FM_exp6_Preethika

October 4, 2021

###

Exp 6 AIR FLOW STUDIES BY PITOT TUBE

0.0.1 Objective:

- To measure the flow velocity by use of a pitot static tube.

0.0.2 Aim:

- To measure velocity / flow using Pitot tube.

0.0.3 Introduction:

- Pitot tube is used for determining the local velocity at various points in a pipe. It consists of an impact tube, which is positioned perpendicular to the direction of flow and a static tube, which is positioned parallel to the direction of flow. One end of the manometer is connected to the impact tube and the other end to the static tube. The resultant difference in manometer level indicates the difference between the sum of kinetic and pressure heads registered by the impact tube and the pressure head as registered by the static tube.

0.0.4 Theory:

Pitot tubes were invented by Henri Pitot in 1732 to measure the flowing liquid or air velocity. Basically a differential pressure (d/p) flowmeter, a pitot tube measures two pressures: the static and the total impact pressure. The static pressure is the operating pressure in the pipe, duct, or the environment, upstream to the pitot tube. It is measured at right angles to the flow direction, preferably in a low turbulence location. The equipment comprises a long smooth walled Perspex pipe connected to the suction of an electrically driven centrifugal blower motor. Air enters the smooth walled pipe through one of the End of pipe. Boundary layer growth is determined by the measurement of the velocity profile at different stations along the pipe using a traversing Pitot tube. A Pitot tube is traversed vertically and horizontally at different distances from the discharge orifice to investigate the dispersion properties. Pressure measurements are made on an inclined cum vertical manometer mounted on the support frame. Pitot tube with static pressure tap and dynamic pressure tap is placed in the pipe with a flexibility to travel across the cross section of the tube. The impact and static end of the tube are connected to a manometer. Provision is made to vary the distance of the impact tube and to measure its distance from the center of the tube through which the fluid flows. The equipment is mounted on a floor standing steel frame with an adjustable support for the extended suction pipe.

0.0.5 Procedure:

1. Make 3 ϕ electric connections to the blower.
2. Select suitable position for measuring the air velocity profile and place the pitot tube in position.
3. Measure the distance from the suction end of the pipe.
4. Adjust the position of the impact tube at the center of the pipe.
5. Connect the manometer tapping to the static pressure end only.
6. Switch ON the motor of the blower using the starter.
7. Adjust the position of the impact tube at a definite position in pipe.
8. Connect the respective tapping's to the Pitot tube and Manometer.
9. Initially keep the manometer in vertical position & then adjust its inclination to obtain better accuracy of the measurement.
10. Take readings for at least 10 different positions of the Pitot tube, five on either side of the central axis of the pipe.
11. Repeat the above for different locations in the pipe.

0.0.6 Formulae:

$$
\begin{aligned}
&\text{Actual Manometer Reading } (\mathrm{h_k}) && = \mathrm{h_{m1}} * \text{ Min. Div. } * \left(\rho_{\text{water}} - \rho_{\text{air}}/\rho_{\text{air}}\right) * 10^{-3} \text{ m} \\
&\text{Air Velocity (V)} && = 0.98 * \sqrt{2gh_v}(\text{ m/s}) \\
&\text{Air Volumetric Flow rate (Q)} && = \mathrm{V} * \text{ A m}^3/\text{s} \\
&\text{Air Mass Flow rate} && = \mathrm{Q} * \rho_{air} \text{ kg/s}
\end{aligned}
$$

[15]:
```python
import numpy as np
from matplotlib import pyplot as plt
```

[30]:
```python
d = 0.094
g = 9.81
area = np.pi*(d**2)/4
rho_w = 1000
rho_a = 1.205
min_div = np.sin(np.deg2rad(30))
hm1 = np.array([169, 200, 217, 226, 228, 225, 224, 204, 183])
d_cen = np.array([-43, -33, -23, -13,0,13, 23, 33, 43])
hv = hm1* min_div * (rho_w - rho_a / rho_a)*1e-3
air_v = 0.98*np.sqrt(2*g*hv)
Q = air_v*area
mfr = Q*rho_a
print("hv values are : {} mm".format(hv))
print("Air velocities are : {} m/s".format(air_v))
print("Air Volumetric Flow rates  : {} m3/s".format(Q))
print("Air Mass Flow rates : {} kg/s".format(mfr))
```

```
hv values are : [ 84.4155  99.9    108.3915 112.887  113.886  112.3875 111.888
101.898
  91.4085] mm
Air velocities are : [39.88289506 43.38687008 45.19321008 46.12087553
```

