MET 335W

Pressure Gauge Calibration

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Experiment Title: Pressure Gauge Calibration

Purpose:

1. Learn the correct operation of a Bourdon pressure gauge.
2. Understand and perform the proper procedure to calibrate a Bourdon pressure gauge utilizing dead weights.
3. Create a graph indicating the results of the calibration curve of a Bourdon pressure gauge.
4. Determine and discuss gauge errors.
5. Summarize the graph and results from the experiment.

Theoretical Considerations:

The primary objective of this lab was to calibrate a Bourdon Gauge by using a deadweight testing method. The results were uniform between the two trials conducted. Linear relationships were obtained between gauge pressure and the pressure exerted by the piston and weights on the system. By looking at the relationship between the trials conducted in the experiment and the relationship between the experimental results and the actual results being measured by adding weight to the cylinder, a calibration of the system can be conducted.

Description of Apparatus:

1. Bourdon tube pressure gauge
2. Cylinder (filled with fluid)
3. Connecting hose
4. Piston/plunger platform assembly
5. Deadweights (0.5 kg, 1.0 kg (2), and 2.0 kg)

Step-by-Step Procedure:

1. The mass and cross-sectional area of the piston/plunger platform assembly was recorded on the data sheet.
2. The piston/plunger platform assembly was inserted into the opening on top of the vertical cylinder.
3. Once the assembly settled into the vertical cylinder, the value (mass added) was recorded on the data sheet, as indicated on the Bourdon pressure gauge.
4. A single 0.5 kg deadweight was added onto the platform of the piston/plunger assembly.
5. The mass added was recorded on the data sheet, as indicated on the Bourdon pressure gauge.
6. The 0.5 kg deadweight was removed and a 1.0 kg deadweight was added onto the platform of the piston/plunger assembly.
7. The mass added was recorded on the data sheet, as indicated on the Bourdon pressure gauge.
8. The 0.5 kg deadweight was added *in addition* to the 1.0 kg deadweight onto the platform of the piston/plunger assembly.
9. The mass added was recorded on the data sheet, as indicated on the Bourdon pressure gauge.
10. Both of the deadweights were removed and a 2.0 kg deadweight was added to the platform.

11. The mass added was recorded on the data sheet, as indicated on the Bourdon pressure gauge.
12. The 0.5 kg deadweight was added *in addition* to the 2.0 kg deadweight onto the platform of the piston/plunger assembly.
13. The mass added was recorded on the data sheet, as indicated on the Bourdon pressure gauge.
14. The entire process was continued with incremental increases of 0.5 kg of deadweights until fully loaded with 5.0 kg of additional deadweight added to the piston/plunger assembly.
15. With 5.0 kg of deadweights still stacked on the piston/plunger assembly, the pressure reading indicated by the Bourdon pressure gauge was recorded on the data sheet.
16. One 0.5 kg deadweight was removed and the pressure reading was recorded onto the data sheet as indicated by the Bourdon pressure gauge.
17. Another 0.5 kg deadweight was removed and the indicated pressure from the gauge was recorded onto the data sheet.
18. The remaining deadweights were removed in increments of 0.5 kg and the indicated reading of each individual weight change was recorded onto the data sheet.
19. The entire procedure was repeated until all of the deadweights had been removed from the piston/plunger platform assembly.

Recorded Data Table (Increasing Pressure):

Piston cross-sectional area (mm^2): 315 mm^2

Piston (plunger) and platform mass (*kg*): 1 *kg*

Increasing Pressure	
Mass added to piston (*kg*)	Gauge reading $\left(\frac{kN}{m^2}\right)$
0.0	32.0
0.5	49.0
1.0	66.0
1.5	78.0
2.0	94.0
2.5	109.0
3.0	122.5
3.5	139.0
4.0	152.5
4.5	167.0
5.0	182.0

Recorded Data Table (Decreasing Pressure):

Piston cross-sectional area (mm^2): 315 mm^2

Piston (plunger) and platform mass (*kg*): 1 *kg*

Decreasing Pressure	
Mass added to piston (*kg*)	Gauge reading $\left(\frac{kN}{m^2}\right)$
5.0	182.0
4.5	167.0
4.0	152.5
3.5	139.0
3.0	122.5
2.5	109.0
2.0	94.0
1.5	78.0
1.0	66.0
0.5	49.0
0.0	32.0

