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OPTIMIZATION OF WATER RATE MEASUREMENT IN SIMPLE FLUID DYNAMICS EXPERIMENTAL EQUIPMENT

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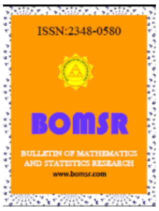

ABSTRACT

The objective of the study is to ascertain the outcomes of enhancing water velocity measurements in a straightforward setup of experimental equipment for fluid dynamics. The study employs an empirical approach utilising five theoretical equations. Research indicates that the optimisation of measurements can only be achieved by examining variations in the water surface position, disparities in diameter pairs, discrepancies in second pipe diameters, and variations in pump conditions. The water speed measurements for references 0, 1, and 2 exhibit distinct patterns that are useful for studying variations in physical quantities and differences in related physical conditions. The water rates for reference levels 0, 1, and 2 decrease as the water level decreases, with corresponding average coefficients of determination of 58%, 76%, and 73%. The calculation of the reference water rate 2 is determined by equations (3) and (5). These equations indicate that a larger diameter of the reference pipe 2 results in a higher value, with an average coefficient of determination of 94%. Conversely, a smaller diameter leads to a lower value, with an average coefficient of determination of 74%. The decrease in reference water rates 0 and 2 is more pronounced when the pump is activated compared to when it is not.

Keywords: Optimization, Measurement, Rate, Dynamics, Fluid

INTRODUCTION

Fluid rate is one of the physical quantities often analyzed in flow systems for certain purposes. Measurement of critical fluid rate in maintaining reservoir pressure at the Ratu well in the Kinantan field, Riau (Musnal, 2014). Calculation of the cooling pond water vapor rate related to the control process of the RSG-GAS reactor operational fuel storage (Dibyo, 2002). Analysis of the effect of changes in electric current and gas flow rate on the flux cored arc welding process (Irfandi, 2020). Fluid rate in a flow system appears as a complex physical quantity, related to many types of physical quantities, and is an indicator of the reactor operational safety system.

In the operation of a hydram pump, the water rate is contained in hydraulic energy, namely kinetic energy plus gravitational potential energy. Hydraulic energy is the ability of water to do mechanical work because there is a supply of electrical energy to the pump.A hydram pump is an automatic water lifter with the energy content of the water itself (Pribadi, 2019). It seems that the comprehensive water rate discussion provides enough space for students to practice thinking in the form of Anderson and Krathwolh's level III thinking skills (Rasagama I. G., 2011).

Measurement of liquid and gas fluid rates is a type of process variable measurement of several variables in the industrial process. Its benefits can determine the comparison of the amount of fuel entering and running out during the industrial process.This variable is a primary indicator for measuring the need for liquid fuel for a particular type of industrial process (Suharto, 1991). Other benefits include controlling the consumption of raw materials (liquid and gas) for plant cultivation, food, beverage production, and application materials, as well as production related to oil hydraulics (Saputra M. R., 2017).

Bernoulli's equation and continuity are 2 main concepts for the study of fluid rates (Giancoli, 2016.). In the long term, mastering it can be a basis for thinking for mechanical engineering graduates, when carrying out production, maintenance, and improvement work engine performance. Second year students of this department study it again in the fluid mechanics course (Rasagama I. G., 2016). Actualization of learning is very much needed and is better with the experimental method of measuring water velocity to overcome the abstractness of the concept of fluid dynamics (Fathiah, 2015). The assumption of water as an ideal fluid makes it easier to apply the Bernoulli equation and continuity to the fluid dynamics experimental equipment system to formulate the theoretical water velocity equation (Aini, 2018).

Figure 1. Arrangement of simple fluid dynamics experimental equipment

The experimental equipment is composed of several pieces of equipment as shown in Figure 1. The hose functions as a manometer to indirectly measure water pressure, 3 reference points are set, namely 0: the water surface in an open vessel; 1: along the axis of pipe I; and 2: along the axis of pipe II. The phenomenon in mercury is the basis for measuring water pressure based on the difference in mercury surface height in 2 hoses.

