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Modeling of High Pressure Loss (Head Loss) in a Flow Measurement Unitwith Various Pipe Network Manifold Openings

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ABSTRACT: The head loss in water flowing through pipes often turns out to be different from what we assume,which is the occurrence of incompressible flow. However, this assumption is not always true because the flow pattern inside the pipe is not visible and can only be measured with precise equipment. The presence of water in the pipes can only be tested on a clear scale, especially whenit is part of the network within a multi-story building. Determining the need for a pipe network within a building is not an easy calculation due to differences in length, diameter, and bends. Hydraulic experts often overlook these differences, which can become a problem when clogs occurduring the flow process.

To find a solution to this problem, it is necessary to conduct tests using a device called a Water Measurement Unit. This is rarely done in laboratories. Testing the water pressure with this devicerequires various instruments and a variety of valve openings supplied with pressurized water by apump at a certain capacity. To analyze the flow rates resulting from the tests with different valve openings, researchers test and measure the flow rate capacity for each opening, starting with openings of 0.5, 0.75, 1.00, and so on. They read the instrument, move the copper from one heightto another, and create a graph of the test results in the form of a pair of connectors. The researcherstest the device and its openings three times for each opening, recording and mapping the pressurevalues and the time it takes on the measuring instrument.

Subsequently, the results of the pressure test (Head Loss) are recommended to provide informationto water pipe installation planners that the test results with various valve openings under certain conditions have different pressure values and travel times. It turns out that in the placement of hoseor copper number 2, stability is observed with pressure, and there is no significant differential pressure increase. In the experiment with hose or copper number 2, it can be said that everything is stable enough to conclude that there is no head loss, and it is recommended to be safe for modeling.

KEYWORD: Head Loss, Water Measurement Unit, various valve openings

1. INTRODUCTION

The loss of head pressure is not a new issue in piping network problems, but it significantly disruptsthe continuity of water processing and distribution services due to uncertainties in travel time andthe volume of distributed water. Head loss in water through pipes often does not occur as we mightexpect, such as incompressible flow.

The presence of water in pipes can only be clearly tested, especially when it is within the building's multiple-floor installation network. Testing the water pressure in this tool requires instruments anda variety of valve openings supplied with pressurized water by a pump at a certain capacity.

To analyze the flow rate test results with various valve openings, researchers test and measure theflow rate capacity for each opening, starting with openings of 0.5; 0.75, 1.00, reading the instrument, moving, and transferring the container from one height to another. Creating a graph ofthe transfer test results in the form of a pair of connectors/cups tested with the device and three tests for each opening, recording, mapping the pressure values, and travel time from the instrumenton the measuring device.

Subsequently, recommending the results of the pressure test analysis (Head Loss) to provide information to water pipe installation planners that the test results with various valve openings under certain conditions have different pressure values with travel time, which can then be appliedto the piping network in other tall building structures to determine the required pump capacity foreach building.

The Flow Measurement Unit is a modeling tool in the field of hydraulics used for flow measurement. However, in this practical experiment, only temperature, pressure, differential dataobtained from the Flow Measurement Unit, and time data obtained from a stopwatch can be collected because the turbine flowmeter and magnetic flowmeter instruments are not functioning.

These valves can also act as thresholds or obstacles in this measurement simulation. The water tank used in this measurement is located separately from the simulation tool and is connected by pipes.

2. LITERATURE REVIEW

2.1. Head Loss in Pipes.

The gradual increase in velocity from upstream to downstream results in head loss (Pudyono, Priyantoro, 2010). In unsteady flow, the water velocity inside the pipe changes due to variations in time (Irianto, 2011).

2.2. Flow Measurement Unit.

A Flow Measurement Unit is a device used to obtain data, including temperature, pressure, differential measurements, and time. Once these four pieces of data are collected, the flow rate (Q)and flow velocity (v) can be determined.

2.2.1. Basic Theory

Flow rate measurement is crucial in the process of flow control. The purpose of this measurementis to determine the capacity of the fluid being transported to obtain measurement variables. Typically, flow rates are measured based on the velocity of the fluid or gas passing through a specific cross-sectional area. Several methods or principles for flow measurement are used:

2.2.1.1. Magnetic Flow Meter

Magnetic flow meters are typically used to measure flow in situations where other measuring devices face difficulties, such as high-viscosity flows, corrosive liquids, slurry (mixtures of oil, sand, detergent, pulp, etc.). The advantages of magnetic flow meters include:

a. High sensitivity and accuracy, typically within ±1% of full scale.
b. Suitable for measuring low to high flows.
c. Can measure bidirectional flows.
d. Linear output.

