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

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ABSTRACT: *Regional Clean Water CompanyTirta 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 water price, flow,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 flow 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 existing conditions, moreover to analyze the improvement alternatives flow 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 flows 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, flow, pressure*

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I. INTRODUCTION

Regional Clean Water Company (PDAM) Palangka Raya City as aRegional Enterprise(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 or 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 water price, flow,andpressure of distributed water. Several customers complained about the exponentialinclination of the water price of PDAM Tirta Kahayan in Palangka Raya City which was not comparable with the service provided.Others also complained about the water distribution and water pressure especially at peak hours in the morning and evening time.The discharge and water pressure were not distributed to somelocationwhich is located insuburbs of service area (PDAM Tirta Kahayan City of Palangka Raya, 2018)

This study aims to identifythe physical condition of the pipeline distribution network of PDAM Tirta Kahayan in Palangka Raya City, to evaluatethe flow and pressure distribution patterns on pipelinedistribution 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 water level, booster, and 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 flow and pressure distribution patterns and analyzing alternative improvements in distribution patterns.

II. THEORETICAL REVIEW

Factors that need attention in the piping network system in the water distribution are pressure, water quality, and its continuity.Several things on distribution pipelines which need to be considered are the location of the pipe, regional topography, customer location, 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 system is also called a delivery pipe system or feeder which consists of the primary feeder and secondary feeder. While the micro system serves as a service pipeline to consumers, such as the public residence. The micro systemcould 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).

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

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

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

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

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

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

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

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

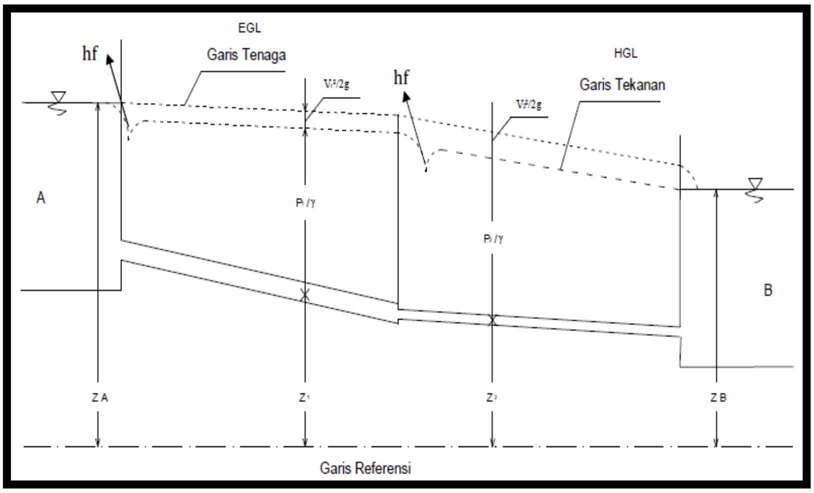

Figure 1. Energy Line and Pressure Line

III. RESEARCH METHODS

This research was conducted at PDAM Palangka Raya city, Central Kalimantan, Indonesia. The data required in this study were water pipeline pressure, flow, number and location of customers, network map, pipeline data (length, diameter, type and age of pipe), elevation data, and the usage quantity of clean water produced. Buildingthewater distribution pipeline network model using Epanet 2.0 software, and conducting the model simulation. Calibration and data validation is carried out to provide a comparison of observation data with the results of network simulation. Map of the research location is in Figure 2.

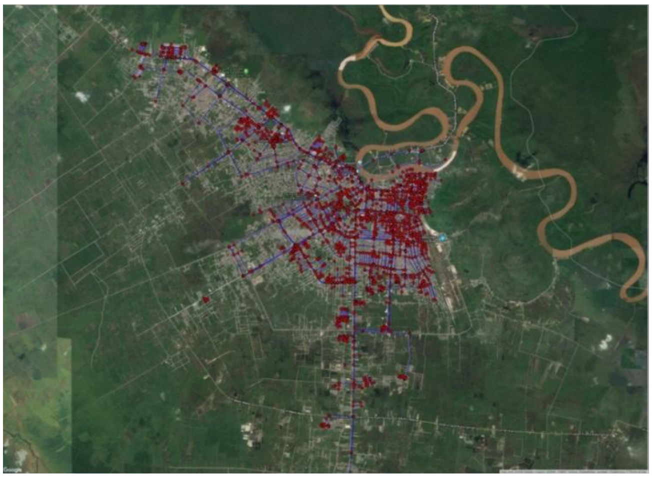

Figure 2. Research Location of PDAM Palangka Raya City

IV. RESULTS AND DISCUSSION

The raw water of PDAM Palangka Raya City is taken from the water resources of Kahayan River which has a discharge quantity of 3,727.5L/sec. The drinking water treatment plant (IPA) capacity is 217.5 L/sec. At the distribution unit, the reservoir distribution has a capacity of 2,500 m³. The system uses 2 (two) distribution pumps each with a capacity of 120 L/sec and 150 L/sec where a 120 L/sec pump operates continuously and a pump with a capacity of 150 L/sec 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 of elevation in the area of Palangka Raya City sincePalangka Raya City is relatively flat. The elevation data ranges from 49.00to 51.69 m (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 m where the lowest pressure is 106.52 mwhichoccur at node 1690 which is ± 9 km from the service center and the highest pressure is 120.12 m which occur 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 aresultof the data link in the Epanet 2.0 simulation program, some water velocity in the network pipe did not meet the standard flow velocity in the pipe (0.3 - 4.5 L/sec) according to the Minister of Public Works Regulation No. 18 of 2007. This is caused by several factors including the ineffective network pipe design, inadequate distribution discharge, and the rise of water requirements exceeding the initial capacity.