From the phenomenon in Figure 1, 7 representative water rate equations have been found with the concept of fluid dynamics, the results of theoretical and experimental studies (Rasagama, 2020).Related to the objectives of this study, the 7 equations were modified into the following 5 representative equations (Rasagama, 2020):

1. Reference water rate 0 when water surface height at position j:

$$v_{0j} = \frac{2(h_{00}-h_{oj})}{t} \text{ ... Eq. 1}$$

2. Reference water rate 1 when the water surface height at position j with reference point pair (0,1):

$$v_{1j} = \sqrt{2\left[\left(\frac{h_{00}-h_{oj}}{t}\right)^2 + g\left(h_{oj} - \frac{\rho_s}{\rho_d}\Delta h_{1j}\right)\right]} \text{... Eq. 2}$$

3. Reference water rate 2 when the water surface height at position j with the reference point pair (0,2):

$$v_{2j} = \sqrt{2\left[\left(\frac{h_{00}-h_{oj}}{t}\right)^2 + g\left(h_{oj} - \frac{\rho_s}{\rho_d}\Delta h_{2j}\right)\right]} \text{... Eq. 3}$$

4. Reference water rate 1 when the water surface height at position j with reference point pair (1,2):

$$v_{1j} = \sqrt{2g\left[\frac{\rho_s}{\rho_d}\right]\frac{[\Delta h_{1j}-\Delta h_{2j}]}{\left[\left(\frac{d_1}{d_2}\right)^4-1\right]}} \text{... Eq. 4}$$

5. Reference water rate 2 when the water surface height at position j with reference point pair (1,2):

$$v_{2j} = \sqrt{2g\left[\frac{\rho_s}{\rho_d}\right]\frac{[\Delta h_{1j}-\Delta h_{2j}]}{\left[1-\left(\frac{d_2}{d_1}\right)^4\right]}}. \text{ ... Eq. 5}$$

With ρ_s and ρ_d respectively the densities of mercury and water, g is acceleration due to gravity of the Earth, d_1 and d_2 are the diameters of pipe I and pipe II respectively, h_{0j} is the height of the water surface at position j to the axis of the lowest reference pipe. Δh_{1j} and Δh_{2j} are the differences in height of the mercury surface at reference 1 and 2 when the height of the water surface is at position j. j is the order of observation of the position of the water surface. In the last 4 equations, the reference water pressure 1 or 2 is higher than the outside air. Discussion of the 5 equations above with a study of several conditions such as 2 pumping conditions, several positions of the water surface height in an open vessel, variations in observation reference points and variations in the diameter pairs of pipe connections has led to efforts to optimize the measurement of water flow in a simple fluid dynamics experimental equipment arrangement.

This study is important in efforts to strengthen the concept of fluid dynamics of students, especially the fluid rate equation. Optimization here is an effort to expand the investigation of several physical quantities that affect physical quantities are measured using equipment as shown in Figure 1.

Optimization of water rate measurement to determine the effect of changes in: (i) the position of the water surface height to the reference water rate 0 for each type of pipe diameter pair and pump condition; (ii) the position of the water surface height to the reference water rate 1 and 2 for each type of pipe diameter pair and pump condition; (iii) pipe diameter to the reference water rate 1 and 2 for each water surface height position and each pump condition; and (iv) pump conditions to the reference water rate 0, 1, and 2 related to the 5 equations above.

METHOD

The study used an experimental method by utilizing the facilities of the POLBAN Applied Physics Lab. Water in the research is considered an ideal fluid. Optimization of water rate measurement is limited to 2 pump conditions (off and on), 3 pairs of pipe diameters (3⁄4 water surface (56 cm, 53 cm, 50 cm, 47 cm, 44 cm, and 41 cm). The initial water surface height in the open vessel is 59 cm.

Direct measurements are divided into 6 stages, each for time and difference in mercury surface height at: 3 pairs of diameters related to the pump off and 3 pairs of diameters related to the pump on.