The tube is made of non-magnetic metal, usually stainless steel, with an inner lining of neoprene to prevent it from shorting due to induced voltage. The electrodes are typically made of stainless steel 361 with Teflon insulation. For highly corrosive substances, platinum electrodes are used. The working principle is based on Faraday's law of magnetic induction. The voltage supply (E) sent to the coil creates a magnetic field (H). Inside the tube, a type of fluid flows through the magnetic field at a velocity (V), with the tube's diameter being (d). According to Faraday's law, the induced voltage (E) on the electrodes appears to come from a conductor along "d" moving at a velocity "V" in the magnetic field "H." Therefore, the induced voltage is given by: E = C.H.d.V,where C is a constant, and H and d are constants. Thus, E is proportional to V, allowing the measurement of flow velocity or capacity within the tube by measuring E or voltage.

2.2.1.2. Turbine Flow Meter

There are two types of turbine flow meters:

a. Mechanical Turbine Flow Meter

Turbine blades or vanes rotate due to the flow, and this motion is transmitted to a mechanical counter to measure the volume of fluid flowing. The linear rotation of the turbine relative to the flow velocity is critical, and the meter works well when the flow velocity is above the critical speed. This meter has an accuracy of around 2%. Factors that affect its calibration include the diameter (BD), viscosity, and temperature.

Advantages of using this meter include low pressure loss, the ability to measure flows containingsolid materials, and having minimal flow rate restrictions.

b. Electric Turbine Flow Meter

Each time the blades pass a pick-up coil, pulses are induced in the coil. These pulses are proportional to the flow velocity. The pulses are then processed through a frequency-to-voltage converter to obtain a voltage proportional to the flow velocity, which is further converted into digital output for display.

This type of turbine flow meter should not be used for fluids containing magnetic particles. It offers high accuracy and is suitable for various types of fluids.

2.2.1.3. Differential Pressure Flow Meter (Head Flow Meter)

This measurement method is based on Bernoulli's law for laminar flow. The Bernoulli equationfor flow as described above is used to calculate head loss in different sections of the pipe.

2.2. Simulation and Modeling

Simulation of river flood wave propagation after a disaster in the city of Nimes, France, was carried out in the laboratory using the 1D routing method, resulting in unsteady flow velocity in the Nimes pipe network (Andre Paguler, 1988). A simulation predicting flood wave propagation for dam break scenarios was calibrated with 1D experiments in the University of Mississippi laboratory, and it was used to determine head loss using valve opening variations (Xinya Ying, 2014). Comparing physical flow experiments with finite element modeling for head loss, it was found that the compressible flow method can simulate head loss (A. Kaceniauskas, 2015). Water flow through a pipe network with various valve openings was simulated to detect differences in flow rates due to different valve settings (Irianto, 2011).

2.3. Specific Energy

Specific energy is the energy load acting on a channel or a part of the device due to differences in energy in the presence of flowing water. It includes changes in pressure and elevation in incompressible flow in open channels and compressible flow in closed pipes.

3. RESEARCH METHODS

3.1. The Research Methodology is outlined as follows:

1. Setting and Research Characteristics

The research was conducted on the Flow Measurement Unit equipment in the water laboratoryat Unesa.

2. Research Procedure

a. Research Simulation involved conducting flow tests on the equipment with three differentvalve openings. The research was carried out from June to November 2018.

b. Equipment and Research Steps:

Equipment Used:

1. A set of Flow Measurement Unit equipment
2. Stopwatch
3. Bucket for water collection
4. Meter to measure the volume of the bucket
5. Writing tools for data recordingWorkflow:
   1. Prepare the above-mentioned equipment.
   2. Prepare the bucket for water collection during the practical work.
   3. Measure the diameter and height of the bucket to calculate its volume.
   4. Set the treatment/actions at each threshold with combinations of 1 ½ and 3/4 valveopenings.
   5. Set the treatment/actions on the hose segments with combinations of positions 1, 2, and 3.