Sample Calculations:

•Piston Area = 315 mm^2 x $\frac{1\ meter^2}{10^6\ mm^2}$ = 0.000315 m^2

•Plunger & Platform Mass = 1 kg

Calculated Pressure = *Total Mass(kg) x $\frac{\textbf{Gravity}}{\textbf{Piston Area}}$ = Total Mass (kg) x $\frac{\mathbf{9.81\ m/s^2}}{\mathbf{0.000315\ m^2}}$

= Total Mass (kg) x 31.14= result in kN/m^2 (metric unit of pressure)

*Total Mass = mass added to piston plus (Plunger and Platform) Mass

Example: For zero mass added,

0 + 1 kg = 1 kg for Total Mass

Then Calculated Pressure = (1kg) (31.14) = 31.14 kN/m^2

<u>Calculated Data Table:</u>

Table 1. Increasing Pressure Data

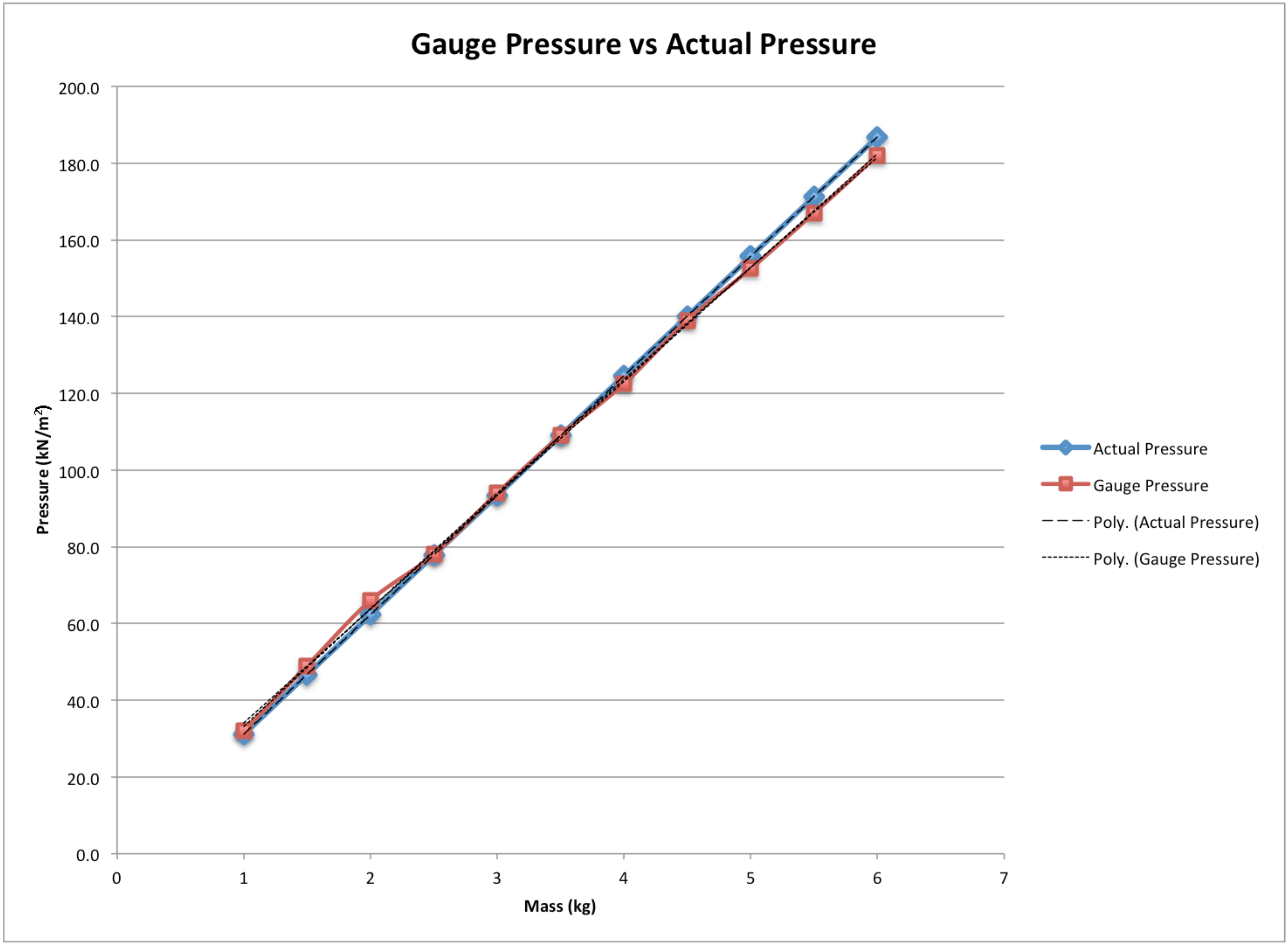
Mass added to piston (***kg***)	**Total mass** = mass added to the piston + piston mass + platform mass (***kg***) Note: piston mass and platform mass = 1 *kg*	**Actual pressure** calculated pressure = total mass x gravity/area (***kN/m²***) Note: gravity = 9.81 m/s^2 area = 0.315 m^2	**Gauge reading** pressure (***kN/m²***)	**Difference** Gauge error = gauge pressure – actual pressure (***kN/m²***)	**% Error** (gauge error/actual pressure)
0.0	1.0	31.14	32.0	0.86	2.76
0.5	1.5	46.71	49.0	2.29	4.90
1.0	2.0	62.29	66.0	3.71	5.96
1.5	2.5	77.86	78.0	0.14	0.18
2.0	3.0	93.43	94.0	0.57	0.61
2.5	3.5	109.00	109.0	0.00	0.00
3.0	4.0	124.57	122.5	2.07	1.66
3.5	4.5	140.14	139.0	1.14	0.81
4.0	5.0	155.71	152.5	3.21	2.06
4.5	5.5	171.29	167.0	4.29	2.50
5.0	6.0	186.86	182.0	4.86	2.60