With the help of the Excel for Windows program, the data is processed to obtain the results of the related water rate measurements. These results are to verify the relationship between the water rate of each reference point (dependent variable) with changes in the physical quantities studied (independent variables). For the sharpness of verification of each type of correlation, the tabulation method is used. To increase the sharpness of the correlation, the average value of the coefficient of determination (R^2) of the Excel for Windows program (Raharjo, 2017) is also used. The tendency of the water rate measurement results is analyzed based on facts from observations of accompanying phenomena of the experiment andequipment conditions, characteristics every inch-1⁄2 inch, 3⁄4 inch-1 inch, and the associated water rate equation, as well as 3⁄4 inch- 3⁄2 inch), 3 reference points (0, 1, and 2), and 6 height positions ideal and non-ideal fluid dynamics concepts.

RESULTS AND DISCUSSION

Data were collected in 6 stages, involving 3 pairs of pipe diameters and 2 pump conditions. Each stage included 6 water surface positions. For each water surface height position, 3 repetitions were performed, for measuring time (t), the difference in mercury surface height from the 2 hose arms on pipe I (Δh_{1j}), and II (Δh_{2j}). A total of 324 initial data were obtained, and after averaging, 108 data were obtained to calculate the related water rate. Data processing was not related to the conditions when the flow was just taking place.

Related to the first research question, a tabulation of the results of data processing of reference water rate 0 based on equation (1) was obtained for each water surface height position on 3 pairs of diameters and 2 pump conditions, as shown in table 1.

Table 1. Relation of height to reference water rate 0 based on equation (1)

	v_{0j} (m/s) with pump condition & pipe diameter pair off & (inch-inch) on & (inch-inch)						
	h_{oj} (cm)	3⁄4 – 1⁄2	3⁄4 – 1	3⁄4 – 3⁄2	3⁄4 – 1⁄2	3⁄4 – 1	3⁄4 – 3⁄2
1	56	0.56	1.06	1.13	1.50	0.86	1.13
2	53	0.55	1.03	1.16	0.86	0.65	0.80
3	50	0.53	1.08	1.17	0.75	0.38	0.62
4	47	0.53	1.03	1.14	0.71	0.30	0,.51
5	44	0.53	1.05	1.13	0.68	0.25	0,46
6	41	0.50	1.03	1.11	0.82	0,22	0,42

Explicit phenomenon I from table 1, there is a tendency: the lower the water surface position, the smaller the reference water rate 0, in 2 pump conditions and 3 diameter pairs. This means that the motion of reference water 0 is slowed down. Based on Newton's Law II, in this phenomenon the Earth's gravitational force works on each water molecule .In an open vessel, the frictional force of cohesion and adhesion, and the external force due to falling water when the pump is on (torque generator) so that the rotational motion of water molecules occurs (Tiwow, 2015). The gravitational force is supportive, the frictional force and external force are inhibiting. The inhibiting force is greater than the and ¾ inch-3 inches largest.

Fluid viscosity defines the size of the friction force in the fluid. The thicker it is, the harder it is to flow. The friction force due to water viscosity is slowing down (Khalimah, 2016). At room temperature, the viscosity constant of water is $1x10^{-3}$ Pa.s and air is $1x10^{-5}$ Pa.s, so the friction force from the viscosity of water compared to air is not ignored. According to Poiseuille, the smaller the viscosity constant of the fluid, the greater the flow rate. Viscosity reduces the rate of fluid (Swartz, 1981).

Turbulent flow occurs because laminar flow (the effect of gravity in an open vessel) experiences disturbance (the effect of water entering when the pump is on). If the disturbance disappears with time, laminar flow occurs, but if it is continuous (the pump is on), it triggers instability (rotation, oscillation, collision) and turbulent flow occurs (Sulaiman, 2000). Water entering when the pump is on is inhibiting and reducing the reference water rate 0.

Explicit phenomenon II from Table 1, at each position of the water surface height, the reference water rate is 0 at the ¾ inch-½ diameter pair.