Variables:

Travel time from the pump to coper I with a 1-inch diameter pipe and a height of coper Y1 meters. Pump to coper II with a 1-inch diameter pipe and a height of coper Y2 meters... and soon.

3.2. Observation and Evaluation

Observation: Conduct observations and create a data report from steady flow simulation with various valve openings at three hose positions with coper using the Flow Measurement Unit equipment in the Water Laboratory at Unesa.

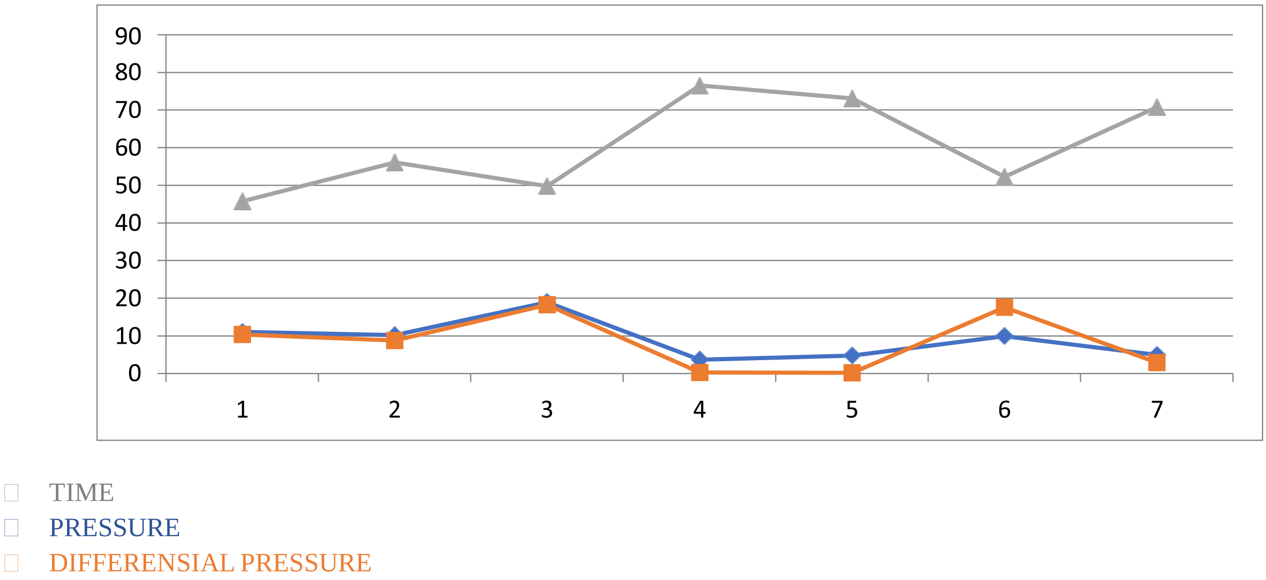
Evaluation: Evaluation is performed with the research team and water technicians, as well as competent hydrology course students, to participate in the water flow testing with the Flow Measurement Unit equipment.

Analysis:

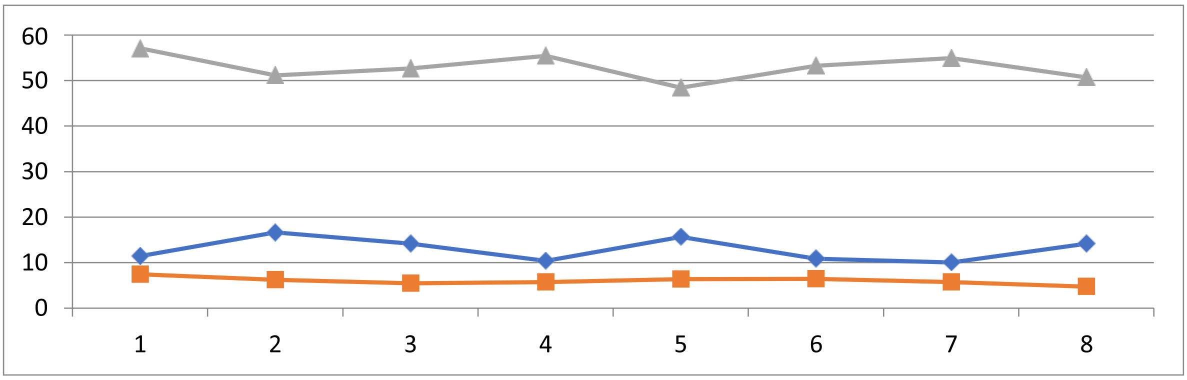
The recorded data is analyzed and discussed with observers regarding the advantages of measuring head loss using the Flow Measurement Unit equipment in the research process. Thisinformation is then described for the preparation of the final report and the creation of an onlinejournal.