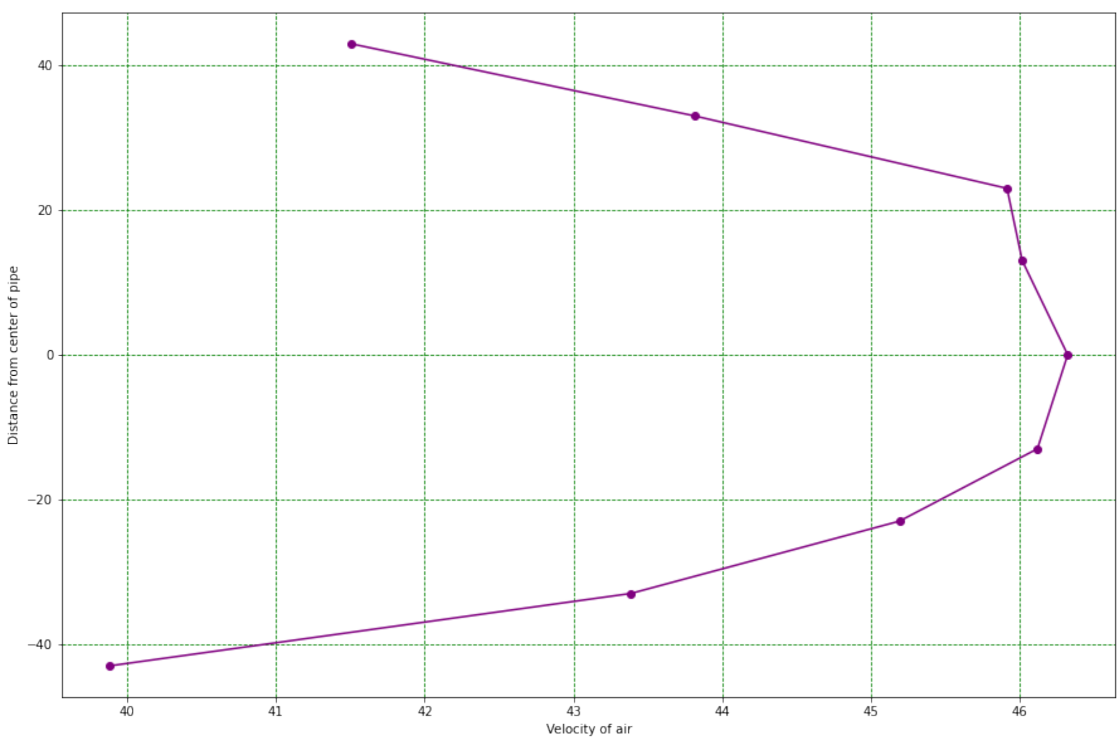
```
46.32450069 46.01872507
 45.91634736 43.81859086 41.50198493] m/s
Air Volumetric Flow rates  : [0.27677844 0.30109525 0.31363085 0.32006865
0.32148176 0.31935974
 0.31864927 0.3040913  0.28801457] m3/s
Air Mass Flow rates : [0.33351803 0.36281978 0.37792518 0.38568272 0.38738552
0.38482849
 0.38397236 0.36643002 0.34705756] kg/s
```

0.0.7 Observations and Calculations:

0.0.8 Graph:

[47]:
```
plt.ylabel('Distance from center of pipe')
plt.xlabel('Velocity of air')
plt.grid(True,linestyle = '--',color="g")
plt.rcParams["figure.figsize"] = (15,10)
plt.plot(air_v,d_cen,"purple",marker = 'o')
```

[47]:
```
[<matplotlib.lines.Line2D at 0x7fd5e6625310>]
```



0.0.9 Conclusions/Inferences:

1. The air velocity at various instants of the tube is determined using a pitot tube.

2. The plot obtained by plotting velocity of air against distance form the centre of pipe is parabolic in nature therby it's a fully developed flow.
3. The velocity of air is maximum in the centre of the pipe and least at the ends of the pipe.
4. This can be explained by the shear stresses being maximum in the walls of the pipe and it progressively decreases towards the centre.

0.0.10 Industrial Applications:

Pitot tubes are used for a wide range of applications across several industries. Most common applications are seen in aircrafts and racing cars. These tubes are fitted on the wing of an aircraft in order to measure the aircraft's speed. Some major industrial applications of these tubes include measuring liquid flow and/or air flow in pipes and channels, ducts, and stacks during construction.