This phenomenon applies to 2 pump conditions. The fact is that at the supporting diameter pair, the smallest inch water surface motion, followed by ¾ inch-1 inch, is slowed down. ¾ inchi-½ inches is a narrow pipe connection profile where water flows from large to small diameters. Different for the ¾ inch-1 inch diameter pair (wider) and ¾ inch- 3/2 inch (wider). Another fact, this profile is at the end of the flow system and the water in the pipe connection interacts with the surface water of the open vessel vessel. This explanation is in line with the theoretical study that the narrow pipe connection profile inhibits the movement of the water surface. The presence of a narrow channel causes water to continuously resist friction and non-elastic collisions by the pipe walls so that the momentum of the water is reduced. When the momentum of the water is unable to overcome it, the water is separated from the main flow contour and a random flow direction is formed, even the opposite direction (Saputra, 2016). This condition certainly reduces the rate of reference w.

Table 2. Relationship between h_{0j} and v_{1j} & v_{2j}, based on equations (2) & (3) respectively.

		v_{1h} (m/s) or v_{2h} (m/s) with			
j	**h_{0j} *(cm)***	**pump mati & ø pipe (d= …. inches)**			
		1⁄2	3⁄4	1	3⁄2
1	56	2.09	#NUM!	2.60	2.78
2	53	2.01	#NUM!	2.56	2.69
3	50	2.03	#NUM!	2.50	2.92
4	47	1.88	#NUM!	2.45	2.82
5	44	1.86	#NUM!	2.34	2.71
6	41	1.80	#NUM!	2.31	2.60

Note: *: average of three measurement results

		v_{1j} (m/s) or v_{2j} (m/s)			
j	**h_{0j} *(cm)***	**with pump running & pipe ø (d= …. inches)**			
		1⁄2	3⁄4	1	3⁄2
1	56	1.87	#NUM!	2.52	2.72
2	53	1.71	#NUM!	2.47	2.70
3	50	1.53	#NUM!	2.40	2.76
4	47	1.32	#NUM!	2.34	2.75
5	44	1.08	#NUM!	2.31	2.65
6	41	0.76	#NUM!	2.20	2.52

Table 3. Relationship between h_{0j} and v_{1j} & v_{2j}, based on equations (4) & (5) respectively.

		v_{1j} (m/s) or v_{2j} (m/s)			
j	**h_{0j} *(cm)***	**with pump off & pipe ø (d= …. inches)**			
		1⁄2	3⁄4	1	3⁄2
1	56	2.39	1.47*	0.93	0.43
2	53	2.32	1.46*	0.91	0.43
3	50	2.30	1.24*	0.95	0.25
4	47	2.13	1.16*	0.88	0.24
5	44	2.23	1.19*	0.91	0.24
6	41	2.13	1.17*	0.86	0.25

		v_{1j} (m/s) or v_{2j} (m/s)			
j	*h_{0j} (cm)*	**with pump running & pipe ø (d= …. inches)**			
		1⁄2	3⁄4	1	3⁄2
1	56	#NUM!	#NUM!	1.46	0.19
2	53	#NUM!	#NUM!	1.36	0.16
3	50	#NUM!	#NUM!	1.33	0.23
4	47	#NUM!	#NUM!	1.28	0.08
5	44	#NUM!	#NUM!	1.26	#NUM!
6	41	#NUM!	#NUM!	1.21	#NUM!

Note: *: average of three measurement results

All results of reference water rate calculation 1 based on equation (2), at each water surface position and each pump condition, some appear as #NUM! both when the pump is off and on, as shown in Table 2. Similar things in Table 3 are the average results of reference water rate calculation 1 based on equation (4) with a pipe diameter of ¾ inch and reference water rate 2 based on equation. (5) with a pipe diameter of ½ inch, when the pump is on. This is because the average calculation results contain the results of algebraic operations in the form of negative number roots. This is not used as the basis for analysis. Similar things in Tables 4, 5, and 6. The explicit phenomenon from Tables 2 and 3 is the tendency for the reference water rates 1 and 2 to decrease when the water surface position becomes lower.

