Modifying Determination Reynolds Number of Water's Flows

Nikmatul Alifah[a)], Juli Astono[b)], Abidaturrosyidah[c)]

Faculty of Mathematic and Sciences, Yogyakarta State University.

[a)]Corresponding author: nikmatulalifah95@yahoo.co.id
[b)]juliastono@staff.uny.ac.id
[b)]abirosyidah@gmail.com

Abstract. Reynolds number is physics' coefficient that rarely proved. Thus, this experimental research aims to determine the Reynolds number for some of fluid's flows which are laminar, transition, and turbulence. Laminar flow is a flow which is straight and calm, with it's Reynolds number is less than 2300. Transition flow's form is a line that a bit fluctuated, and it's Reynolds number 2300-4000. Turbulence flow is a flow which turbulently fluctuated and forming rolls, and it's Reynolds number is more than 4000. A fluid that used in this research is water with density 1000 kg/m^3 and viscosity 0.001 Pa.s.To determine Reynolds number of water's flows the velocity of water is variated trough the arrangement of its debit. Variables of this research is water's debit as independent variable, Reynolds number as dependent variable and pipe's diameter, density and viscosity has been used as a controlled variables. Result shown that the Reynolds number 1291.1 – 2151.833 is the Reynolds number for water with a laminar flow. The Reynolds number 2754.347 – 3625.08 is the Reynolds number of transitions water's flow. Reynolds number 4045.447-4906.18 is the Reynolds number for water with a turbulence flow. The results supported the theory.

INTRODUCTION

The nature of the flow, whether laminar or turbulent, as well as their relative position on a scale which shows the importance relative the tendency of laminar to the tendency of turbulent flow is shown by Reynolds number [3]. The important parameters involved (i.e. Reynolds number) and their critical values depend on the specific flow situation involved. For example, flow in a pipe can be laminar or turbulent, depending on the value of Reynolds number involved [1]. Generally, the first thing a fluids engineer should do is estimate the Reynolds number range of the flow under study. A very low Re indicates viscous creeping motion, where inertia affect are negligible. Moderate Re implies a smoothly varying laminar flow. High Re probably spells turbulent flow which is slowly varying in the time-mean but has superimposed strong random high frequency fluctuations. The changeover is called transition to turbulence [2].

The Reynolds number is a dimensionless number defined as the ratio of inertial forces to viscous forces and consequently quantifies the relative importance of these two types of forces for given flow conditions;

$$\mathrm{Re} = \frac{vD\rho}{\mu} \tag{1}$$

where Re = Reynolds number, v = velocity of the flow, D= diameter or length scale of the flow, ρ= density, μ= dynamic viscosity.

Reynolds found that when a laminar flow velocity always be lowered such that R is less than 2000. By the usual pipe installation, will be transformed into a turbulent flow in the range Reynolds numbers from 2000 to 4000 [3]. Examining German engineer, G.H.L. Hagen's data that reported in 1839 and compute the Reynolds number at V = 1.1 ft/s we obtain $\mathrm{Re}_d = 2100$. The flow became fully turbulent, V = 2.2 ft/s, at $\mathrm{Re}_d = 4200$. The accepted design value for pipe transitioning now taken to be $\mathrm{Re}_{d,\,crit} \approx 2300$.

If the flow is laminar, there may be occasional natural disturbance that damp out quickly. If transition is occurring, there will be sharp burst of intermittent turbulent fluctuation as the increasing Reynolds number causes a breakdown or instability of laminar motion. At sufficiently large Re, the flow will fluctuate continually and is termed fully turbulent [2].

Many researchers have developed the determination of the Reynolds number with a variety of methods, but this study determines the Reynolds number with a much simpler way. However, there is no research yet in determining Reynolds number by the variation of volume. This variation of volume is important because it can be used in varying debit of water flow, which different debit affects different velocity of the water flow. So, we can get a various value of the Reynolds number.

