Evaluation And Analysis Of Flow and Pressure Patterns On Water-Pipeline Network Of Regional Clean Water CompanyTirta Kahayan, Palan

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Evaluation And Analysis Of Debit Distribution Patterns And Pressure On Water-Pipeline Network Of Pdam Tirta Kahayan Palangkaraya City

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ABSTRACT: *PDAM Tirta Kahayan of Palangkaraya city has a technical problem regarding with inadequate service standard (coverage level). As a result from the direct observations at the service area of PDAM Tirta Kahayan of Palangka Raya city, there were numerous public complaints related to PDAM services, especially the issue on fees, debit and distributed water pressure. Lossing water in PDAM Palangka Raya City ranges from 23% -35%. The aims of this study is to identify the condition of the pipeline distribution network of PDAM Tirta Kahayan in Palangka Raya City, to evaluate the debit distribution patterns and pressure on pipeline network of PDAM Tirta Kahayan Palangka Raya City by simulating the Epanet 2.0 program and to compare the simulation results with the exiting conditions, moreover to analyze the improvement alternatives debit and pressure on distribution piping networks. Based on the results of the simulation of Epanet 2.0 program there are still some locations that have debits and flow rates below 0.3 LPS. This is due to differences in elevation, the distance which is getting much more apart from the service source and mismatching of the pipe dimension. The improvement alternatives that have been made are by installing booster pumps in several locations that aim to increase the flow and flow velocity, continuous reservoir filling and regulation of distribution pump operation; therefore the water pressure is always maintained.*

KEYWORDS:*Epanet 2.0, distribution network system, debit, pressure*

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I. INTRODUCTION

Perusahaan Daerah Air Minum(PDAM) Palangka Raya City as aBadan Usaha Milik Daerah (BUMD) owned by the Palangka Raya City Government, was formed based on the Palangkaraya Regional Government Regulation No. 1 of 1986 which has the mission of providing/producing, distributing and selling, on time, good quality water to the community who meet health standards and provide excellent service to customers and prospective customers (PDAM Kota Palangka Raya, 2011).

As well as the other PDAM in other cities in Indonesia, PDAM Tirta Kahayan City of Palangka Raya also has a problem, particularly aninadequate service standard (coverage level). From the direct observations at the location of the service area of PDAM Tirta Kahayan, Palangka Raya City, there were several complaints from the public due to PDAM services, for instance the issue of fees, debit and pressure of distributed water. Several people complained about the inclining exponantially of the fees of PDAM Tirta Kahayan in Palangka Raya City which was not comparable with the service provided, also others complained about the water distribution and water pressure were little distributed especially at peak hours in the morning and evening, the discharge and water pressure were not distributed to the some locationswhich is located at suburbs of service area (PDAM Tirta Kahayan City of Palangka Raya, 2018)

This study aims to identify accurately the physical condition of the pipeline distribution network of PDAM Tirta Kahayan in Palangka Raya City, to evaluate carefully the flow and pressure distribution patterns ofpipeline distribution network of PDAM Tirta Kahayan in Palangka Raya City and to analyze in detail the alternatives to enhance the distribution and discharge distribution patterns in pipeline distribution networks through evaluation of reservoir filling, booster , pump operation at the research location.

This research is expected to be able to provide merits to the education field, especially in the development of water resources engineering by utilizing several existing applications to solve the problems faced in water resources engineering and as input for PDAM Tirta Kahayan in Palangka Raya City in terms of identifying the conditions of pipeline distribution network, evaluating debit and pressure distribution patterns and analyzing alternative improvements in distribution patterns.

II. THEORITICAL REVIEW

Factors that need attention in the piping network system in the water distribution are pressure, quality and continuityfor this reason, several things such as distribution pipelines need to be considered, consisting of main pipes, branch pipes and service pipes. The things which must be considered of the pipe distribution placement is the location of the pipe, regional topography, citizen deployment, availability of gravitational energy and the number of loops needed (Riduan, et al., 2012, Riduan, et al., 2017). This is useful to facilitate the operation and control, as well as pipeline equalization and service. The meant of service equity is to create a pipeline system in such way that entire city is well served (Ardiansyah, et al, 2012, Haq, &Masduqi, 2014, Idris, et al, 2012, Krisnayanti, et al, 2013, Natalia, et al, 2012, Paryono&Susilo, 2014, Pasaribu, 2005, Pekuwali, et al, 2005).

