Exp1_Bernoulli_Preethika

October 18, 2021

###

Exp 1 Bernoulli's Theorem Apparatus

0.0.1 Objective:

- To verify Bernoulli's equation experimentally.

0.0.2 Aim:

- To calculate the total energy at different points and plot the graph between total energy at different points.
- Plot Graph between Total Energy (E) at the Different locations at Different Flow rates (Q).

0.0.3 Introduction :

Bernoulli's theorem states that when there is a continuous connection between particles of flowing mass of liquid, the total energy at any section of flow will remain the same provided there is no reduction or addition of energy at any point.

0.0.4 Theory :

Bernoulli's equation is an energy equation and is based on the law of conservation of energy. This equation states that at two sections of flow field the total energy remains the same, provided that there is no loss or gain of energy between the two sections. This equation is valid only for steady flow. This equation is expressed as:

$$\mathbf{E} = \frac{\mathbf{p}_1}{\rho g} + \frac{\mathbf{v}_1^2}{2g} + \mathbf{Z}_1 = \frac{\mathbf{p}_2}{\rho g} + \frac{\mathbf{v}_2^2}{2g} + \mathbf{Z}_2$$

Where:

E = Total Energy

p_1 = Pressure of fluid at point 1

p_2 = Pressure of fluid at point 2

V_1 = Velocity of fluid at point 1

V_2 = Velocity of fluid at point 2

$\frac{p_1}{\rho g}$ = Pressure energy per unit weight of fluid or pressure head at point.

$\frac{p_2}{\rho g}$ = Pressure energy per unit weight of fluid or pressure head at point.

$\frac{V_1^2}{\rho g}$ = Kinetic energy per unit weight or kinetic head at point 1

$\frac{V_2^2}{\rho g}$ = Kinetic energy per unit weight or kinetic head at point 2

Z1 = Potential energy per unit weight of potential head at point 1

Z2 = Potential energy per unit weight of potential head at point 2

ρ = Density of fluid.

g = Acceleration due to Gravity

Pressure head is measured by piezometer tube, so all the points are at same horizontal level, so potential head is constant for all points and can be taken as zero. So Bernoulli's Equation can be written as,

$$\mathbf{E} = \mathbf{h} + \frac{\mathbf{V}^2}{2\mathbf{g}}$$

where

$$\mathbf{h} = \frac{p}{\rho g}$$

0.0.5 Procedure:

Starting Procedure: 1. Clean the apparatus and make all the tanks free from dust. 2. Close the drain valves provided. 3. Fill sump tank ¾ with clean water and ensure that no foreign particles are there. 4. Close flow control valve given at the end of test section. 5. Ensure that all On/Off Switches given on the panel are at OFF position. 6. Now switch On the Main Power Supply (220 V AC, 50 Hz). 7. Switch on the pump. 8. Regulate flow of water through test section with the help of given gate valve at the end of test section. 9. Measure flow rate using measuring tank and stopwatch.

Closing Procedure: 1. When experiment is over, switch off pump. 2. Switch off power supply to panel.

0.0.6 Formulae:

1. Total energy

$$\mathbf{E} = \mathbf{h} + \frac{\mathbf{V}^2}{2\mathbf{g}}$$

2. Velocity of fluid

$$\mathbf{V} = \frac{\mathbf{Q}}{\mathbf{s}} m/s$$

0.0.7 Calculations:

[18]:
```
import numpy as np
from matplotlib import pyplot as plt
import pandas as pd
```

[182]:
```
Q = np.array([820,730,560,600,660,480])                      #lph
pz1 = np.array([26.4,20.4,35,31.8,26,35.6])
pz2 = np.array([26.2,20.2,34.8,31.6,26,35.4])
pz3 = np.array([24.2,18.4,34.2,30.2,24.4,34.8])
pz4 = np.array([20.8,15.6,32.2,28.2,21.8,32.8])
pz5 = np.array([13.4,9.4,28,23.8,16.6,29])
pz6 = np.array([18.2,13.2,30,25.8,19.8,30.6])
pz7 = np.array([21.4,16,32.2,28.4,22,32.8])
pz8 = np.array([22.8,17,33,29.4,23.2,33.6])
pz9 = np.array([23.2,17.4,33,29.2,23.4,33.8])
g = 9.81
ac = np.array([6.1575,4.7143,3.463,2.405,1.539,2.405,3.463,4.7143,6.1575])*1e-4
```

[186]:
```
obs = pd.DataFrame({'LPH':Q,'pz1':pz1,'pz2':pz2,'pz3':pz3,'pz4':pz4,'pz5':
 ↪pz5,'pz6':pz6,'pz7':pz7,'pz8':pz8,'pz8':pz8,
                   'pz9':pz9})
print(obs)
```

