مختبر الموائع

للفصل الدراسي الأول

المرحلة الثانية

قسم هندسة الطرق والنقل

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Experiment 2

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Experiment No.2

Calibration of a Bourdon Pressure Gauge

1- The purpose of experiment:

   a- To calibrate a Bourdon type pressure gauge and to establish the calibration curve of Bourdon Gauge.

   b- Also determine the gauge errors.

2- Equipment and apparatus:

   - Dead Weight Calibrator.
   - Set of Test weights.
   - Weight balance.
   - Bourdon pressure gauge.

2-1 introduction:

Instrument calibration is one of the primary processes used to maintain instrument accuracy. It is the process of configuring an instrument to provide results within an acceptable range. Known weights have been applied on a Dead Weight Calibrator to apply pressure to a fluid for checking the accuracy of readings from a pressure gauge.

Various types of pressure measuring instrument have been used to measure the pressure intensity at any point in static or moving fluid. One of these devices is the Bourdon tube pressure gauge. Bourdon-tube pressure gauges are most widely used now-a-days because of their reliability, compactness, low cost and ease of use. It consists of a curved tube (Figure 1) of elliptical cross-section bent into a circular arc.

When pressure is applied to the tube, it tends to straighten out, and the deflection of the end of the tube is communicated through a system of levers to a recording pointer. This gauge is widely used for steam and compressed gases. The pressure indicated is the difference between the system pressure and to the external (ambient) pressure, and is usually referred to as the gauge pressure.
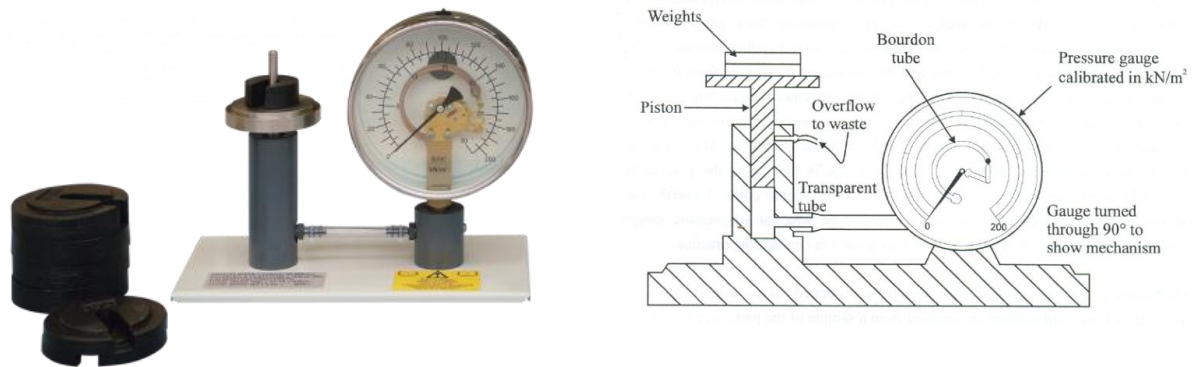
Figure 1

2-2 Related Theory:

The bourdon gauge is the most popular pressure measuring device for both liquids and gasses. It can be connected to any source of pressure such as a pipe or vessel containing a pressurized fluid.

I. Bourdon Gauge: The Bourdon Gauge (Figure 2) is fitted with a transparent dial, which lets you see the internal workings of the gauge. The gauge consists of a thin walled closed ended tube which is oval in cross section. This tube is bent through an angle of about 270o along its long axis. The open end of the tube is welded to a hollow mounting block which allows the pressurized fluid to reach the tube. This causes the pressure from the source to be transmitted directly to the inside of the bourdon tube. The applied pressure causes the oval tube to become rounder (since a round cross section has the maximum area for a given circumference). As it becomes rounder, the bourdon tube tends to uncurl which causes its free end to move. A system of linkages and levers transmits this motion to the gauge needle which moves over the scale.
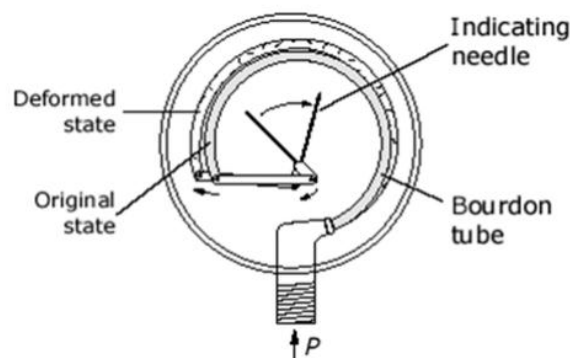

Figure 2

II. **Dead Weight Calibrator:** In order to obtain very accurate pressure measurements, it is essential to regularly re-calibrate the gauge. This is because the tube tends to become weaker with extended use. The usual procedure is to apply a known pressure to the gauge using a device called a Dead Weight Calibrator. The normal calibration procedure is to load the gauge for known pressures, using a dead weight calibrator including a liquid of known specific gravity (use water as the liquid).

