Estimation of Error in Bourdon type pressure Gauge using Dead Weight Tester

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Abstract— **Stability of the pressure measuring instruments over the years is one of the important parameters in defining the quality of results quantitatively. Indeed, several commercial instruments are available for pressure measurements, whenever such instruments are used for precise and accurate pressure measurements, it is obligatory on the part of measurement authority to indicate the accuracy of results. In the present investigation, we have studied dead weight tester to calibrate Bourdan type pressure gauge, After Experimental work it is found that the gauge is giving better result at lower reading and as we increase weight the gauge reading seems to give significant changes in the result with respect to actual pressure.**

Keywords— **Boardan type pressure gauge, Dead Weight tester, Absolute Error**

I. INTRODUCTION

Calibration is a method mostly used by research laboratories and companies looking for quality and reliability. It means to compare the instrument under analysis to a higher standard. These labs develop their procedures to standardize and control the calibration. The numerous works performed related to calibration by certified laboratories are the calibration guides developed by INMETRO - National Institute of Metrology, Standardization and Industrial Quality (INMETRO, 2010), and the one developed by EURAMET - European Association of National Metrology Institutes (EURAMET, 2007). Among the works carried out by researchers investigating this issue are those of Bao et al. (2003), Wuest et al. (2007), Kojima, Saitou and Kobata (2007) and Ripper et al. (2009), each one with innovative approaches, demonstrating the feasibility of the employment of new methods for calibration. In order to achieve the objective proposed in this paper, a previous study of different forms of calibration of pressure gauges was developed to define the optimal method for pressure calibration.

II. EXPERIMENTAL SETUP AND PROCEDURE

Figure 1 shows the sample schematic diagram of experimental set-up used in this investigation

Before setting up the equipment, determine the weight of the individual calibration masses and the weight of the piston too, using a balance and note the measurement errors associated with this balance. If a balance is not available to check the accuracy then the nominal values may be assumed (the piston has a nominal weight of 0.5 kg). Note that the piston is a high precision component and must be treated with care. Correct pairing can be ensured by checking that the mark on the end of the piston matches the mark on the flange of the cylinder. Position the dead-weight 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. Using the spirit level attached to the base, level the cylinder by adjusting the feet. Attach the flexible tube from the base of the cylinder to one of the tapings at the base of the Bourdon gauge. Before operating the calibrator it will be necessary to prime the cylinder, the Bourdon gauge and the interconnecting tubing to eliminate all air bubbles. This can be achieved by pouring water into the cylinder using the measuring cylinder or the filling tube. Alternatively water can be drawn into the system by raising the piston while one of the open tapping's is connected to a source of water using flexible tubing. Whichever technique is used to fill the system, it will be necessary to open and close the cocks at the base of the Bourdon gauge and raise and lower the piston several times until the flexible tubing is full of water with no air bubbles and the cylinder remains full of water with the piston at the top of its travel.

The procedure to perform the experimental work is as follows, With the piston at the top of its travel inside the cylinder, spin the piston to reduce the striction. The pressure exerted by the piston will be indicated on the Bourdon gauge. Note the reading on the gauge and the weight applied. Place a 0.5 kg weight on the piston then spin the piston and weight. Ensure that the piston rotates freely. The increased pressure due to the weight will be indicated on the Bourdon gauge. Note the reading on the gauge and total weight applied. Add calibration weights in steps of 0.5 kg, spinning the piston and noting the gauge reading and total weight applied after each increase in load. If, due to the slight, but necessary, leakage (the piston must fit closely, but freely in the cylinder), the piston reaches the cylinder bottom, more water must be admitted to the cylinder as described in the equipment set up procedure. Repeat the above process removing the weights progressively.

It should be noted that a dead weight tester apparatus uses known traceable weights to apply pressure to a fluid for checking the accuracy of readings from a pressure gauge. A dead weight tester (DWT) is a calibration standard method that uses a piston cylinder on which a load is placed to make an equilibrium with an applied pressure underneath the piston. Deadweight testers are so called primary standards which means that the pressure measured by a deadweight tester is defined through other quantities: length, mass and time. Typically deadweight testers are used in calibration laboratories to calibrate pressure transfer standards like electronic pressure measuring devices.