This phenomenon occurs in 2 pump conditions, all types of pipe diameters and all types of reference water rate equations 1 and 2. From the principle of work energy can be explained the lower the position of the water surface triggers the condition of the mechanical energy of reference 0 to decrease due to the negative work of the inhibiting force on the water surface. A similar phenomenon is experienced by water in pipes I and II. In references 1 and 2, the mechanical energy of water is 100% in the form of kinetic energy because its potential energy is zero. The speed of water is a representation of kinetic energy. Indirectly the lower the position of the water surface causes the kinetic energy of reference water 1 and 2 to decrease. The effect of the roughness of the pipe walls and the bends of the pipe joints also appears so that there is a frictional force that reduces the speed of water in pipes I and II (Subagyo, 2012). The average value of R2 Table 2 of the relation v1j version of equation (2) or v2j version of equation (3) to h0j in both pump conditions, specifically for the six water rate data that can be calculated is 0.76. 76% of the water rate along the pipe axis is influenced by the position of the water surface height. 24% is influenced by other factors. The average value of R2 Table 3 of the relation v1j version of equation (4) or v2j version of equation (5) to h0j in the 2nd pump conditions, specifically for 5 calculated water rate data is 0.73. 73% of the water rate along the pipe axis is influenced by the position of the water surface height. 27% is influenced by other factors. Thus, the average R2 for the relationship of water rate along the pipe axis according to equations (2), (3), (4), and (5) to the position of the water surface height is 74.5%. This is a high relationship between the water rate in the pipe and the position of the water surface. The water rate in the pipe is smaller when the position of the water surface is lower. This phenomenon is similar to the phenomenon of fluid dynamics in an open vessel, as explained by Torricelli's theorem, namely the square of the water rate on a perforated (leaky) base is proportional to the height of the water surface in an open vessel.

This concept is identical to the phenomenon of free-falling objects above the Earth's surface. If it is conditioned to fall from a lower position, the speed of the object when it arrives at the Earth's surface is also smaller (Young, 2016.). Related to research question III, it was obtained: (i) Tabulation of the results of processing water rate data along the pipe axis using equations (2) and (3) equivalent. 4 types of pipe diameters and 2 pump conditions, as shown in Table 4; and (ii) Tabulation of the results of processing water rate data along the pipe axis using equations (4) and (5) on 4 types of pipe diameters and 2 pump conditions, as shown in Table 5.

The explicit phenomenon from Table 4 when a certain water surface position appears there is a tendency for the reference water rate 2 to be higher in relation to the pipe diameter.

The opposite is shown by Table 5. The explicit phenomena of Tables 4 and 5 show similar tendencies for the 2 pump conditions. The calculation results of reference water rate 1 from Tables 4 and 5 appear to be unusable as a basis for tendency analysis because 75% of them are negative number roots. Therefore, the analysis only uses reference water rate 2, related to the difference in pipe diameter II.

Table 4. Relation of changes in d_1 or d_2 to reference water rate 1 or 2, based on equation (2) or (3)

d_1 or d_2 (inch)	**v_{1j} or v_{2j} (m/s) with the condition of pump off and h_{0j} (cm)**					
	56	53	50	47	44	41
½	2.09	2.01	2.03	1.88	1.86	1.80
¾	*#NUM!**	*#NUM!**	*#NUM!**	*#NUM!**	*#NUM!**	*#NUM!**
1	2.60	2.56	2.50	2,45	2,34	2.31
3⁄2	2.78	2.69	2.92	2.82	2.71	2.60

d_1 or d_2 (inch)	**v_{1j} or v_{2j} (m/s) with the condition of pump on and h_{0j} (cm)**					
	56	53	50	47	44	41
½	1.87	1.71	1.53	1.32	1.08	0.76
¾	*#NUM!**	*#NUM!**	*#NUM!**	*#NUM!**	*#NUM!**	*#NUM!**
1	2.52	2.47	2.40	2.34	2.31	2.20
3⁄2	2.72	2.70	2.76	2.75	2.65	2.52

Description: *: average of three average measurement results;