METHODS

Instruments used in this research is designed such as shown:

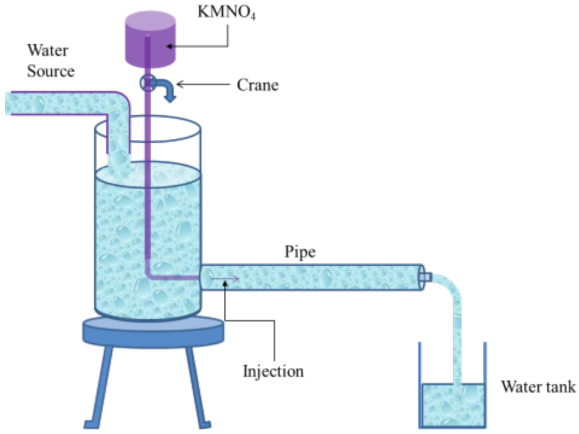


FIGURE 1. Instruments

The principle of this instrument is, if water tube filled with the water so the water will flow into the glass tube. After glass pipe filled with water, the water faucet is opened, so that the water in the glass pipe will flow into the reservoir. Kind of water flows in the glass pipe can be seen by opening the tap of the tube $KMNO_4$. $KMNO_4$ will flow into the glass pipe in the form of a red trajectory. The shape of the trajectory will show the kind of water's flows in a glass pipe.

As for determining the value of Reynolds number of water's flows by means of varying the size of the tap on the glass pipe so that the volume of water is spilled will vary. Pipe's diameter, temperature, water's density and viscosity are controlled. In this research, the data is measured 9 times the volume variation each for 20 seconds. Reynolds number is calculated using the equation (1), according to the law of continuity:

$$Q = \frac{V}{t} \tag{2}$$

And,
$$Q = vA \tag{3}$$

By combining equation (2) and equation (3), we get:

$$\frac{V}{t} = vA \tag{4}$$

$$v = \frac{V}{tA} \tag{5}$$

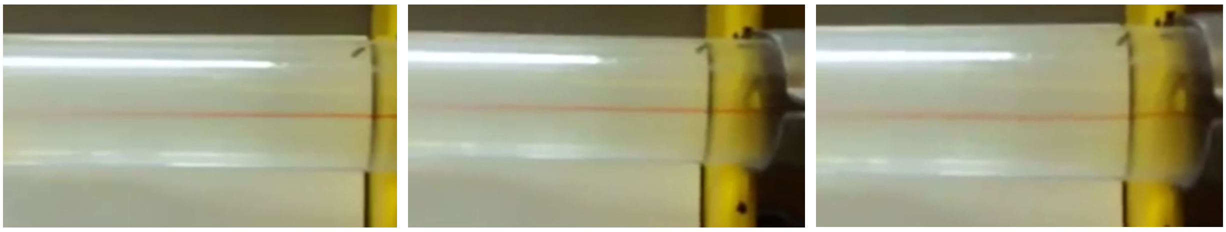
Where Q = continuity, V = volume, and A= surface area of pipe. Equation (5) substitute to equation (1), we get:

$$\mathrm{Re} = \frac{VD\rho}{tA\mu} \tag{6}$$

RESULT AND DISCUSSION

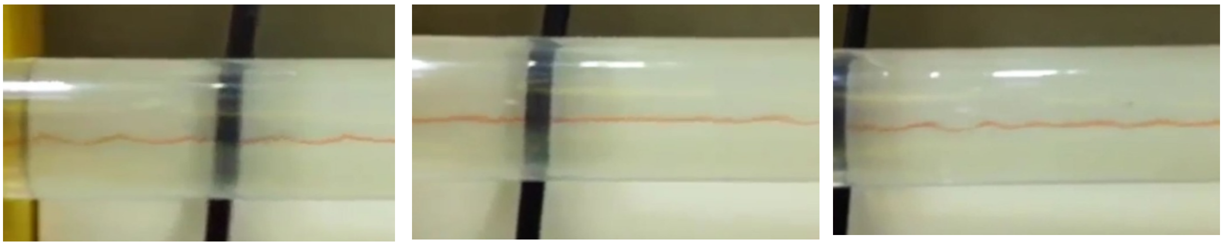
TABLE 1. The Range of Reynolds Numbers and Trajectories for Measured Volume