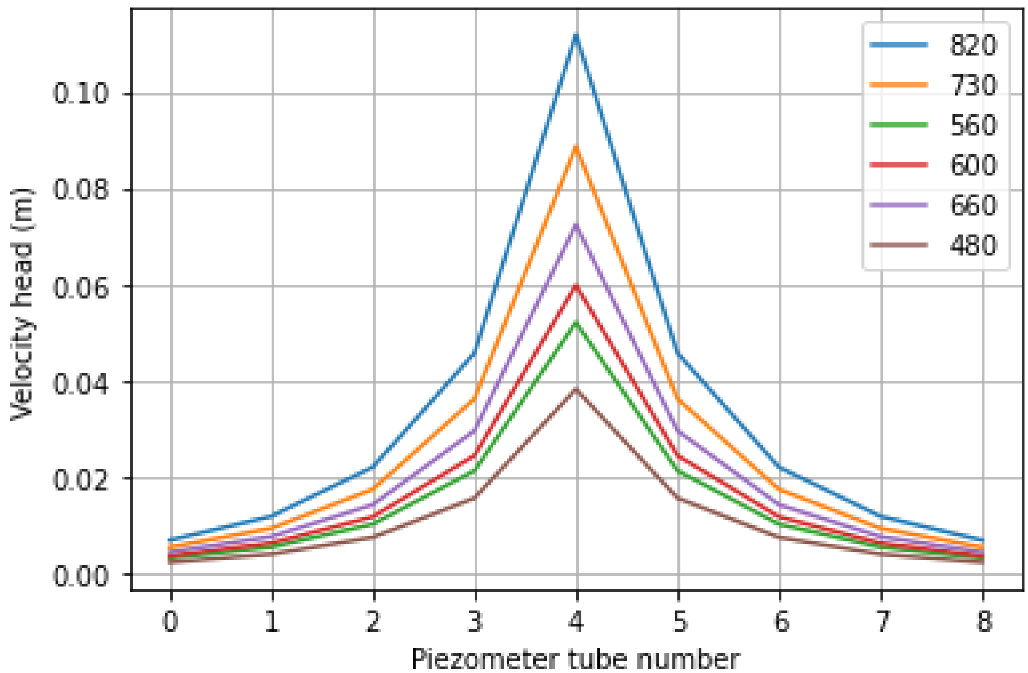
```
   LPH   pz1   pz2   pz3   pz4   pz5   pz6   pz7   pz8   pz9
0  820  26.4  26.2  24.2  20.8  13.4  18.2  21.4  22.8  23.2
1  730  20.4  20.2  18.4  15.6   9.4  13.2  16.0  17.0  17.4
2  560  35.0  34.8  34.2  32.2  28.0  30.0  32.2  33.0  33.0
3  600  31.8  31.6  30.2  28.2  23.8  25.8  28.4  29.4  29.2
4  660  26.0  26.0  24.4  21.8  16.6  19.8  22.0  23.2  23.4
5  480  35.6  35.4  34.8  32.8  29.0  30.6  32.8  33.6  33.8
```

[203]:
```
pzhead = obs.to_numpy().T[1:].T*1e-2                                     #Pressure␣
 ↪Head
vhead = np.array([(elem*1e-3/(ac*3600))**2/(2*9.8) for elem in Q])      #V
thead = vhead+pzhead                                                     #Total␣
 ↪energy
print("The total energy at different points is {} m".format(thead))
```

```
The total energy at different points is [[0.27098165 0.27391056 0.26407301
0.25376532 0.24576077 0.22776532
  0.23607301 0.23991056 0.23898165]
 [0.20953319 0.21143953 0.20149362 0.19227058 0.18257423 0.16827058
  0.17749362 0.17943953 0.17953319]
 [0.35325616 0.35355496 0.35229461 0.34334444 0.332124   0.32134444
  0.33229461 0.33555496 0.33325616]
 [0.32173794 0.32237686 0.31381779 0.30650255 0.29783623 0.28250255
  0.29581779 0.30037686 0.29573794]
 [0.26452291 0.267716   0.25829953 0.24764808 0.23840183 0.22764808
  0.23429953 0.239716   0.23852291]
 [0.35839228 0.35808119 0.35556339 0.34368163 0.32829518 0.32168163
  0.33556339 0.34008119 0.34039228]] m
```