4. RESULTS AND DISCUSSION

EXPERIMENT ON HOSE 1				
Aperture	perature(°C)	Pressure (Pa)	DIFFERENSIAL PREASURE TRANSMITER (mmHg)	Time
1 , 1 , 1	35 - 37	11,1	10,4	45,84
1/2 , 1/2, 1/2	35 - 37	10,2	8,8	56,13
1 , 1 , ½	35 - 37	19	18,3	49,84
1/2 , 1/2, 1	35 - 37	3,7	0,3	76,53
1/2 , 1 , 1/2	35 - 37	4,8	0,2	73,13
1 , 1/2 , 1	35 - 37	10	17,6	52,29
1/2 , 1 , 1	35 - 37	5,0	2,9	70,83

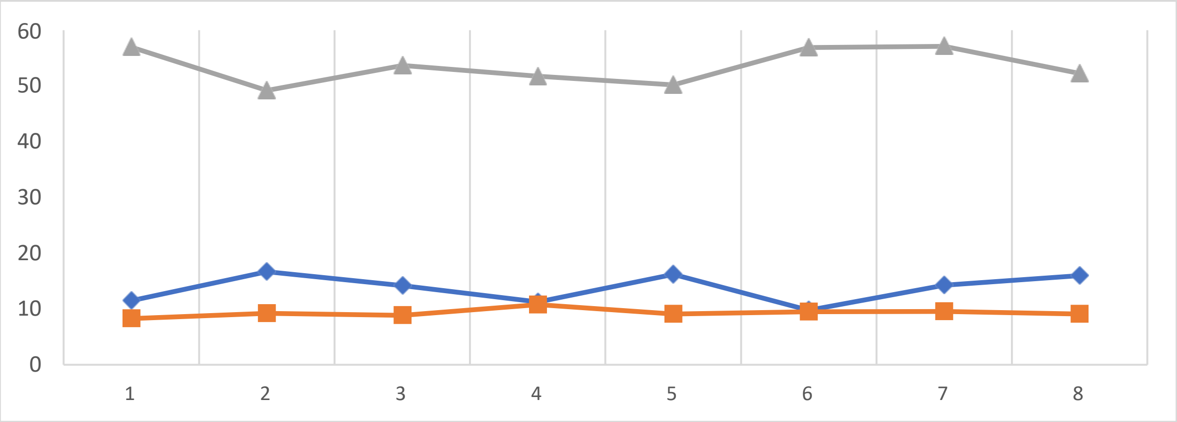


EXPERIMENT ON HOSE 2				
Aperture	perature(°C)	Pressure (Pa)	DIFFERENSIAL PREASURE TRANSMITER (mmHg)	Time
1 , 1 , 1	35 - 37	11,5	7,5	57,12
1 , 1 , 1/2	35 - 37	16,7	6,3	51,22
1/2 , 1/2 , 1/2	35 - 37	14,2	5,5	52,75
1/2 , 1 , 1	35 - 37	10,4	5,8	55,51
1 , 1/2 , 1/2	35 - 37	15,7	6,4	48,51
1 , 1/2 , 1	35 - 37	10,9	6,5	53,32
1/2 , 1/2 , 1	35 - 37	10,1	5,8	55
1/2 , 1 , 1/2	35 - 37	14,2	4,8	50,79



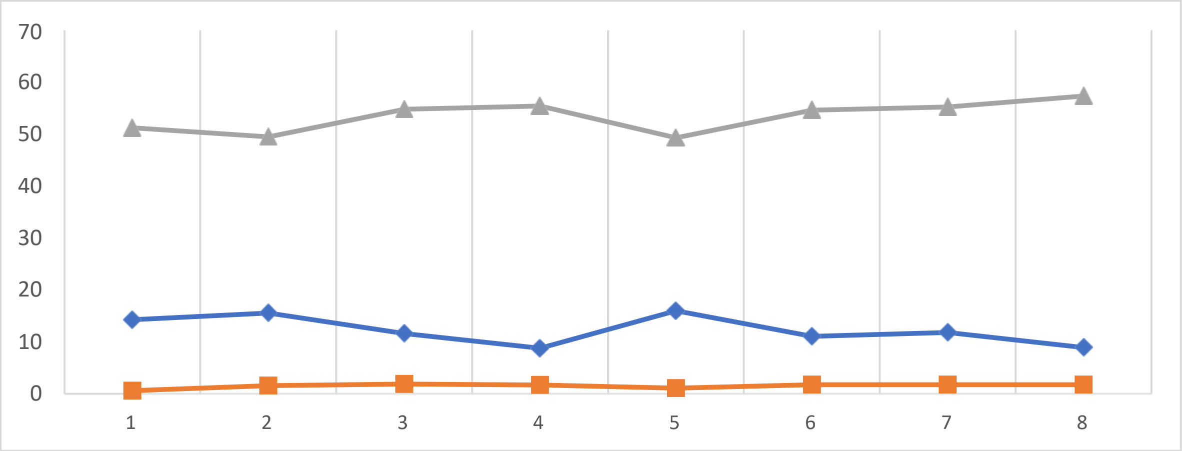
☐ TIME
☐ PRESSURE
☐ DIFFERENSIAL PRESSURE

EXPERIMENT ON HOSE 3				
Apperture	perature(°C)	Pressure (Pa)	DIFFERENSIAL PREASURE TRANSMITER (mmHg)	Time
1 , 1 , 1	35 - 37	11,5	8,3	56,95
1 , 1 , 1/2	35 - 37	16,7	9,2	49,21
1/2 , 1/2 , 1/2	35 - 37	14,2	8,9	53,70
1 , 1/2 , 1	35 - 37	11,3	10,8	51,75
1 , 1/2 , 1/2	35 - 37	16,2	9,1	50,24
1/2 , 1/2 , 1	35 - 37	9,8	9,5	56,90
1/2 , 1 , 1	35 - 37	14,3	9,6	57,14
1/2 , 1 , 1/2	35 - 37	16	9,1	52,26



☐ TIME
☐ PRESSURE
☐ DIFFERENSIAL PRESSURE

EXPERIMENT WITHOUT HOSE				
Apperture	perature(°C)	Pressure (Pa)	DIFFERENSIAL PREASURE TRANSMITER (mmHg)	Time
1/2 , 1 , 1/2	35 - 37	14,3	0,6	51,26
1 , 1/2 , 1/2	35 - 37	15,6	1,6	49,51
1 , 1 , 1	35 - 37	11,6	1,9	54,83
1/2, 1/2 , 1	35 - 37	8,8	1,7	55,44
1 , 1 , 1/2	35 - 37	16	1,1	49,32
1 , 1/2 , 1	35 - 37	11,1	1,8	54,63
1/2 , 1/2 , 1/2	35 - 37	11,8	1,8	55,27
1/2 , 1 , 1	35 - 37	8,9	1,8	57,36



☐ TIME
☐ PRESSURE
☐ DIFFERENSIAL PRESSURE

5.1. CONCLUSION.

The results of the measurements in the flow measurement unit study were obtained based on thetable description from the modeling results as follows:

1. For hose 1, the highest time was recorded, but it does not necessarily mean that the pressure and differential pressure were also high. On the contrary, it can be seen in openings ½, ½, 1, and
½, 1, ½.
2. Hose 2 exhibited relatively stable time with no significant pressure or differential pressure spikes. In the experiments with hose 1, everything remained fairly stable.
3. Hose 3 showed fluctuating or less stable times. In the experiments with openings 1, ½, and 1,the highest differential pressure values were obtained, but the pressure was low, resulting in a fluctuating graph.

From the above modeling, it is concluded that the most appropriate choice for use in buildings is the second loop, ensuring that the contraction between water and the hose, as well as the pressure generated in the modeling, is not dangerous.

5.2. Recommendations.

Subsequent modeling will be more meaningful if it is provided to participants specializing in piping network installations.

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