Volume (mL)	Range of Reynolds Number	Trajectories of $KMNO_4$
750 mL – 800 mL	(1291.1±7.8) – (1377. 173±7.8)	straight line
1000 mL – 1.050 mL	(1721.5±8.1) – (1807.54±8.2)	straight line
1200 mL – 1250 mL	(2065.8±8.4) – (2151.8±8.5)	straight line
1600 mL – 1650 mL	(2754.5±9.0) – (2840,4±9,0)	line that a bit fluctuated
1750 mL – 1900 mL	(3012.6±9.2) – (3270.8±9.3)	line that a bit fluctuated
2100 mL – 2200 mL	(3615.1±9.6) – (3787. 2±9.7)	line that a bit fluctuated
2350 mL	(4045.4±9.9)	forming rolls
2500 mL	(4303.7±10.0)	forming rolls and fade
2800 mL -2850 mL	(4820, 1±10.4) – (4906.2±10.5)	forming rolls and fade



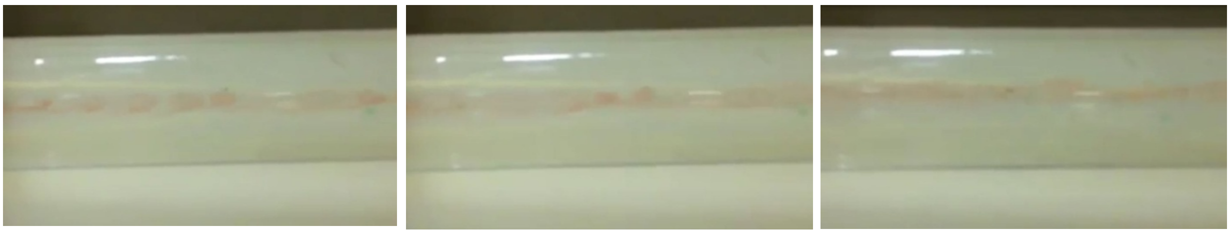
(a) (b) (c)

FIGURE 2. Trajectories of the Laminar flow (a) Re = 1291.1±7.8 ; (b) Re = 1721.5±8.1; (c) Re = 2065.8±8.4



(a) (b) (c)

FIGURE 3. Trajectories of The Transition Flow (a) Re = 2754,5±9,0; (b) Re = 3270,8±9,3; (c) Re = 3615,1±9,6



(a) (b) (c)

FIGURE 4. Trajectories of The Turbulent Flow (a) Re = 4045,4±9,9 ; (b) Re = 4303,7±10,0; (c) Re = 4820, 1±10,4

Result show that at the first measuring, by using volume of water 750 mL – 800 mLthe Reynolds number we got are between (1291.1±7.8) – (1377. 173±7.8) and $KMNO_4$'s trajectory is a straight line. Volume of water 1000 mL – 1.050 mL, the Reynolds number is (1721.5±8.1) – (1807.54±8.2) and shape of KMNO4's track is straight line. Volume of water 1200 mL – 1250 mL, the Reynolds Number is (2065.8±8.4) – (2151.8±8.5) and shape of $KMNO_4$'s track is straight line. While Volume of water 1600 mL-1650 mL, the Reynolds number is (2754.5±9.0) – (2840,4±9,0) and shape of $KMNO_4$'s track is a line that a bit fluctuated. Volume of water is 1750 mL – 1900 mL, the Reynolds Number is (3012.6±9.2) – (3270.8±9.3) and shape of $KMNO_4$'s track isa line that a bit fluctuated. When the volume of water is 2100 mL - 2200 mL, the Reynolds number is (3615.1±9.6) – (3787. 2±9.7) and shape of $KMNO_4$'s track is a line that a bit fluctuated. While volume of water

2350 ml, the Reynolds number is (4045.4±9.9) and the shape of $KMNO_4$'s track forming rolls. Volume of water 2500 mL, the Reynolds number is (4303.7±10.0) and the shape of $KMNO_4$'s track forming rolls and mingling with water. Volume of water 2800 ml -2850 ml, the Reynolds number is (4820, 1±10.4) – (4906.2±10.5) and the shape of $KMNO_4$'s track forming rolls and mingling with water.

Based on the analysis result, Reynolds number 1291.1 until 2151.8 is Reynolds number for laminar flows, Reynolds number 2754.5-3787.2 is Reynolds number for transition flow, and Reynolds number 4045.4-4906.2 is Reynolds number for turbulent flow.

CONCLUSION

Based on the data and discussion we can conclude that Reynolds number 1291,1 until 2151,8 is Reynolds number for laminar flows, Reynolds number 2754,5-3787,2 is Reynolds number for transition flow, and Reynolds number 4045,4-4906,2 is Reynolds number for turbulent flow.

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