Judging from the position of pipes I and II in the equipment arrangement in Figure 1, the position of the pipes with a diameter of ½ inch, 1 inch, and3⁄2 inch is always at the end of the 3rd flow of the diameter pair type. For ¾ inch-½ inch pairs form a narrowed joint profile, ¾ inch-1 inch wide, and ¾ inch-3 inches wider. Studies show that the drag effect of narrowed joint profiles is stronger than that of widened joints on the rate of fluid. It is natural that the phenomenon of the smallest reference water rate 2 occurs when the pipe diameter is ½ inch, then 1 inch, and the largest is 3 inches as shown in Table 4.

Table 5. Relation of changes in d1 or d2 to the reference water rate 1 or 2, based on equation (4) or (5)

d_1 or d_2 (inch)	**v_{1j} or v_{2j} (m/s) with the condition of pump off and h_{0j} (cm)**					
	56	53	50	47	44	41
½	2.39	2.32	2.30	2.13	2.23	2.13
¾	1.47*	1.46*	1.24*	1.16*	1.19*	1.17*
1	0.93	0.91	0.95	0.88	0.91	0.86
3⁄2	0.43	0.43	0.25	0.24	0.24	0.25

d_1 or d_2 (inch)	**v_{1j} or v_{2j} (m/s) with the condition pump on and h_{0j} (cm)**					
	56	53	50	47	44	41
½	_#NUM!_	_#NUM!_	_#NUM!_	_#NUM!_	_#NUM!_	_#NUM!_
¾	_#NUM!_*	_#NUM!_*	_#NUM!_*	_#NUM!_*	_#NUM!_*	_#NUM!_*
1	2.60	2.41	2.36	2.28	2.25	2.34
3⁄2	0.75	0.65	0.92	0.31	#NUM!	#NUM!

Description: *: average of three measurement results.

From other studies, equations (2) and (3) are the results of formulations without being based on the application of the continuity equation. The formulation of reference water rate 1 uses the reference point pair (0,1). The formulation of reference water rate 2 uses the reference point pair (0,2). In this case, these two pairs of reference points function only as a place to apply the Bernoulli equation to formulate reference water rates 1 and 2. The formulation of equations (2) and (3) does not condition the relationship between reference water rates 1 and 2 at all, so it is natural that equations (2) and (3) do not explicitly contain the diameter of either pipe I or II. Equations (2) and (3) seem inconsistent with the concept of the continuity equation. namely the fluid rate increases if the pipe diameter becomes smaller.It is different for the formulation of equations (4) and (5), each for reference water rates 1 and 2. The basis for the formulation of equations (4) and (5) is the reference point pair (1,2). This pair of reference points is used as a place to apply the continuity and Bernoulli equations. This condition repositions the explicit phenomenon from Table 4 to Table 5, where the water rate decreases as the pipe diameter increases (Serway, 2018). This phenomenon is shown in Table 5 when the pump is off. Only part of the tendency in Table 5 when the pump is off is shown in Table 5 when the pump is on. The average value of R2 Table 4 of the v2j relation based on equation (3) to d2 for d2 = ½, 1, and 3pipe I (pipe II) is influenced by the diameter of pipe I (pipe II). This means that the reference water rate 1 (reference 2) is greater if the diameter of pipe I (pipe II) is smaller according to the concept of the continuity equation.Related to research question III, a tabulation of the results of processing water rate data for each reference point using equations (1) to (5) is obtained, as shown in Table 6. At each reference position 0, there is a tendency that the reference water rate 0 based on equation (1) is greater when the pump is on than off for the ¾ inch-½ inch diameter pair, but smaller when the pump is on than off for the ¾ inch-1 inch and ¾ inch-inch diameter pairs is 0.94. 94%

of the water rate in pipe II is influenced by the diameter of pipe II. This means that the reference water rate 2 is greater if the diameter of pipe II is larger.