The amount of the distributed flow in the PDAM Palangka Raya City network system is 0.01 - 26.85 L/sec. The largest flow value is on a network which is obviously close to the service center, while the flow 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 arein Table 1 below.

Table 1. Results of Pressure Measurement

Time	Pressure (m)												
	Elevation (m)												
	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 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 6,7,9 and 10 are located 5 kilometers radius from the service center has a pressurevalue less than 10 m. The monitoring point 6 which is on Sepakat street Bangas Permai residence Palangka Raya city has low pressure because the main pipe passes through a location that has high elevation. Monitoring point 9 is located 12 km from the service center also having lowpressure less than 10 m. 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 increaseitspressure.

a. Data Calibration

The result of pressuregaugemeasurement in Figure 3 shows that calibration at point 13 obtained a correlation value of 69.5%. The comparison of Epanet 2.0 simulation result with measured data is nearlyclose. There are several factors that show the correlation value did not reach 100% due to the age of the pipe network used which would affect the Hazen William roughness coefficient.

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 Flow Validation

The measurementof flow 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 (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.

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.

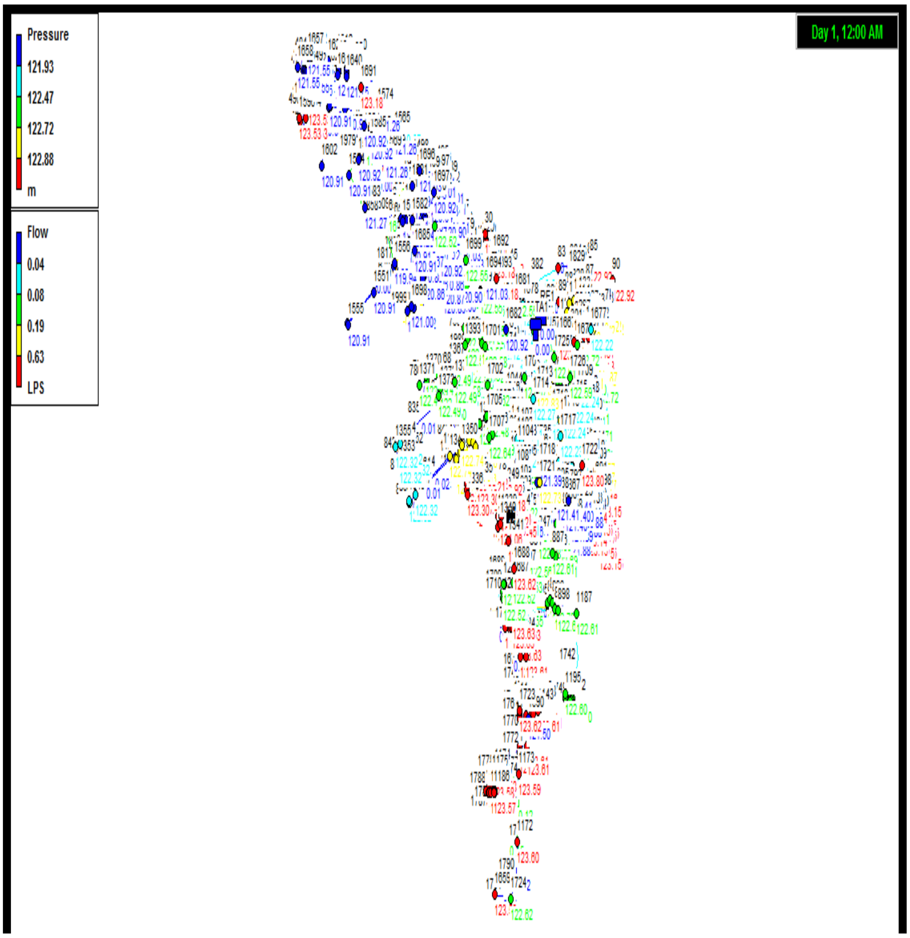

Figure 4. Pressure stimulation at peak hours

4.4 Improvement alternatives

Improvement alternatives are the installation of booster pumps in several places where flow velocity less than 0.3 L/sec. This booster pump has a discharge specification of 60 L/sec and 3 meters head value. This pump is installed in several locations with considerations the ease of installation, location,and 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 m	105,7 – 120,25 m	105,7 – 120,25 m	105,7 – 120,25 m
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
Flow 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 flow standard	103	497	496	496
The number of links that are below the flow 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

Inconclusion, there are several points could be drawn from the result of this research:

1. The pipe network system uses 2 (two) distribution pumps, each of which has a capacity of 120 L/sec and 150 L/sec, where a pump with a capacity of 120 L/sec 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 m (meters of water column) that value has met the standards allowable 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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