The distribution system consists of 2 (two) parts namely the macro system and micro system. The macro system functions as a conduit for pipelines. This pipeline could not flow directly to consumers since it could be resulted in a huge reduction in energy. This system is also called a delivery pipe system or feeder which consists of primary feeder and secondary feeder. While the micro system serves as a service pipeline to consumers, such to the public residence. The micro system could form a service network. Micro systems are often called pipeline service systems consisting of small distribution mains (main service pipelines), service lines and pipe services (Syahputra, 2005, Swamee, et al, 2008, Suyitno, 2008, Safii, 2012).

According to Bernoulli, the amount of height place, height pressure and height speed at each point of the water flow are always constant. The Bernoulli equation might be seen as an energy conservation equation considering that z is the liquid potential energy of each unit in weight (Figure 1).

$$\frac{m.g.z}{m.g} \approx z \qquad (2.1)$$

$$\frac{p}{\gamma} \approx \text{Potential strength of liquid pressure} \qquad (2.2)$$

$$\frac{p.v}{m.g} \approx p\frac{m.g}{\gamma} \approx \frac{F}{\gamma} \qquad (2.3)$$

$$\frac{v^2}{2g} = \quad \text{kinetic power} \qquad (2.4)$$

$$\frac{\frac{1}{2}m.v^2}{m.g} \approx \frac{v^2}{2g}$$

With the similarity of in and out mass balance of energy, the energy of A could be equal to the energy of B, therefore

$$H = z + \frac{p}{\gamma} + \frac{v^2}{2g} \qquad (2.5)$$

$$z_1 + \frac{p_1}{\gamma} + \frac{v^2}{2g} + hf = z_1 + \frac{p_2}{\gamma} + \frac{v^2}{2g} + hf \qquad (2.6)$$

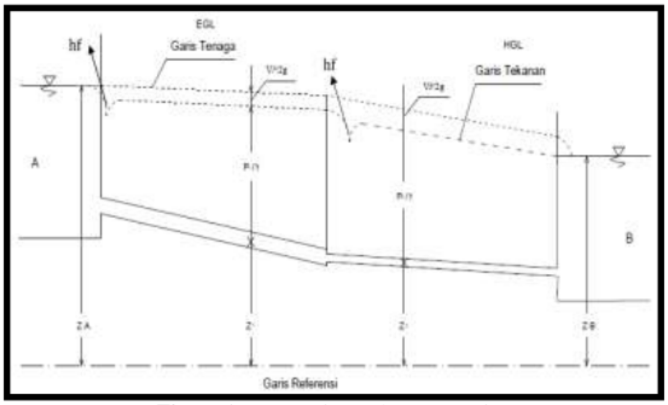

Figure 1. Energy Line and Pressure Line

III. RESEARCH METHODS

This rearch was conducted at PDAM Palangka Raya city, The Central Kalimantan.The data needed in this study were pressure data, debit data, number of customers, network map, pipeline data (length, diameter, type and age of pipe), elevation data, and the usage of water data. Moreover, build a network model using Epanet 2.0 software then inputting data and simulating models. After that, calibration and data validation are carried out to provide a comparisom of observation data with the results of network simulation. Map of the research location might be seen in Figure 2.

Figure 2. Research Location of PDAM Palangka Raya City

IV. RESULTS AAND DISCUSSION

The raw water of PDAM Palangka Raya City is taken from the water resources of Kahayan River which has a discharge quantity of 3,727.5liters/second. The IPA capacity is 217.5 liters/second which was built in 1997/1997. At the distribution unit the reservoir distribution has a capacity of 2,500 m³. The drainage system uses 2 (two) distribution pumps each with a capacity of 120 L/s and 150 L/s where a 120 L/ sec pump operates continuously and a pump with a capacity of 150 L/s only operates at the peak hours every morning and evening. The piping system uses a branch system through a PVC pipe and a small portion of HDPE pipe with a pipe diameter from Ø500 mm to Ø63 mm. The number of customers until the end of 2017 was 17,286 customers spread in 4 (four) sub-district locations.