The average value of R2 Table 5 of the v1j relation based on equation (4) to d1 or d2 or the v2j relation based on equation (5) to d1 or d2 specifically for the pump off is 0.74. 74% of the water rate along the axis 3 inches. As has been stated

in the discussion of the phenomenon Table 1 that the condition of the pump on generates a torque As a result, the water molecules rotate in addition to translating due to the effect of Earth's gravity. The rotational motion inhibits the movement of water from the open vessel to the pipe connection. Thus the reference water rate 0 is smaller when the pump is on than off. There is an anomalous condition that occurs in the ¾ inch-½ inch diameter pair, which needs further verification based on wider experimental data.

The change in the reference water rate 0 every 3 cm of distance traveled appears to be greater when the pump is on than off. The deceleration also appears to be greater when the pump is on than off. If referring to the concept of non-ideal fluids, the effect of water viscosity generates frictional cohesion and adhesion that inhibit. On the other hand, the effect of water entering generates a situation similar to the frictional force from the effect of water viscosity. When the pump is off, the resistance is only from the viscosity effect and when the pump is on, the resistance is from the viscosity effect and the water enters. At each reference position 0, the reference water rate 2 based on equation (3) appears smaller when the pump is on than when it is off. This applies to each type of pipe diameter II. Because the condition of the calculation result of the reference water rate 1 based on equation (2) contains #NUM! then the phenomenon of this reference water rate 1 is not analyzed.

The phenomenon of reference water rate 2 occurs because there is additional resistance from the effect of incoming water, which is transmitted to the water in pipes I and II through the mechanism of oscillation and collision. This does not occur when the pump is off. The change in the reference water rate 2 based on equation (3) for every reference distance traveled 03 cm appears larger when the pump is on than off. Because the condition of the calculation result of reference water rate 1 based on equation (2) contains #NUM! then the reference water rate 1 cannot be analyzed. The phenomenon of reference water rate 2 shows a change in the reference water rate 2 in the direction of getting smaller and faster when the pump is on than off. This phenomenon reaffirms that the effect of incoming water does not only occur in water in open vessels, but also in water in pipes I and II, so that the reference water rate 2 based on equation (3) changes faster when the pump is on than off.

Table 6. Relation of pump conditions with reference water rates 0, 1, and 2 based on equations (1) to (5) v_{0j} *(m/s)* for pipe pairs $\emptyset_1$-$\emptyset_2$(inches) and pump conditions through equation(1)

		¾-½		¾-1		¾-2/2	
S.NO	h_{0j} (cm)	Dead	Alive	Dead	Alive	Dead	Alive
1	56	0.56	1.5	1.06	0.86	1.13	1.13
2	53	0.55	0.86	1.03	0.65	1.16	0.8
3	50	0.53	0.75	1.08	0.38	1.17	0.62
4	47	0.53	0.71	1.03	0.3	1.14	0.51
5	44	0.53	0.68	1.05	0.25	1.13	0.46
6	41	0.5	0.82	1.03	0.22	1.11	0.42

v1j or v2j (m/s) for ø pipe (inches) and pump conditions via equations (2) and (3)

		½		¾		1		3/2	
S.NO	h_{0j} (cm)	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive
1	56	2.09	1.87	#NUM!*	#NUM!*	2.6	2.52	2.78	2.72
2	53	2.01	1.71	#NUM!*	#NUM!*	2.56	2.47	2.69	2.7
3	50	2.03	1.53	#NUM!*	#NUM!*	2.5	2.4	2.92	2.76
4	47	1.88	1.32	#NUM!*	#NUM!*	2.45	2.34	2.82	2.75
5	44	1.86	1.08	#NUM!*	#NUM!*	2.34	2.31	2.71	2.65
6	41	1.8	0.76	#NUM!*	#NUM!*	2.31	2.2	2.6	2.52

v_{1j} or v_{2j} (m/s) for pipe ø (inches) and pump conditions through equations (4) and (5)

		½		¾		1		3/2	
S.NO	h_{0j} (cm)	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive
1	56	2.39	#NUM!	1.47*	#NUM!*	0.93	1.46	0.43	0.19
2	53	2.32	#NUM!	1.46*	#NUM!*	0.91	1.36	0.43	0.16
3	50	2.3	#NUM!	1.24*	#NUM!*	0.95	1.33	0.25	0.23
4	47	2.13	#NUM!	1.16*	#NUM!*	0.88	1.28	0.24	0.08
5	44	2.23	#NUM!	1.19*	#NUM!*	0.91	1.26	0.24	#NUM!
6	41	2.13	#NUM!	1.17*	#NUM!*	0.86	1.21	0.25	#NUM!