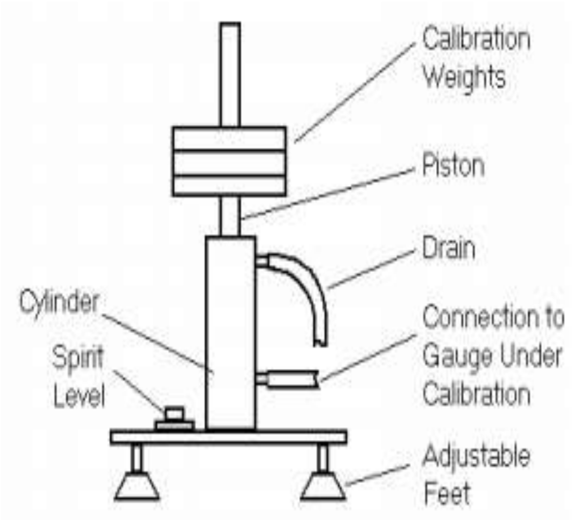

Fig. 1 Dead weight Tester

III. THEORY

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

P= F/A (Pascal)

Where, F = mg

F is the force applied to the liquid in the calibrator cylinder

M is the total mass (including that of the piston = 0.498 kg)

A is the area of piston

The area of the piston can be expressed in terms of its diameter (0.01767 m), d as:

$A = (\pi d^2)/4$

Also the pressure generated on Bourdon type pressure Gauge due to weight apply on piston is recorded corresponding to every incremental weight on piston. After completing the experimental work, the pressure recorded at Bourdon type pressure Gauge is compared with actual pressure generated at cylinder due to incremental weight.

IV. INPUT DATA

The input data required for computation of cylinder reading and gauge reading and finally computing error in pressure Gauge are diameter of Piston to get the area on which weight is applied. Secondly to get variation in pressure reading, various set of weight are required. For this experiment weight in 0.5kg multiple are applied on weight tester. The input showing diameter of piston, Area of piston, Total mass is shown in table I.

TABLE I
INPUT DATA

Sno	Piston Dia,m	Area A,m^2	Total Mass-kg
1	0.01767	0.0002451	0.498
2	0.01767	0.0002451	0.998
3	0.01767	0.0002451	1.498
4	0.01767	0.0002451	1.998
5	0.01767	0.0002451	2.498
6	0.01767	0.0002451	2.998
7	0.01767	0.0002451	3.498
8	0.01767	0.0002451	3.998
9	0.01767	0.0002451	4.498
10	0.01767	0.0002451	4.998

V. COMPUTATION AND RESULT

The calibration of the pressure gauge using a dead weight tester was carried out; Based on the experimental results obtained a deviation in the calibrated reading was compared to the theoretical values. Therefore applied load/weight is directly proportional to the obtainable pressure gauge calibration meter readings

Table II shows actual reading,Gauge reading,Absolute Gauge error, and % Gauge error. The slope between actual reading and gauge reading is found to be 43.17 degree . Moreover, the correlation coefficient between two is found to be 0.99.

The figure,2 show relation between actual reading and recorded gauge reading, while figure 3-4 shows relation between Gauge Error and Gauge pressure.

TABLE III
RESULT

Sno	Cylinder Reading, kN/m^2	Gauge Reading Kn/m^2	Absolute Gauge Error	% Gauge Error
1	19.91	19.5	0.41	2.07
2	39.90	39	0.91	2.26
3	59.89	59	0.89	1.49
4	79.88	78	1.88	2.36
5	99.87	97	2.88	2.88
6	119.87	117	2.88	2.39
7	139.86	136	3.86	2.76
8	159.85	152	7.85	4.91
9	179.84	171	8.85	4.92
10	199.84	189	10.84	5.42
Slope	43.17 Degree			
Correlation	0.99			
Equation	G=0.94P+2.2			