There is no major difference in the area of Palangka Raya City sincePalangka Raya City is relatively flat. The elevation data ranges from 49.00to 51.69 m.dpl (meters accounted above the sea level). Plot counter data from the pipeline network elevation when compared with pressure data at each junction (node) indicates that the elevation of a location is inversely proportional to the pressure at that location. The greater the elevation of a location, the smaller the pressure at that location and vice versa.

The range of the pressure in the distribution network system ranges from 106.52 to 120.12 mka where the lowest pressure is 106.52 mkawhich occurs at node 1690 which is ± 9 km from the service center and the highest pressure is 120.12 mka which occurs at node 1052 which is distant ± 2.4 km from the service center. The pressure range value has met water pressure standards by the Minister of Public Works Regulation No. 18 of 2007 (Minister of Public Works Regulation No. 18 of 2007).

As a result of the data link in the Epanet 2.0 simulation program, there were found that there was some speed of water in the pipe that did not meet the standard flow velocity in the pipe (0.3 - 4.5 liters/second) according to the Minister of Public Works Regulation No. 18 of 2007. This is caused by the drainage system which has not been optimal due to several factors including the ineffective piping design, inadequate distribution discharge, and the risingof high water requirements exceeding the initial piping design capacity.

The amount of the distributed debit in the PDAM Palangka Raya City network system is 0.01 - 26.85 Liter/second (LPS). The largest debit value is on a network which is obviously close to the service center, while the debit with a small value is on a network that is extremelyfar from the service center.

Pressure is measured at several locations that are considered to represent critical points, while the tool used is a pressure recorder. Measurement results might be seen in Table 1

Table 1. Results of Pressure Measurement

Time	Pressure (mka)												
	Elevation (mdpl)												
	48.71	49.40	49.68	50.00	50.46	49.81	49.84	49.66	49.71	50.26	51.55	51.66	49.66
01.00	4.90	9.81	9.98	10.00	10.00	1.00	2.90	11.77	1.00	2.94	7.85	4.90	4.80
02.00	4.90	9.81	9.80	10.00	10.00	1.00	2.90	11.77	1.00	2.94	7.85	4.90	4.80
03.00	4.90	9.81	9.80	10.00	10.00	1.00	2.90	11.77	1.00	2.94	7.85	4.90	4.80
04.00	4.90	9.81	9.80	10.00	10.00	1.00	2.90	11.77	1.00	2.94	7.85	4.90	10.80
05.00	10.90	15.81	15.80	16.00	10.00	1.00	8.90	11.77	1.00	8.94	13.85	10.90	10.80
06.00	10.90	15.81	15.80	16.00	10.00	1.00	8.90	11.77	1.00	8.94	13.85	10.90	10.80
07.00	10.90	15.81	15.80	16.00	10.00	1.00	8.90	11.77	1.00	8.94	13.85	10.90	10.80
08.00	10.90	15.81	15.80	16.00	10.00	1.00	8.90	11.77	1.00	8.94	13.85	10.90	10.80
09.00	10.90	15.81	15.80	16.00	10.00	1.00	8.90	11.77	1.00	8.94	13.85	10.90	4.90
10.00	4.90	9.81	9.80	10.00	10.00	1.00	2.90	11.77	1.00	2.94	7.85	4.90	4.90
11.00	9.48	9.81	9.80	10.00	10.00	1.00	2.90	11.77	1.00	2.94	7.85	4.90	4.90
12.00	4.80	9.81	9.80	10.00	10.00	1.00	2.90	11.77	1.00	2.94	7.85	4.90	4.90
13.00	4.80	9.81	9.81	10.00	10.00	1.00	2.90	11.77	1.00	2.94	7.85	4.90	6.90
14.00	6.80	11.81	11.98	12.00	10.00	1.00	4.90	13.77	1.00	4.94	9.85	6.90	5.90
15.00	5.80	10.81	10.98	11.00	10.00	1.00	3.90	12.77	1.00	3.94	8.85	5.90	9.90
16.00	9.80	14.81	14.98	15.00	7.50	1.00	7.90	16.77	1.00	7.94	12.85	9.90	9.90
17.00	9.80	14.81	14.98	15.00	10.00	1.00	7.90	16.77	1.00	7.94	12.85	9.90	9.90
18.00	9.80	14.81	14.98	15.00	11.00	1.00	7.90	16.77	1.00	7.94	12.85	9.90	9.90
19.00	9.80	14.81	14.98	15.00	10.00	1.00	7.90	16.77	1.00	7.94	12.85	9.90	6.90
20.00	6.80	11.81	11.98	12.00	12.50	1.00	4.90	13.77	1.00	4.94	9.85	6.90	4.90
21.00	4.80	9.81	9.98	10.00	9.00	1.00	2.90	11.77	1.00	2.94	7.85	4.90	4.90
22.00	4.80	9.81	9.98	10.00	8.00	1.00	2.90	11.77	1.00	2.94	7.85	4.90	4.90
23.00	4.80	9.81	9.98	10.00	8.00	1.00	2.90	11.77	1.00	2.94	7.85	4.90	4.90
24.00	4.80	9.81	9.98	10.00	8.00	1.00	2.90	11.77	1.00	2.94	7.85	4.90	4.90

