MANUFACTURE AND TESTING OF VIBRATION TEST SCHEMES FOR PIPING SYSTEMS

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Abstract-- *Piping system is the distribution of fluids through pipes. This is often in everyday life, an example is the water pipe in every house that is used to fulfill desires and in the industrial field pipes are often used to distribute petroleum fluids as well as offshore and onshore. Supports have a very important role to overcome the loads that occur at points that experience excessive loads caused by the weight of pipes and other devices. In general, dynamic failures in pipe systems are caused by resonance from the vibrations of the pipe stretch. Therefore, this research is intended to determine the effect of valve opening variation and pedestal distance variation on vibration in the pipe system so that it can be used for consideration in designing a piping system. This research uses an experimental approach starting with the preparation of a vibration test scheme and then testing using a vibration meter. The test data was processed and statistically analyzed so that it was found that at 100% valve opening, the largest value is at a pedestal distance of 180 cm with a flow rate of 2.8 m/s2 and the largest 50% valve opening is at the same pedestal distance of 180 cm with a flow rate of 2.3 m/s2. The farther the pedestal distance, the greater the vibration and deflection and the greater the flow discharge produced, the higher the vibration produced.*

Keywords: *piping, vibration, valves and supports*

1. INTRODUCTION

Piping is a fluid distribution system through intermediate pipes [1]. Good plumbing system planning will provide safety and comfort. In fluid flow, the characteristics of velocity, pressure and changes in both characteristics that occur in a fluid flow can contribute to vibration. [2].

Problems that arise in fluid flow due to flow factors, back pressure, and vibration can result in pipe bending. In fatal cases, this can lead to cracks and failure of the piping system. Pumps and valves are a major cause of vibration and flow shock due to the drastic changes in pressure and velocity that occur in these components. [3].

The support has a very important role to overcome the loads that occur at points that experience excessive loads caused by the weight of pipes and other devices. [4].

During operation, the pipeline may experience internal pressure if any valves in the pipeline are forgotten/unable to open. In addition, the operating pressure of the pump increases the fluid flow rate, causing high internal pressure in the pipeline. Under these conditions, the fluid distributed in the pipeline can cause deformation and bending in the pipeline, the magnitude of the force received by the pipeline and the influence from the inside to the outside of the pipeline are the result of the pressure in the pipeline. [5].

The method used is the experimental method in the form of direct manufacture and testing using the help of a vibrationmeter tool to get the root mean square (RMS) value which shows the value of vibration that occurs. Root mean square (RMS) is a measurement of the actual strength that is under the curve with a value of 0.707 peak. Average is a value of 0.637 times the sine wave peak [6].

The purpose of this study is to analyze the effect and determine the value of vibration that occurs in the piping system due to variations in valve openings and variations in pedestal distance using a vibration meter measuring instrument.

2. METHODOLOGY

2.1. FLOWCHART

The stages of this research are shown in the flow chart in Figure 1 below.

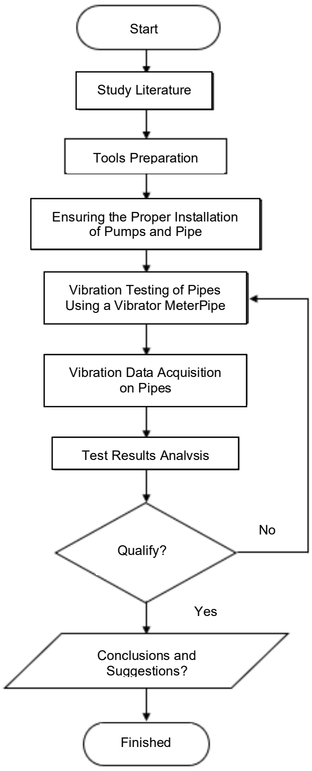

Figure 1. Flow Chart

2.2. Vibration

Vibration is an alternating motion within a time interval. Objects that have mass and are elastic are capable of vibration, so most engineering machinery and structures experience vibration to some degree and their design usually requires consideration of oscillatory properties. [7].

$$\omega = \sqrt{\frac{k}{m}} \qquad \text{equation. (1)}$$

Where : ω = angular velocity (rad/s)
k = spring constant
m = mass (kg)

Vibration analysis can be defined as the study of oscillatory motion. The aim is to find out how vibrations affect the performance and safety of systems and how to control them. A mass suspended by a spring is pulled down and released, the spring stretches, causing oscillatory motion to occur over a period of time. The frequency produced by this oscillatory motion is known as the natural system frequency, which is the result of mass and stiffness. [8].