Calculated Data Table:

Table 2. Decreasing Pressure Data

Mass added to piston (***kg***)	**Total mass** = mass added to the piston + piston mass + platform mass (***kg***) Note: piston mass and platform mass = 1 *kg*	**Actual pressure** calculated pressure = total mass x gravity/area (***kN/m²***) Note: gravity = 9.81 m/s^2 area = 0.315 m^2	**Gauge reading** pressure (***kN/m²***)	**Difference** Gauge error = gauge pressure – actual pressure (***kN/m²***)	**% Error** (gauge error/actual pressure)
5.0	6.0	186.86	182.0	4.86	2.60
4.5	5.5	171.29	167.0	4.29	2.50
4.0	5.0	155.71	152.5	3.21	2.06
3.5	4.5	140.14	139.0	1.14	0.81
3.0	4.0	124.57	122.5	2.07	1.66
2.5	3.5	109.00	109.0	0.00	0.00
2.0	3.0	93.43	94.0	0.57	0.61
1.5	2.5	77.86	78.0	0.14	0.18
1.0	2.0	62.29	66.0	3.71	5.96
0.5	1.5	46.71	49.0	2.29	4.90
0.0	1.0	31.14	32.0	0.86	2.76

Graph:


Gauge Pressure vs Actual Pressure
Pressure (kN/m²)
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
1
2
3
4
5
6
7
Mass (kg)
Actual Pressure
Gauge Pressure
Poly. (Actual Pressure)
Poly. (Gauge Pressure)

Discussion of Results and Conclusions:

In the graph demonstrating gauge pressure versus actual pressure, many of the values were similar in numbers. Therefore, many of the data points overlap and it is difficult to see the increasing pressure in the cylinder plotted due to the decreasing data points covering them. Overall, the data gathered in this lab demonstrates mostly linear relationships between cylinder pressure and different variables of measuring the data within the lab. As the cylinder pressure increased in all of the trial types run, the gauge reading linearly increased. The percent of error for this experiment was highest when only a few weights were added, and when nearly all of the weights were added. At the 2.5 kg mark of added weight, the percent of error was at 0%. This may be an indication of problems with the piston inlet such as restricted motion or poor lubrication. This could also be a symptom of mechanical fatigue in the Bourdon tube itself. One solution that may help in this instance would be to use a high lubricant fluid in the cylinder instead of water in order to prevent any restricted motion.