Hydraulic Analysis Software Comparison of Water Distribution System at Telkom University Area III

Agus Kusnayat ¹, Syadzwinia Sendra Sari ², Doan Perdana ³, Sri Martini ⁴

¹, ², ⁴ School of Industrial Engineering, Telkom University, Indonesia, Bandung
³ School of Electrical Engineering, Telkom University, Indonesia, Bandung

agus_kusnayat@yahoo.com, ssendrasari@gmail.com, doanperdana@telkomuniversity.ac.id, srimartini59m@gmail.com

Abstract - Simulation has been widely used as a tool to overcome the limitations that occur in purely analytical modelling research or to provide practical solutions. Various kinds of simulation software are available as an open source or commercial software. Hydraulics analysis software is needed to facilitate the evaluation process in the design or maintenance of a Water Distribution System (WDS). Hydraulics analysis software provide the desired result in fluid dynamics such as flow rate and head loss value on each pipe. Previous research has been done to optimize the pipe network in WDS by using WaterCAD software to assess the proposed design. In this study a comparison is carried out between WaterCAD software and PipeFlow Expert to illustrate the different performance of each software for Ground Water Tanks, GWT. Our results show the average flow rate difference is 0.08 for both models, while the average head loss difference is 0.04 for GWT 1 model and 0.05 for GWT 2 model.

Keywords - Water distribution system, hydraulic, pipe, head loss, WaterCAD, Pipe Flow Expert

I. INTRODUCTION

Water Distribution Systems, WDS, are designed to fulfil the water needs in domestic, commercial, industrial, or hydrant purpose. Hydraulic analysis of water distribution system is an essential step towards understanding the behavior of water supply and distribution system in each WDS components such as pipe, pump, elbow, tees, and valves [1]. The information gained from hydraulic model simulation of WDS can also assist in management planning for maintenance and replacement of system equipment [2].

A water distribution system consists of three major components, there are; pumps, storage/tank, and piping network. Most of the water distribution systems require pumps to supply extra head to overcome the head loss due to friction. There is several common WDS analysis software that has been widely uses in WDS planning and maintenance field to analyze the WDS model by simulating and calculating the hydraulic analysis needed such as WaterCAD and EPANET software [3]. The WDS analysis software offers cost and time efficiency in planning, maintaining, and evaluating WDS [4].

Telkom University as the institution that needs a large number of water supplies to support the activity at the campus area needs to manage the WDS well. There are three main distribution areas in Telkom University. The research at area III of WDS in Telkom University which is consisting of two GWT (Ground Water Tank) in dormitory area has been done. The result from previous research using WaterCAD software, the average value of flow rate is 1.63 l/s and the average head loss value is 0.54 m for GWT 1, meanwhile for GWT 2 the result is 1.61 l/s and 0.36 m [5]. Based on those previous research, the comparison of two WDS analysis software will be done between WaterCAD and Pipe Flow Expert.

II. LITERATURE REVIEW

A. Fluids on Pipe Network

The relation between cross-sectional area and speed is called as the equation of continuity for the flow of an ideal fluid [6]. It is said that the flow speed increase when we decrease the cross-sectional area through which the fluid flows.

\[ A_1 v_1 = A_2 v_2 \]  
\[ Q_1 = Q_2 + Q_3 \]  

B. Headloss Equation

The basic relation that is used in a hydraulic design of a pipeline system is the one that describing the dependence of discharge Q (say in m³/s) on a head loss of hf (m) caused by a friction between hf the flow of fluid and the pipe wall [7]. This section will discusses two of the most commonly used relations of head-loss: the Darcy-Weisbach and Hazen-Williams equations. This equations can be seen as shown below:

\[ h_f = f \frac{L}{D} \frac{V^2}{2g} \]
Whereas $f$ is Darcy friction factor that obtained from Reynolds number with equation below:

$$f = \frac{4f}{Re}$$  \hspace{1cm} (4)

Meanwhile the hazen-Williams equation can be seen as shown below:

$$h_f = 10.65 \cdot \left( \frac{C}{d} \right)^{1.85} \cdot \frac{l}{d}$$  \hspace{1cm} (5)

With:

- $h_f$ = headloss friction (m)
- $Q$ = flow rate ($m^3/s$)
- $C$ = Hazen-Williams coefficient
- $l$ = pipe length (m)
- $d$ = pipe diameter (m)

The rougher the pipe, the longer the fluid can travel, and the greater the energy loss. Note that in particular, the dependence of the discharge $Q$ on the pipe diameter $D$ is highly nonlinear, this in fact has a great significance to the pipeline designs because the head losses can dramatically be reduced by using a large-diameter pipe, whereas a rather small pipe can restrict the flow significantly, like a partially closed valve.