2.3. Pedestal

A pedestal is where a construction rests and reactions work. Each type of pedestal has unique features. There are joint, roller, and hinge pedestals [9].

2.4. *Root mean square* (RMS)

Root means square (RMS) is a unit of vibration used as a classification of machine vibration severity. The RMS price measures the effective energy of the machine to create vibration. The sinusoidal average price (RMS) is 0.707 times the maximum price [10].

The RMS value of the machine vibration velocity signal, according to ISO Standard 10816, is proportional to the machine damage level for thorough diagnosis. However, the RMS value of the measured signal is always lower than it should be. [11].

2.5. Vibration meter

Basically, a vibration meter is a measuring device made to measure the vibration of a particular object. In this case, the object in question is a mechanical component, or machine, that performs its function. For example, pump engine vibration, motor vibration, and processing machine vibration, whether small, medium, or heavy. [12].

The values that can be obtained from the vibration meter itself are the rms, peak, acceloro, and velocity values.

2.6. Tools and Materials

a. Tools

Tools used: reservoir, elbow, base, meter, pipe, pump, flowmeter, ballvalve, hollow iron, vibration meter, and dial indicator.

b. Materials

Materials used: water.

2.7. Tool Design Stage

The design of the tool is carried out by paying attention to the technical drawings below shown in Figure 2.

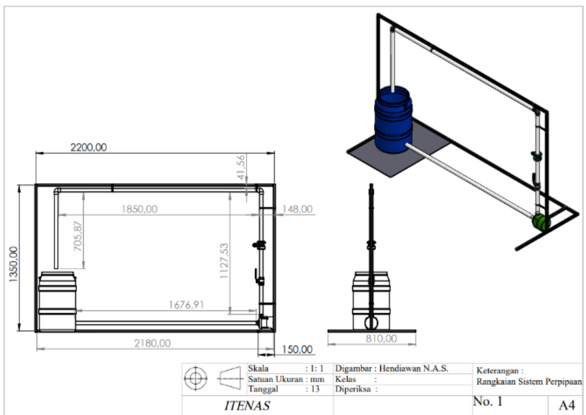

Figure 2. Engineering drawings

2.8. Tool Setup Stage

Data collection in this study, using a pump installation with a closed loop system, the water that comes out rotates and returns to the pump shown in Figure 3 below.

Figure 3. Tool Installation

This study uses variations in pedestal distance, namely the pedestal distance between the hinge pedestal and the roll pedestal (15 cm, 30 cm, 45 cm, 60 cm, 75 cm, and 90 cm) and the distance between the roll pedestal and the hinge pedestal (30 cm, 60 cm, 90 cm, 120 cm, 150 cm, and 180 cm). And the next variation is the variation of 50% and 100% valve opening.

Data collection from 2 points, namely on the Y and Z axes, is taken at the location between the pedestals using a vibration meter. For more details can be seen in Figure 4 and Figure 5 below.

