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EFFECT OF FLUID TYPE ON THE ACCURACY OF A BOURDON GAUGE SYSTEM

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ABSTRACT

The bourdon Gauge is an instrument for indicating or testing that incorporates both primary elements and indicating devices. The accuracy of a bourdon gauge system is determined by the gauge span conformity to an accepted standard. The system is normally filled with fluid to cushion damping effects when subjected to high alternating dynamic loads, strong vibrations and pulses. The effect of the type of fluid on the accuracy of the measurement is a matter of conjecture. In this paper the authors have used different fluids for gauge calibration to determine their effect on the accuracy of the system measurement. Laboratory conditions were observed and inferences made using the result obtained.

INTRODUCTION

Pressure is defined as the force exerted by solid, gases and liquids due to their weights, such as the pressure of the atmosphere on the surface of the earth and the pressure containerized liquids exert on the bottom and walls of a container [1].

Gauge pressure is the amount by which total absolute pressure exceeds the atmospheric pressure. The bourdon Gauge is an instrument for indicating or testing that incorporates both primary elements and indicating devices.

Mechanical pressure measurement uses the principle of an elastic measuring element, which generates a precisely defined reproducible deflection when subjected to pressure. In bourdon tube system, pressure differences between high pressure side and low pressure side are read off directly in form of a dial [2][3]. The accuracy of this system is determined by the gauge span conformity to an accepted standard (e.g. deadweight tester). Inaccuracy is the difference (error) between the true value and the dial indication, expressed as a percent of the span. It includes the combined errors of method, observer, apparatus and environment [4]. Bourdon tubes are normally filled with fluids to cushion damping effects when subjected to high alternating dynamic loads, strong vibrations and pulses. The fluid also ensures easy readability through steady pointer movement. This paper examines error deviation of different fluids to determine if fluid type affects the accuracy of a bourdon tube system and also to recommend, using the result obtained, a better fluid selection guide when using the bourdon tube system for pressure gauges. In this calibration experiment, the authors have used a bourdon tube system pressure gauge (Tecquipment,H3A serial nos A7514/2) to determine fluid-the relationship of fluid type to the accuracy of a bourdon system.

MATERIALS AND METHOD

For more accuracy, the following factors were considered in the calibration of a pressure gauge.

- Operating environment: Laboratory environment
- Storage temperature range: –25°C to +55°C
- Operating temperature range: +5°C to +40°C. The performance is independent of temperature [8].
- Operating relative humidity range: 80% at temperatures < 31°C decreasing linearly to 50% at 40°C

Equipment Specification.

- Nett Dimensions: 470 mm x 420 mm x 270 mm
- Packed Dimensions: 0.11 m^3 and 10 kg
- Weights: Four 1 kg weights, two 0.5 kg weights, one 0.2 kg weight
- Bourdon gauge scale: graduated in 0 to 200 kN/m^{-2} in 10 kN/m^{-2} intervals [5].
- Bourdon tube arc: approximately 270°
- Maximum dead weight tester load: 5.2 kg
- Typical gauge error: 1 $kN.m^{-2}$ over the entire range
- Cross sectional area of piston = 315mm^2

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Materials Used

- Tecquipment pressure gauge (H3A serial nos A7514/2)
- Weights: 1kg x 5
- Fluids: Water, Brake fluid DOT3 (E5 SAE 1703)

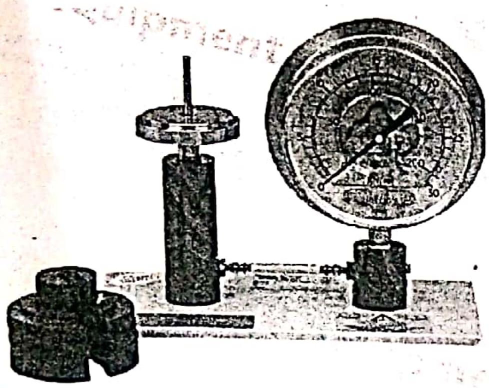

Figure 1: Tecquipment pressure gauge (tecequipment Ltd.)

