the location of the Simarito spring water pump, Aek Nauli Village, South Siantar District, Pematangsiantar City

Observation data :
Capacity (Q) = 27.10 l/sec = 1.626 m3/min
At T = 25.5 oC, the value of γ = 996.87 kg/m3 is obtained
Based on equation 2.12, the calculation of water power is as follows:

1. Calculation of Water Power

Water Power is the minimum power needed by the impeller to move water

Is known :

γ = 996.87 kg/m^3

Q = 0.0271m^3/sec = 1.626 m3/min

H =14.62 meters

Basic Formula:

$Pw = \ 0{,}163\ x\ \gamma\ x\ Q\ x\ H$

Pw = 0.163 x 996.87 x 1.626 m3/minute x 14.62 meters

=3,862.7 Watts

=3.86 Kw

2. Shaft Power Calculation

Shaft Power is the minimum power required by the Pump shaft to drive the impeller.

According to the measurement data in the field, it is known that:

V = 380 Volts

I_n =35 amperes

$Cos\ \varphi$ = 0.85

Basic Formula: P = x V x In x Cosfi$\sqrt{3}$

=$\sqrt{3}$ x 380 x 35 x 0.85

= 19,580.83 Watts

= 19.58 kW

3. Calculation of the Nominal Power of the Initial Driver (Driver)

Initial driving power is the power or electrical energy required to drive the pump, which can be calculated by equation 2.15

Is known :

P =19,580.83 Watts

η_{trans}= Transmission efficiency of the gear box, belt, chain or clutch (0.95 to 0.97)

Selected value = 0.95η_{trans}

α = reserve factor (for induction motors = 0.1 to 0.2)

Markαselected = 0.2

Then according to the equation:

$$\mathbf{Pm} = \frac{\boldsymbol{P}\ (\mathbf{1} +\ \boldsymbol{\alpha})}{\eta_{trans}}$$

$$\mathbf{Pm} = \frac{19.580{,}83\ (\mathbf{1} + \mathbf{0{,}2})}{0{,}95}$$

=24,733.68 Watts

= 24.7 kW

CLOSING

Conclusion

In accordance with the conclusions of the research results obtained are:

Submersible Pump Specification Selection System at the Location of the Simarito spring, Aek Nauli Village, South Siantar District, Pematangsiantar City:

Selection of Pump Specifications:

The selection of specifications is carried out on target provisions that have not been on target, this is evidenced by the graphic images in the manual issued by the pump manufacturer. However, according to the performance of the existing cuve, the capacity that should have been pumped up to the reservoir was 30 l/s and the pump head was 37 meters, but in the author's direct observation in the field (in this case reading the numbers (water meter), the pump's operating capacity only reached 27 ,10 l/sec .

This can happen due to several supporting possibilities, including:

1. The water meter is not installed, so the results of the measurements taken (with a portable water meter) are not updated.
2. From several physical conditions, the accessories that are installed may be damaged, causing higher head losses and this can affect the operating capacity of the pump.
3. It is possible that the physical condition of the pump and/or electric motor may have decreased in performance, considering that the operating hours of the pump are enforced for 22 hours in 1 (one) day, causing damage to certain parts of the pump components.
4. There is a possibility that there is a leak in the discharge pipe, so that the capacity carried by the pump is not as optimal as expected.

Suggestions

To anticipate the possibility that the condition of the pump is installed at the location of the Simarito spring, Aek Nauli Village, South Siantar District, Pematangsiantar City, the authors suggest:

a. Every time you plan to install a pump, you should make a more accurate calculation using a comparison of the performance curve and technical data from the pump manufacturer.
b. Seeing the condition of the water source at the Simarito spring location, Aek Nauli Village, South Siantar District, Pematangsiantar City, it is best if the Tirtauli PDAM replaces the type of submersible pump with a single stage centrifugal pump.
c. Check the installed accessories, make repairs if possible, purchase new accessories if necessary and install water meters and manometers. This is done to provide a solution, in order to know what action to take next.
d. In the pump installation, according to the author's observation, a check valve that functions properly has not been installed, this will have a negative impact on pump operation if back pressure occurs, for this reason, a check valve installation is needed.

e. Check the installed pump with the measuring tools in the manual issued by the pump manufacturer and ask for direct instructions from the pump manufacturer.
f. Improving better quality of operation and maintenance of pumps and other equipment such as panels used by pumps.
g. Continuously monitor the condition of the raw water parameters that will be distributed to each customer and then control any disturbances to the condition of the raw water parameters so that customer service is maintained and excellent.
h. Continue to monitor the condition of the water level to anticipate cavitation not to occur when the pump is operating.
i. Considering that the current condition of water sources is increasingly difficult to obtain, the author also suggests that the PDAM Tirtauli Pematangsiantar City can make improvements to the water catchment area by planting trees.

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