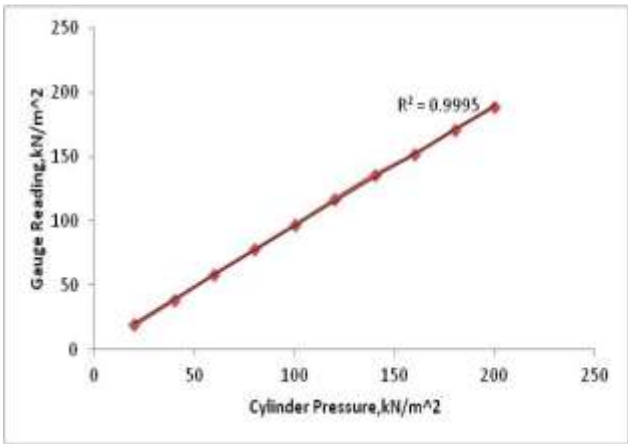

Fig. 2 Gauge pressure verses Actual pressure curve

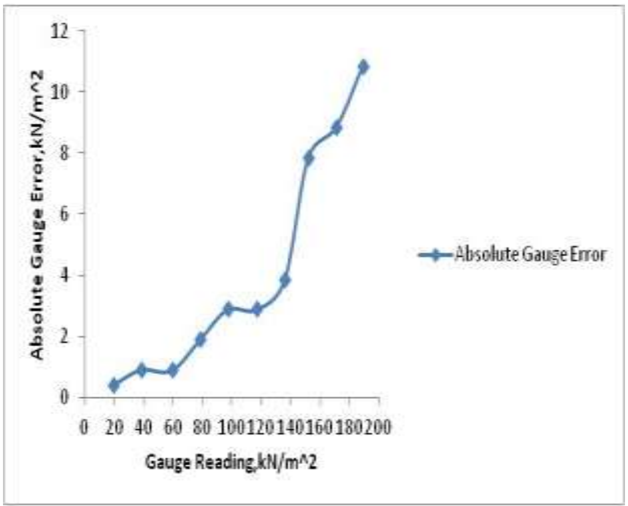

Fig. 3 Absolute Gauge Error verses Gauge pressure Curve

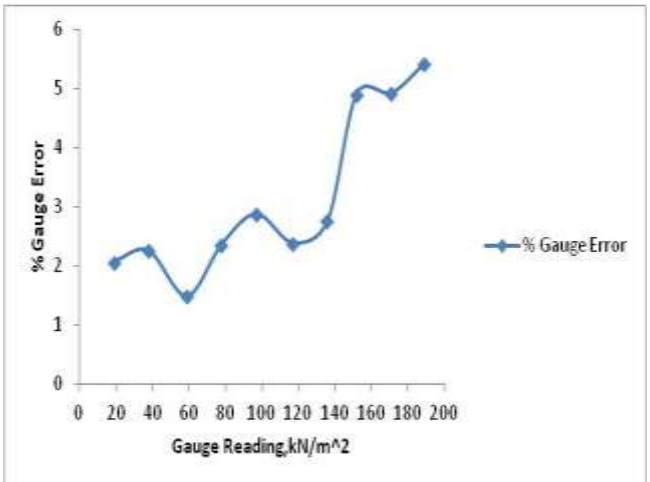

Fig. 4 Gauge Error verses Gauge pressure Curve

VI. CONCLUSION

After doing Experimental work and computation, it is found that the relationship between actual pressure and Gauge pressure shows linear variation with small deviation for gauge pressure reading upto 140 kN/m^2 and above this it gives significant deviation. Moreover the slope between actual pressure reading and Gauge pressure is very near to 45 degree. which indicate the reliability of Bourdan type pressure gauge. While comparing the actual pressure and gauge pressure, we obtained a good fit straight line. The coefficients R^2 calculated equal to 99.99% shows that there is high correlation between actual pressure and gauge pressure which further indicates the reliability of pressure gauge. Moreover, for further study we should take gravity effect and temperature effect into consideration as some of the error can be caused by these parameter, which is not taken into account in this experimental work.

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