EXPERIMENT

STEP ONE: The piston was removed from the apparatus and the cylinder was filled with water above the over flow hole. See figure 1

STEP TWO: The apparatus was positioned on a bench and the piston was replaced ensuring that the apparatus was absolutely level.

STEP THREE: Air bubbles were removed from the transparent tube by tilting and tapping the apparatus.

STEP FOUR: The piston was gently rotated to prevent it sticking in the cylinder and the Bourdon gauge reading was recorded.

STEP FIVE: Weights were added to the piston in increment of 1kg and at each increment, record the gauge reading and the load on the piston.

STEP SIX: Steps one to five was repeated with brake oil as the fluid in the cylinder.

RESULT

Error percentage will be compared with a theoretical true pressure as given below.

$PT = w \times 9.81 \times 10^{-3}/A$ (kn/m^2) …… (1)

Error deviation = (p-pt)/100% …….(2)

The gradient of the two tables were calculated to be 0.8992 for water and 0.9955 for brake fluid

TABLE 1: WATER VALUES

Weight added to piston (kg)	Total load on piston W (Kg)	True pressure Pt (KN/m2)	Gauge Reading P (KN/m2)	Gauge Error (KN/m2)
0	1	31.14	39	7.86
1	2	62.29	75	12.71
2	3	93.43	103	9.57
3	4	124.57	140	15.43
4	5	155.71	175	19.29

TABLE 2: BRAKE OIL VALUES

Weight added to piston (kg)	Total load on piston W (Kg)	True pressure Pt (KN/m2)	Gauge Reading P (KN/m2)	Gauge Error (KN/m2)
0	1	31.14	36	4.81
1	2	62.29	67	4.71
2	3	93.43	98	4.57
3	4	124.57	130	5.43
4	5	155.71	167	11.29

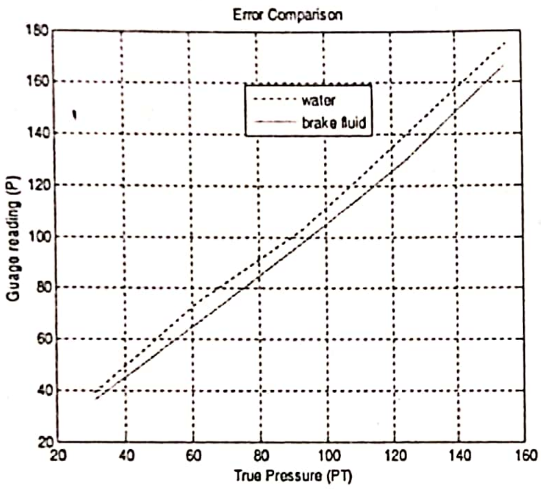

Figure 2: Error comparison of the fluids

DISCUSSION

Shear stress is a distributed force, or force per unit area, whose direction of action is within the plane of application. By definition, viscosity is the material property that defines the quantitative relation between the applied shear stress and the shear deformation rate in a fluid. Qualitatively the viscosity indicates the "thickness" or resistance to flow of a fluid [1]. Hence Viscosity of the fluids used in this work gives an explanation on the significance of the result obtained. Comparably, table 3 indicates that the viscosity of brake fluid is much higher than that of water at all selected temperature rates [6],[7].

Table 3: Fluid Viscosity comparison

TEMPERATURE (0c)	WATER viscosity (m^2/s)	BRAKE FLUID DOT 3 SPECIFICATION viscosity (m^2/s)
0	1.787	-
40	0.658	936
100	0.29	2.0

CONCLUSION

It is not possible to have any measuring instrument that can indicate the exact value of its measurands. Thus, the result as obtained in figure 2 is a close comparison of the error deviation of two fluids water and brake fluid respectively. From the slope obtained and the linearity of the graphs in figure 2, the fluids displayed a close relationship with a difference of 0.0963 which is not significant. Hence from the above experiment, the viscosity of the fluid used determines to an extent the accuracy of the obtained result.

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