This dead weight tester uses a simple piston and cylinder arrangement to provide a source of pressurized liquid (in the experiment water will produced a better result than oil) which is transmitted to the gauge. Since the true pressure of the liquid can be easily calculated, the value can be compared directly to the reading on the gauge over the complete scale range. (The scale range is the range of pressures from zero to the full-scale deflection value).

The dead weight tester consists of a cylindrical piston which is free to move vertically in a close fitting cylinder.

A Platen is attached to the piston which can be loaded with a series of accurate weights. The pressure developed in the cylinder is transmitted via a transparent tube to the gauge under test. The cylinder is mounted on a base board which is supported on leveling screws and fitted with a spirit level.

3- Equations:

The use of the piston and weights with the cylinder generates a measurable reference pressure:

$$P=F/A \qquad F=M*g$$

Where:

F = Force applied to the liquid in the calibrator cylinder in Newton (N).
M = Total mass including the mass of the piston in kilogram (kg).
A = Cross-sectional area of the piston in square meter (m^2).
g = Acceleration due to gravity in meter per square second (m/s^2).
M_p = Mass of the piston (kg).
d = Diameter of the piston (m).

4- <u>Set Up of Equipment:</u>

- Position the calibrator without the piston on the hydraulic bench top and ensure that the base is horizontal by adjusting the feet and using the spirit level. This is necessary to ensure vertical transfer of the applied load and free rotation of the piston.
- Open all cocks on the pressure gauge base.
- Connect the inflow cock to the bench flow connector and the outflow cock to the lower tube from the calibrator cylinder.
- Open slowly the bench valve to produce a flow, tilt the pressure gauge to ensure that air is driven out from the manifold and then close the middle cock on the manifold.
- When there is no further air emerging and the calibrator cylinder is full, close the bench valve and the inflow cock on the manifold.

5- <u>Procedure:</u>

1- Measure the weight of the calibration masses.
2- Note down the weight of the piston and it's cross sectional area.
3- Remove the piston and pour the water into the cylinder until it is full to overflow level. Any air trapped in the tube may be cleared by tilting and gently tapping the apparatus.
4- Insert the piston carefully and spin it to minimize any friction effects.
5- Note the pressure reading from the gauge.
6- Add the weights in convenient increments, and at each increment, observe the pressure gauge reading.
7- Take the similar sets of readings with decreasing weights.

Note: If due to the slight leakage, piston reaches the cylinder bottom, more water must be added to the cylinder.

6- <u>Theoretical background and calculate:</u>

All readings and calculations are to be tabulated as follows:

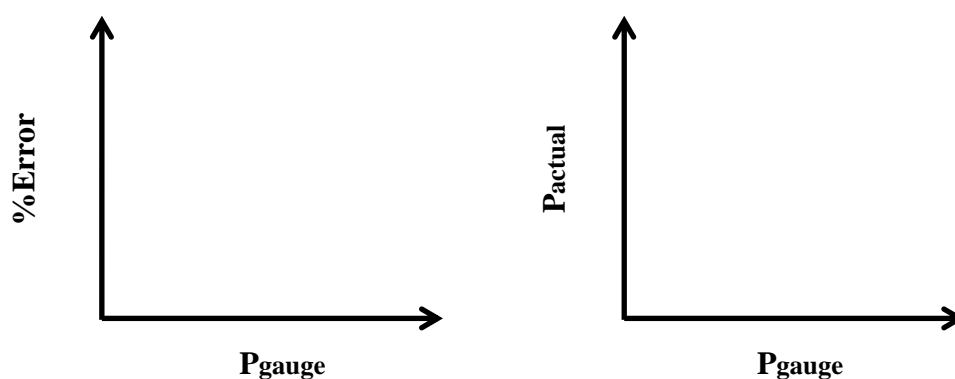| Mass (kg)	Actual Pressure (KPa)	Gauge Reading (kPa)		Percent Error (%)	
		Loading	uploading	Loading	uploading

Relative Error = (Measured Value – Actual Value) /Actual Value

Percent Error = │Relative Error│ × 100

Note: Also, show the sample calculation to calculate the Relative Error and Percent Error.

7- <u>Graphical Relationship:</u> **Plot the following graphs:**

1) Actual Pressure (**P**actual) against Measured Pressure (**P**guage) (Gauge Reading).

2) Percent Error (**%Error**) against Measured Pressure (**P**guage) (Gauge Reading).

8- <u>Discussion:</u>
❖ Is the relative height between the calibrator and the gauge important in calibration?
❖ Is there a difference between actual pressure and gauge pressure?
❖ General comments about the experiment.

تجربة رقم (   )

- <u>اسم المجموعة:</u>

- <u>اسم التجربة:</u>

- <u>الغرض من التجربة:</u>

- <u>وصف الجهاز:</u>
  - ١.
  - ٢.
  - ٣.
  - ٤.
- <u>نموذج البيانات:</u>

اسم وتوقيع مدرس المادة