Based on the measurement results in several locations of PDAM Kota Palangka Raya, the results obtained in accordance with Table 1 above,it could be seen that the pressure at several points of measurement location has different values depending on the distance of the location with the main source of service and the difference in elevation according to the research location. The monitoring point is 6,7,9 and 10 are located at 5 kilometers (km) from the service center and the elevation is much more than 50 m.dpl which has a low pressure less than 10 mka. The monitoring point 6 which is on Sepakat street Bangas Permai residence Palangka Raya city has a low pressure because the main pipe passes through a location that has a high elevation,then the water pressure drops at that location. While the monitoring point 9 is located 12 km from the service center having a low pressure of less than 10 mka. In some points, the measured pressure actually rises during peak hours, between 6:00 a.m. and 5:00 p.m. to 7:00 p.m., due to the use of a distribution pump where at that time the operating pump uses 2 (two) units to increaseits pressure.

a. Data Calibration

The result of pressure recorder in Figure 3 shows that after calibration with pressure sampling at 13 in the study location obtained a correlation value of 69.5%. The parameter used as a variable for calibration is ahead pump.In the calculation results of Epanet 2.0 with measured data in the field the comparison is nearly approaching. There are several factors that show the correlation value did not reach 100% due to the age of the piping network used would affect the Hazen William coefficient the older the pipe life, the roughness pipe would be.

Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
20	24	12.10	50.23	38.126	38.477
83	24	12.81	49.99	37.181	37.437
304	24	12.18	49.61	37.426	37.819
977	24	9.83	48.67	38.840	39.018
1007	24	12.29	49.21	36.923	37.331
1176	24	7.46	46.72	39.265	40.202
1188	24	1.00	46.64	45.645	46.020
1220	24	1.00	47.04	46.037	46.360
1301	24	5.19	49.21	44.014	44.373
1353	24	5.23	48.75	43.518	43.885
1493	24	10.14	48.02	37.874	38.234
1507	24	7.19	47.77	40.580	40.930
1724	24	7.15	46.39	39.239	40.040
Network	312	7.97	48.33	40.359	40.900

Correlation Between Means: 0.695

Figure 3. Pressure Calibration Results

4.2 Debit Validation

The measuremment of direct debit in the field at several monitoring points that are considered to represent the condition of the entire network, also needs to be proven by means of validation data from Epanet 2.0 calculations with field measurements to obtain an actual result as the object in the field case (riduan et al., 2012). Validation results from the Epanet 2.0 model simulation were carried out to determine the accuracy of the Epanet 2.0 simulation results with measured data in the field.

4.3 Simulation of Pressure Distribution Patterns

Based on the simulation results in Figure 4 all the nodes in the network system have met the pressure standard. Pressure is strongly influenced by the elevation, distance and pump head, the further away from the water source the pressure would be smaller due to friction energy (reduction of energy due to friction) between the water and the pipe.