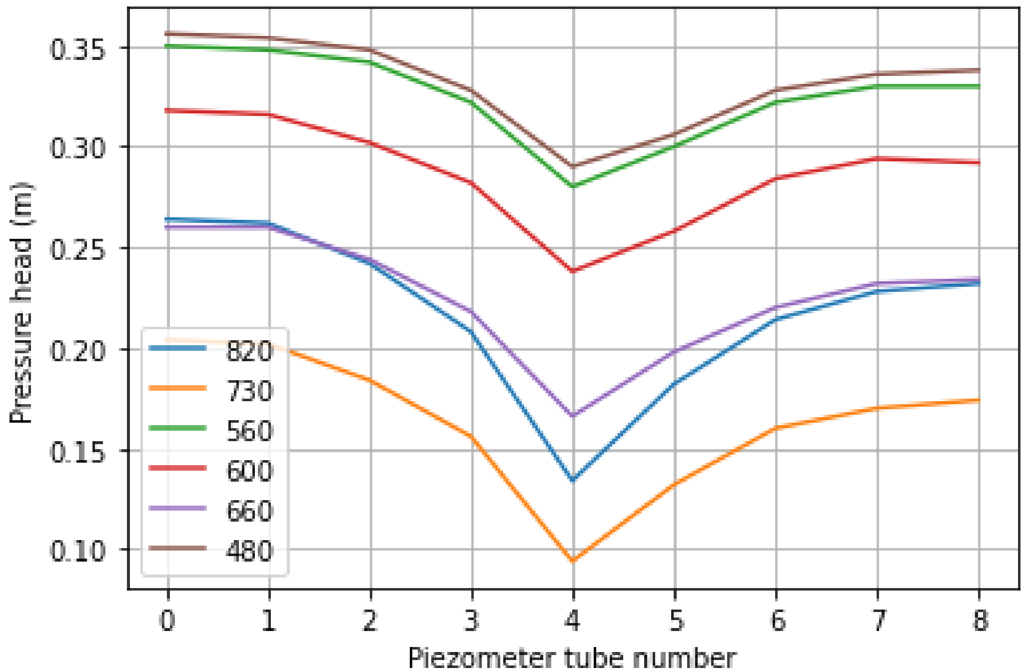
[204]:
```
plt.figure()
for elem,f in zip(vhead,Q):
    plt.plot(elem,label=f)
plt.grid()
plt.legend()
plt.xlabel('Piezometer tube number')
plt.ylabel('Velocity head (m)')
```

[204]: Text(0, 0.5, 'Velocity head (m)')



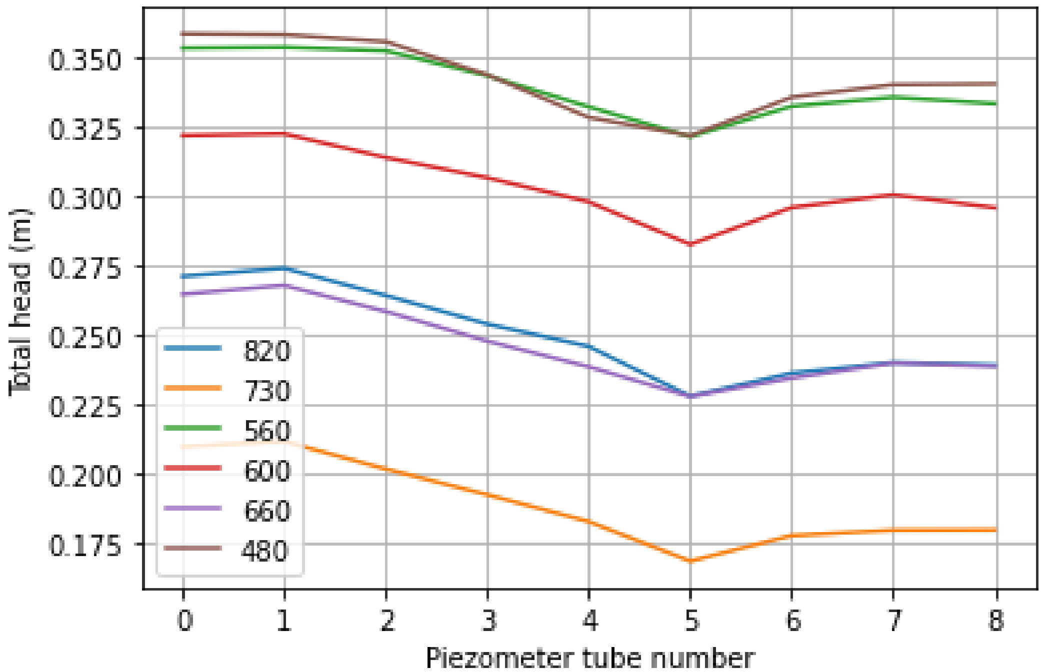
[205]:
```
plt.figure()
for elem,f in zip(pzhead,Q):
    plt.plot(elem,label=f)
plt.grid()
plt.legend()
plt.xlabel('Piezometer tube number')
plt.ylabel('Pressure head (m)')
```

[205]: Text(0, 0.5, 'Pressure head (m)')



[206]:
```
plt.figure()
for elem,f in zip(thead,Q):
    plt.plot(elem,label=f)
plt.grid()
plt.legend()
plt.xlabel('Piezometer tube number')
plt.ylabel('Total head (m)')
```

[206]: Text(0, 0.5, 'Total head (m)')



0.0.8 Inferences:

1. From the experiment it can be concluded that with decrease in area of flow there is an increase in velocity and decrease in the flow pressure of the fluid.
2. The velocity peaks at the converging part of the nozzle and then again decreases.
3. Therefore, it can be concluded that the Bernoulli's equation is valid when applied to steady flow of water in tapered duct and absolute velocity values increases along the same channel and then decreases.

0.0.9 Reccomendations:

1. Repeat the experiment several times to get an accurate result.
2. The eye of observers should be placed parallel to the scale of manometer to get an accurate reading.
3. Make sure the bubbles in the manometer are completely removed by adjusting the bleed screw.

0.0.10 Industrial Application:

This concept of increasing velocity by decreasing area and therby pressure is exploited in converging-diverging nozzle to create supersonic velocities. Which inturn is the underlying principle behind scramjets and steam turbines.