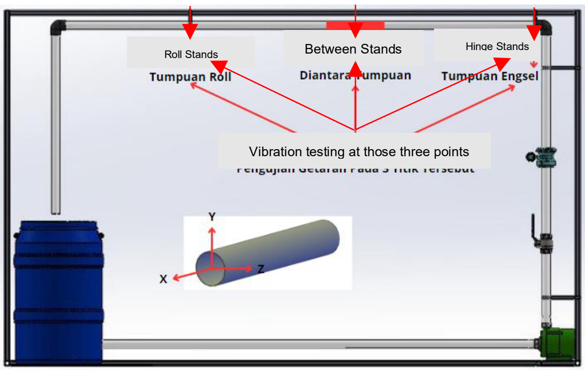

Figure 4. Location of data collection

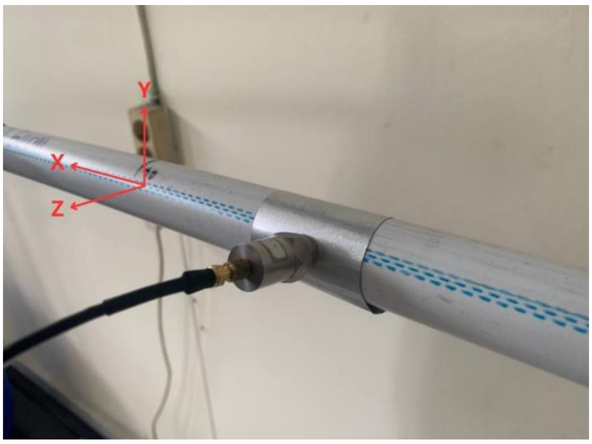

Figure 5. Data collection with vibration meters

2.9. Data Capture Stage

The following are the steps taken to collect data:

1. Ensure that the device is properly installed.
2. Make sure there is water in the reservoir.
3. Turn on the water pump and wait for the pump until it stabilizes (± 5 minutes).
4. Perform 50% and 100% valve opening variation.
5. Determine the point for data collection. Taking vibration values using vibration meter at the hinge fulcrum, between the pedestal, and sliding roll pedestal.
6. Prepare vibration meter test equipment with accelerometer sensor.
7. Record vibration signal data using using the accelerometer sensor.

Steps to use a vibration meter:

1. Connect the accelerometer sensor cable with the vibration meter
2. Turn on the vibration meter by pressing the power button, the button is on the accelerometer section.
3. Bring the sensor close to the data collection point, the vibration speed value will appear on the vibration meter monitor.
4. Record the results of the test data on the sensor.
5. Repeat the above steps until you get all the desired results.

3. RESULTS AND DISCUSSION

After designing and then testing, the results obtained starting from the 1st test to the 6th test on the variation of the pedestal distance and the variation of the 50% valve opening with a flow rate of 30.6 l/min and 100% with a flow rate of 32.7 l/min are shown from table 1 to table 6, as follows:

3.1. Valve Opening 100%

Table 1. 1st test

N0	Axis	Hinge Stands	Between Stands (15 cm)	Roll Stands (30 cm)
1	Y	1.3 m/s²	0.8 m/s²	1.3 m/s²
	Z	1.4 m/s²	0.7 m/s²	1.4 m/s²

Table 2. 2nd test

N0	Axis	Hinge Stands	Between Stands (30 cm)	Roll Stands (60 cm)
2	Y	1.3 m/s²	1.1 m/s²	1.1 m/s²
	Z	1.4 m/s²	1.2 m/s²	1.2 m/s²

Table 3. 3rd test

N0	Axis	Hinge Stands	Between Stands (45 cm)	Roll Stands (90 cm)
3	Y	1.3 m/s²	1.5 m/s²	1.4 m/s²
	Z	1.4 m/s²	1.4 m/s²	1.6 m/s²

Table 4. 4th test

N0	Axis	Hinge Stands	Between Stands (60 cm)	Roll Stands (120 cm)
4	Y	1.3 m/s²	1.6 m/s²	1.6 m/s²
	Z	1.4 m/s²	1.6 m/s²	1.7 m/s²

Table 5. 5th test

N0	Axis	Hinge Stands	Between Stands (75 cm)	Roll Stands (150 cm)
5	Y	1.3 m/s²	1.7 m/s²	1.8 m/s²
	Z	1.4 m/s²	1.8 m/s²	1.8 m/s²

Table 6. 6th test

N0	Axis	Hinge Stands	Between Stands (90 cm)	Roll Stands (180 cm)
6	Y	1.3 m/s²	1.8 m/s²	2.7 m/s²
	Z	1.4 m/s²	1.9 m/s²	2.8 m/s²

3.2. Valve Opening 50%

Table 7. 1st test

N0	Axis	Hinge Stands	Between Stands (15 cm)	Roll Stands (30 cm)
1	Y	1.5 m/s²	0.7 m/s²	0.9 m/s²
	Z	1.4 m/s²	0.7 m/s²	0.9 m/s²

Table 8. 2nd test

N0	Axis	Hinge Stands	Between Stands (30 cm)	Roll Stands (60 cm)
2	Y	1.5 m/s²	0.8 m/s²	1 m/s²
	Z	1.4 m/s²	0.9 m/s²	0.9 m/s²