C. Water Distribution System Modelling Softwares

WaterCAD V8i (2014) is a software package for hydraulic modelling that comprised of a wide range functionality included graphical and profiling advancements in GUI and its customization, and etc [8]. Some features like steady state and extended period of simulations, hydraulic and water quality analysis are made to function with strong data management along with AutoCAD and GIS integrations, and enhanced capabilities. The advantages of WaterCAD V8i rather than other softwares are simplified model building with geospatial modules and tools like LoadBuilder and TRex, fire flow analysis, water quality modelling, optimization and scenario management, and etc [3]. WaterCAD V8i is easy to use and versatile water distribution, as well as quality modelling software packages that accepted for wide range of applications. 3. Pipe Flow Expert designed to support engineers to solve and analyze a wide range of hydraulic problems where the pressure losses, pumping requirements, and flow rates throughout a pipe network have to be determined [9]. The Pipe Flow Expert software will easily allow you to draw a pipeline system and also analyze the system’s performance when the flow is occurring. Pipe Flow Expert calculates the pressure conditions and the balanced steady flow of the system. The software will allow you to perform an analysis of an alternate systems under some various operating conditions.

III. METHODS

A. Modelling WDS on Pipe Flow Expert

The modeling process was done by making the WDS model in Pipe Flow Expert software. The software itself offers the easier and more user-friendly graphic in drawing the WDS. With grid as base layout and point precision to insert the WDS components such as node, pipe, tank, pump, and many more that make it easier to draw the WDS. Both model of WDS in area III which are GWT 1 and GWT 2 can be seen on Figure 1 and Figure 2 repetitively. The specification and definition also done by specify and identify the WDS components such as pipe length, pump power, number of nodes, nodes elevation, and tank capacity.

![Figure 1 GWT 1 Modelling on Pipe Flow Expert](image_url)
B. WDS Simulation on Pipe Flow Expert

After making the WDS models on Pipe Flow Expert, the calculation are done to obtain the hydraulic analysis such as flow rate, head loss, and pressure. The result itself can be shown by Imperial or Metric units depend on the users needed. Those results can be used in further WDS analysis. Like in most common hydraulic analysis software, in Pipe Flow Expert, the general result also can be seen as the color range within the network pipes. From green color to red color has its own meaning regarding the number range result. The red color indicates the highest number on the system and green color defining the lowest number from the system. The general result of WDS simulation based on GWT 1 and GWT 2 model can be seen in the Figure 3 and Figure 4 repetitively.
IV. RESULT AND DISCUSSION

The analyses that will be undertaken in this research are the value of flow rate and head loss result from Pipe Flow Expert software and previous research with WaterCAD software. The comparison will be done by calculate the difference value of the result from each software on each model. From the simulation that has been done in Pipe Flow Expert software there is a slight difference between each value with percentage range of fewer than 5% and the two digits decimal value. The difference result commonly caused by the calculation calibration and different rounding off system from each software. With that slight difference, both software is compatible to analysis the hydraulic behavior of Water Distribution System at Telkom University. And it may also apply to other kind of WDS based on the analysis needed. Based on the simulation result, the analysis has been done to calculate the average difference for flow rate and head loss result. The average flow rate result difference for GWT 1 is 0.08 and the average head loss result difference is 0.04. The difference result of flow rate and head loss value from GWT 1 and GWT 2 will be shown on the graph that can be seen on Figure 5 and Figure 6 for GWT 1. From the graph we can see the various numbers resulting from the difference between the flow rate result on WaterCAD and from Pipe Flow Expert. There are also several pipes that have 0 differences which mean the calculations from both software are identical.
From the graph we can see the various numbers resulting from the difference between the flow rate result on WaterCAD and from Pipe Flow Expert. There are also several pipes that have 0 differences which mean the calculations from both software are identical. Meanwhile, for GWT 2 the average flow rate result difference is 0.05 and the average head loss result difference is 0.03. Figure 7 and Figure 8 will show the result of GWT 2.
Similar graphic results can also be seen from GWT 2. There are also several pipes that have identical calculation result of both flow rate and head loss value. There is also one pipe, number 140, that has the highest difference number which is not just the two digit decimal number but also difference in the base number which is 1.56 and thus, resulting the unusual form of line graph in the GWT 2 head loss value difference result graphic. The uses of hydraulic analysis software make it easier for maintenance unit in managing and evaluating the WDS performance. Based on the research, both software WaterCAD and Pipe Flow Expert have their own advantages and disadvantages. Moreover, to order to decide which software should be used in analyzing the pipe network, we need to identify the specification of our network such as its fluids, network component, etc. The desired result also affects the software choice criteria, and whether there are issues regarding other aspect such as pump scheduling, network coordinates location, and many more.

V. CONCLUSIONS

In this study we used hydraulic analysis software for utilities planning, maintenance and evaluation processes in Water Distribution Systems to determine more accurate results than was achieved in previous studies. The software also helped to demonstrate time efficiencies in analyzing the WDS models. Comparison of hydraulic analysis from WaterCAD and Pipe Flow Expert software for average flow rate resulted in a difference of 0.08 for both models. While the average head loss result difference was 0.04 for GWT-1 model and 0.05 for GWT-2 model. It can be concluded that there is no significant difference between the two WDS analysis software and both can be used based on the needs of the individual user.

ACKNOWLEDGMENT

Thanks are due to the maintenance unit at Telkom Property in helping the authors to conduct the research and to explain the details of the research object. Thanks are also due to colleagues for their support in completing the research paper.

REFERENCES