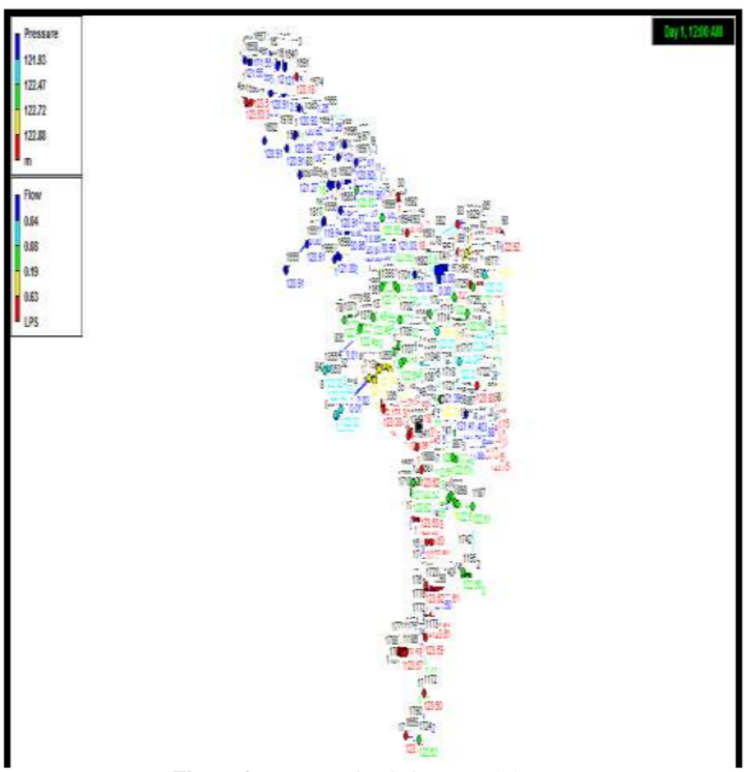

Figure 4. Pressure stimulation at peak hours

4.4 Improvement alternatives

Improvement alternativesare installation of booster pumps in several places where these place has a flow velocity of less than 0.3 liters/second. This booster pump has a discharge specification of 60 liters/second and a head of 3 meters. This pump is installed in several locations with considerations in terms of ease of installation, location and network security. After installing several boosters in several locations there are changes in the network as shown in Table 2.

Table 2. Improvement alternatives

Repairing indicator	Current Condition	Booster addition	Addition of Reservoir Dimensions	The changes in operating time of pump distribution
The range pressure in the distribution network	106,52 – 120,12 mka	105,7 – 120,25 mka	105,7 – 120,25 mka	105,7 – 120,25 mka
The number of nodes that are above the pressure standard	1727	1727	1727	1727
The number of nodes that are under pressure standards	0	0	0	0
Debit range in the distribution network	0 – 71,88	0 – 102,73	0 – 108,76	0 – 108,76
The number of links that are above the debit standard	103	497	496	496
The number of links that are below the debit standard	1909	1525	1525	1525
Flow velocity range in the distribution network	0 – 0,37	0 – 10,81	0 – 10,81	0 – 10,81
The number of links that are above the flow speed standard	1	67	67	67
The number of links that are below the flow speed standard	2011	1955	1955	1955
The need for electrical energy	104,44	119,74	119,74	119,74
Electricity cost	250.636,60	4.216.552,00	4.216.552,00	4.216.552,00

V. CONCLUSION

By way of conclusions, there are several points could be drawn from this research, as follows:

1. The drainage system uses 2 (two) distribution pumps, each of which has a capacity of 120 L/s and 150 L/s, where a pump with a capacity of 120 L/s operates continuously and a pump with a capacity of 150 L/sec only operates at peak hours every morning and evening, with a branch system through a PVC pipe with a pipe diameter of Ø500 mm - Ø63 mm.
2. The value of water pressure at peak hours in the morning hours at 06.00 AM and at 18:00 PM in the entire service area of PDAM Palangka Raya City ranges between 106.52 to 120.12 mka (meters of water column) that value has met the standards water pressure
3. Pressure values are very influential on high elevation, reservoir distance to customers and customer needs.
4. Installation of booster pumps in several places is able to increase the discharge and flow velocity in several locations that are below standard.

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