Table 9. 3rd test

N0	Axis	Hinge Stands	Between Stands (45 cm)	Roll Stands (90 cm)
3	Y	1.5 m/s²	1 m/s²	1.3 m/s²
	Z	1.4 m/s²	0.9 m/s²	1.2 m/s²

Table 10. 4th test

N0	Axis	Hinge Stands	Between Stands (60 cm)	Roll Stands (120 cm)
4	Y	1.5 m/s²	1 m/s²	1.5 m/s²
	Z	1.4 m/s²	1.1 m/s²	1.4 m/s²

Table 11. 5th test

N0	Axis	Hinge Stands	Between Stands (75 cm)	Roll Stands (150 cm)
5	Y	1.5 m/s²	1.2 m/s²	1.8 m/s²
	Z	1.4 m/s²	1.2 m/s²	1.7 m/s²

Table 12. 6th test

N0	Axis	Hinge Stands	Between Stands (90 cm)	Roll Stands (180 cm)
6	Y	1.5 m/s²	1.2 m/s²	2.3 m/s²
	Z	1.4 m/s²	1.3 m/s²	2.2 m/s²

From the table above, there are significant values, namely in the variation of the pedestal distance betwee[illegible] cm [illegible] l and the 180 cm roll pedestal [illegible] and [illegible] valve opening, as follows:

a. Valve Opening 50 %

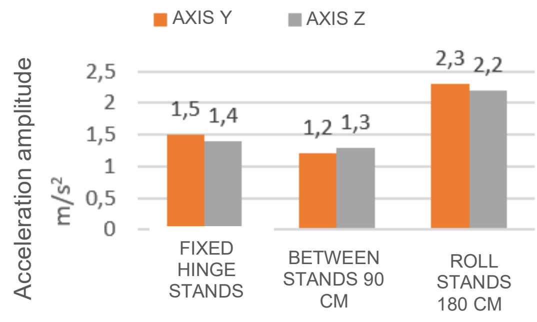

Figure 6. 50% valve opening

b. Valve Opening 100%

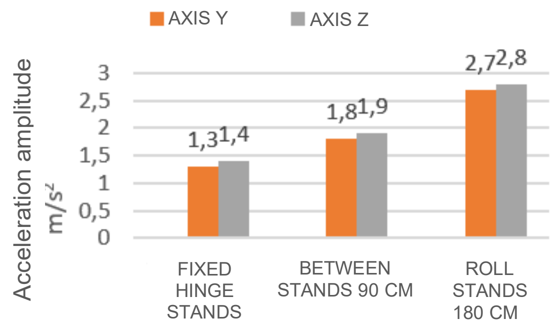

Figure 7. 100% valve opening

Based on the 1st table to the 6th table, it can be seen that the amplitude value of the 50% valve opening acceleration with a flow rate of 30.6 l/min is the largest in the 6th test can be seen in Figure 6, with a pedestal distance variation of 90 cm with an average value of 1.3 m / s2 and a roll pedestal distance of 180 cm with an average value of 2.3 m / s2, this is because if the pedestal distance is far away, the vibration that occurs is getting bigger. The same thing also happens at 100% valve opening that the amplitude value of 100% valve opening acceleration with a flow rate of 32.7 l/min is the largest in the 6th test can be seen in Figure 7, with a pedestal distance variation of 90 cm with an average value of 1.9 m/s2 and a roll pedestal distance of 180 cm with an average value of 2.8 m/s.

Then for the percentage difference in the average value between the 50% and 100% valve openings at the 90 cm pedestal distance variation is 46.15%, while for the percentage difference in the average value between the 50% and 100% valve openings at the roll pedestal distance variation is 21.73%, this is due to the increase in fluid flow discharge load which has increased by 2.1 l/min.

4. CONCLUSIONS AND SUGGESTIONS

4.1. CONCLUSIONS

From this research it can be concluded that:

a. The farther the pedestal distance, the greater the vibration and deflection that occurs.
b. The greater the flow discharge generated the higher the vibration.
c. The large vibration excitation force in piping system is caused by components such as elbows, flowmeters and valves because they interact with the fluid.

4.2. SUGGESTIONS

a. Using valve types with more accurate opening parameters.
b. Using a flowmeter with better accuracy.

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