Description: *: average of three measurement results;

At each reference position 0, the reference water rate 2 based on equation (5) appears to have a greater tendency when the pump is on than when it is off for a diameter of 1 inch, but smaller for a diameter of 3 inches and cannot be analyzed for a diameter of ½ inch. The same thing applies to the reference water rate 1 based on equation (4) so it is not analyzed. With Thus, there are 2 contradictory phenomena due to water ingress. The reference water rate 2 based on equation (5) for a pipe diameter of 1 inch does not comply with the concept of non-ideal fluid dynamics, but for a pipe diameter of 3 inches it complies with the concept of non-ideal fluid dynamics. Therefore, further verification is needed based on broader experimental data to see the validity of the concept in the phenomenon of a pipe diameter of 1 inch where the effect of water ingress is able to increase the rate of translational motion of water molecules. The phenomenon of reference water rate 2 in a pipe with a diameter of 3 inches has followed the concept of non-ideal fluid dynamics, namely the effect of water ingress inhibits the translational motion of water molecules. The phenomenon diameter ½ inch cannot be analyzed. The same thing applies to the condition of reference water rate 1 (diameter ¾ inch) based on equation (4) so that this rate also cannot be analyzed. The explicit phenomenon of reference water rate 2 based on equation (5) shows a similar tendency to reference water rate 2 based on equation (3) and reference water rate 0 based on equation (1) namely the water rate becomes smaller and smaller when the pump is on compared to off. The effect of water entering the open vessel has induced water in pipes I and II so that the motion of the entire system is influenced by the torque generating the rotational motion of water molecules in a pipe with a diameter of 3 this inch also confirms the effect of water entering the open vessel has been transmitted through the mechanism of oscillation and, or impact to the water in pipe II.

CONCLUSION AND SUGGESTIONS

The change in the reference water rate 2 based on equation (5) for each reference travel distance of 0 .3 cm appears to be greater when the pump is on compared to off. This occurs at diameter 1 inch and 3.

Conclusion

1. The water surface rate is smaller when the water surface height position is lower in each pump condition and each pair of pipe diameters with an average determination coefficient of 58%;
2. The water surface rate at each height position is the smallest inches. When the open vessel is connected ¾ inch-½ inch diameter pair, followed by ¾ inch-1 inch diameter pair, the largest ¾ inch - 3 inch diameter pair in both dead and alive pipe conditions;
3. The water rate in pipes I and II is getting smaller when the water surface position is getting lower in each pump condition, each type of pipe diameter and each type of water rate equation in pipes I and II;
4. The average coefficient of determination of the relationship between the water rate in pipes I and II to the water surface height position when using equations (2) and (3) is 76%, equations (4) and (5) are 73%, and the average of the 4 is 74.5%;
5. The water rate in pipe II based on equation (3) in each pump condition and each water surface position is getting bigger if the diameter of pipe II is getting bigger, but for the water rate in pipe II based on equation (5) the opposite applies. The tendency of the water rate in pipe I based on equations (2) & (4) is not analyzed. 4. The average coefficient of determination of the water rate in pipe II by the diameter of pipe II when using equation (3) is 94% and equation (5) is 74%.
6. The water surface rate and the water rate in pipe II, are mostly smaller when the pump is on than off, with a greater change per 3cm water surface distance. The tendency of the water rate in pipe I is not analyzed.

Suggestion

It is necessary to collect more extensive experimental data related to the results of water rate measurements in the form of #NUM! and anomalies to the concept of ideal and non-ideal fluid dynamics.

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