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Experiment Number (10)

Reynolds number

Type of the report: short report

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Performing Date: 24-8-2022

Submitting Date :31-8-2022

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Abstract:

This experiment's objective is to be able to determine the Reynolds Number, as a function of flow rate and to characterize the type of flow of liquid in a circular pipe. Reynold's number is used to characterize the regimes of flow. The types of flow characterized are laminar, transitional, and turbulent flow. The flow is laminar when the fluid is flowing slowly, and turbulent when the fluid flows fast and transitional when the flow switches between laminar and turbulent. It was observed that at laminar flow where the velocity is low, the dye forms a thin thread line then it slightly swirls as velocity is increased and at further increase of velocity which characterizes turbulent flow, the flow of dye fully swirls then disperses. This shows that as the water flow rate increases, the calculated Reynolds number also increases.

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Result:

Table (1): Raw data for Reynold Number experiment

Trial NO.	Temperature (C°)	Volume (L)	Time (sec)	observed Flow regime
1	22	1.840E-01	7.34	turbulent
2	22	9.600E-02	2.38	turbulent
3	22	1.480E-01	3.035	turbulent
4	22	1.600E-01	3.35	turbulent

Table (2): parameters at T=22°C.

Test pipe section diameter	10 mm
Test pipe section length	675 mm
cross section area	7.850E-05 m^2
density of water	997.8 Kg/m^3

Table (3): Calculated data for Reynold Number experiment

Volumetric flow rate (L/s)	Volumetric flow rate (m^3/s)	Velocity (m/s)	Re
2.507E-02	2.507E-05	3.193E-01	3.326E+03
4.034E-02	4.034E-05	5.138E-01	5.352E+03
4.876E-02	4.876E-05	6.212E-01	6.471E+03
4.776E-02	4.776E-05	6.084E-01	6.338E+03

Discussion:

Reynolds number (Re) is a dimensionless parameter that is used in classifying the type of flow whether it is Laminar, Transition or Turbulent.

The velocity of flowing fluid was increased in much trial and in each trial the volume and time were recorded, in 4 trials the volume increases with time, and it was noticed that the type of flow was Turbulent.

The Reynolds number of each trial was calculated using the obtained data and then tabulated in Table 1. Also, displayed in the aforementioned table is the type of flow as observed with the naked eyes. All four trials showed laminar and smooth flow and their Reynolds Numbers were both calculated to be below 2300. Laminar Flow occur at low velocities, where the layers of fluid seem to slide by one another without eddies or swirls being present; on the other hand, turbulent flow occurs at higher velocities, where eddies are present giving the fluid a fluctuating nature. Possible errors arrived in the experiment especially when expecting a turbulent flow as the velocity was increased might be possible due to a defective equipment and the instability of the area where it was situated.

Conclusion:

- Reynolds number is directly proportional with velocity. In this experiment, the Reynolds Number as a function of flow rate was determined. It was found out that as the water flow rate increases, the calculated Reynolds number also increases.
- The flow type is laminar when $Re < 2300$ turbulent when $Re > 2300$ and transitional if $2000 < Re < 3000$
- With increasing in fluid flow rate, the red dye changed into very thin and smooth line, the line color vanished gradually in the pipe till it became colorless. This was in coherence with Reynolds phases: laminar, transition and turbulent.
- The value of Reynolds number depended on the physical properties of the fluid such as density and viscosity.
- Some errors occurred during the experiment which were mainly due to human errors such as taking readings, timing errors and inconsistency in reflexes and synchronization between operators.

Recommendations:

- This experiment can be done more accurately by increasing reading number of trials and increasing the waiting time between each reading of the flow rate, especially in laminar phase. Person who oversees taking readings should be focused and alert during the experiment to obtain accurate results. Besides, by using more accurate graduated beaker and darker dye. Therefore, the readings taken from the beaker should be taken at eye level which is perpendicular to our eyes to avoid parallax error.

References:

1.Website: Water Viscosity Calculator (2022) from

https://calculator-online.net/water-viscosity-calculator/

2.Book: Chemical engineering laboratory "1" (0915361); University of Jordan; factual of engineering and Technology; Department of Chemical engineering.

Appendices:

Sample of calculation (first row):

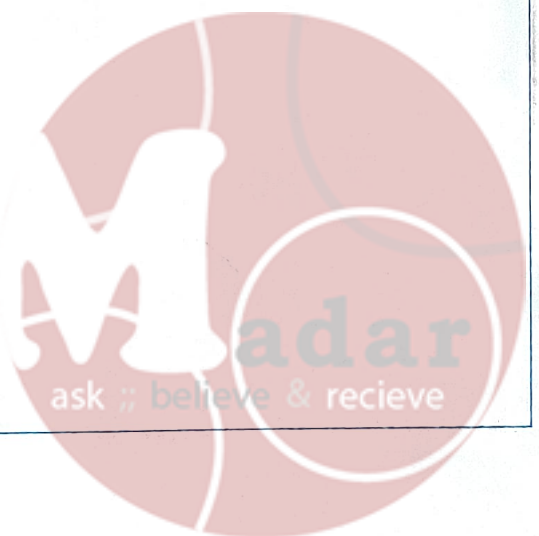
- Density of water at 22 C° =997.8 Kg / m^3
- Viscosity of water at 22 C° = 0.9579 Pa. s
- Test pipe section dimeter(d)= 10 mm

1. Cross section Area $= \frac{\pi}{4}d^2 = \frac{\pi}{4} * (10 * 10^{-3})^2 = 7.85 * 10^{-5} m^2.$

2. Volumetric flow rate $= \frac{184*10^{-3}}{74*1000} = 2.507 * 10^{-5} m^3 / s.$

3. Velocity $= \frac{\text{volumetric flow rate}}{\text{Area}} = \frac{2.506*10^{-.5}}{7.85*10^{-.5}} = 0.319$ m/s.

4. Re $= \frac{\rho dv}{\mu} = \frac{997{\cdot}8*10*10^{-3}*0{\cdot}314}{.9579*10^{-3}} = 3326.$



Reynolds Number Experiment Data Sheet

Raw data:

Trial	Observed flow regime	Volume (L)	Time (sec)	Temperature ° C
1	انسيابي	184mL	7.34S	22
2	[illegible]	96 mL	2.38 S	
3	[illegible]	148 mL	3.03 S	
4		160 mL	3.35	
5				
6				
7				

Instructor signature:
Date: