STATIC CHARACTERISTICS OF INSTRUMENTS & CALIBERATION

Dr. V. Karteek
Assistant Professor, EIED
Thapar Institute of Engineering & Technology,
Patiala, Punjab

STATIC CHARACTERISTICS OF INSTRUMENTS

The performance characteristics of an instrument are mainly divided into two categories:

- Static Characteristics
- Dynamic Characteristics

Some applications involve measurands which are either constant or varying very slowly with time.

The set of criteria defined for the instruments, which are used to measure the quantities that are slowly varying with time or mostly constant is called the static characteristics.

ACCURACY

- This is the closeness with which the measuring instrument can measure the true value of the measurand under stated conditions of use, i.e. its ability to tell the truth.
- The accuracy of an instrument is quantified by the difference of its readings and the one given by the ultimate or primary standard.
- Accuracy depends on inherent limitations of instrument and shortcomings in measurement process.

REPRESENTATION OF ACCURACY

1. Percentage of true value (% of T.V.)

$$= \frac{(\text{Measured value} - \text{True value}) * 100}{\text{True value}}$$

2. Percentage of Full Scale Deflection (% of fsd)

$$\text{fsd}) = \frac{(\text{Measured value} - \text{True value}) * 100}{\text{Maximum Scale value}}$$

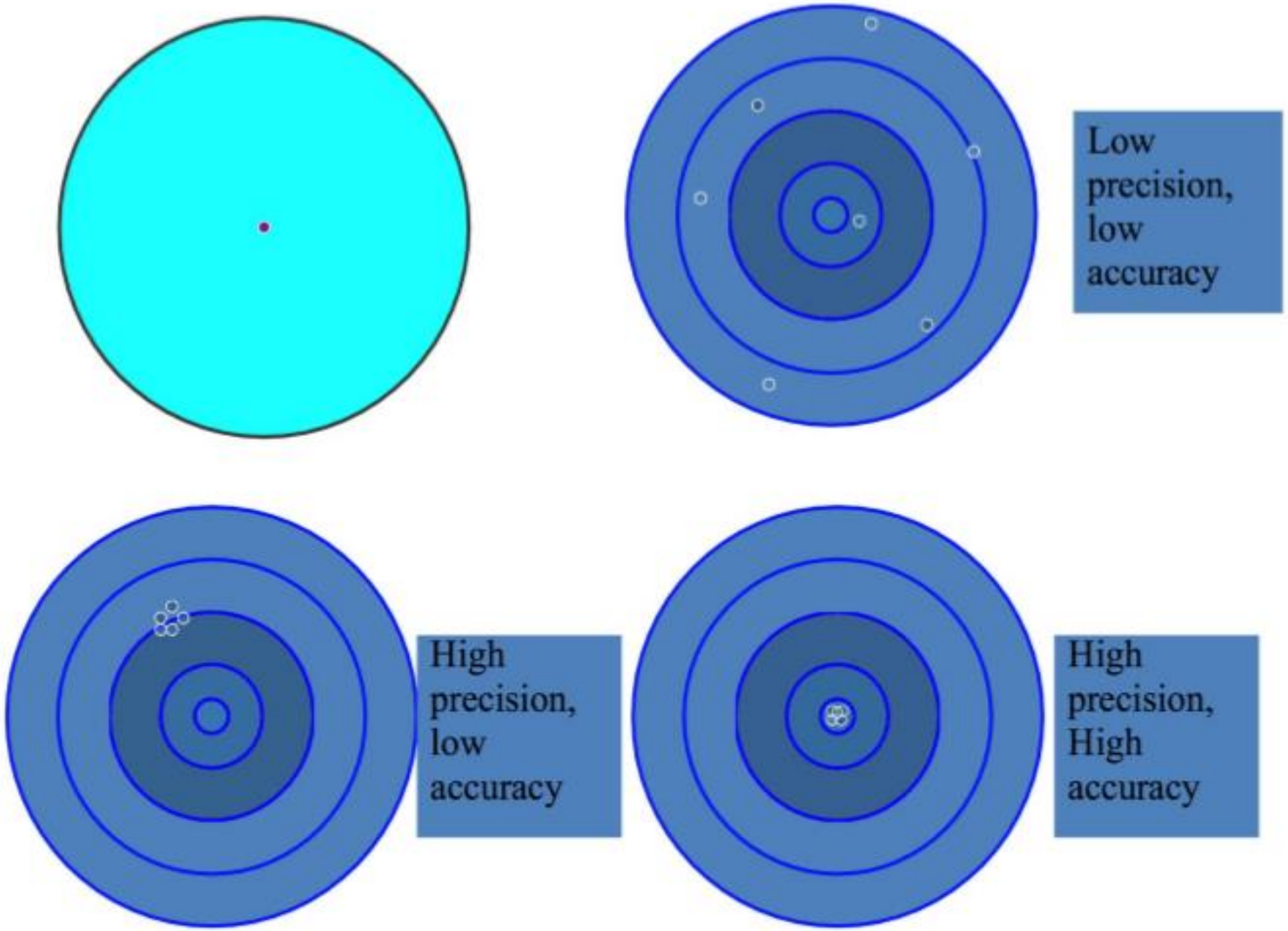
For example, a 100 psi gauge with 0.1 % of FS accuracy would be accurate to ± 0.1 psi across its entire range. By convention, a gauge specified as 0.1% accuracy is implied to be 0.1% FS.

When manufacturers define their accuracy as "% of reading", they are describing the accuracy as a percentage of the reading currently displayed. For example, a gauge with 0.1 % of reading accuracy that displays a reading of 100 psi would be accurate to ± 0.1 psi at that pressure. At 50 psi, the same gauge would have an accuracy of ± 0.05 psi (twice as accurate).

PRECISION

- Precision is defined as the ability of instrument to reproduce a certain set of readings within given accuracy.
- Precision describes an instrument's degree of random variations in its output when measuring a constant quantity.
- Precision depends upon repeatability.
- Precision is often confused with accuracy. High precision does not imply anything about measurement accuracy.

ACCURACY VS PRECISION



RESOLUTION & THRESHOLD

Resolution

It is the minimum change or smallest increment in the measured value that can be detected with certainty by the instrument.

It can be least count of instrument.

Threshold

Threshold is defined as the range of different input values over which there is no change in output value in starting.

RANGE AND SPAN

RANGE

The range of an instrument defines the maximum value of a quantity that the instrument is designed to measure.

The ***span*** of an instrument defines the minimum (Min) and maximum (Max) values of a quantity that the instrument is designed to measure.

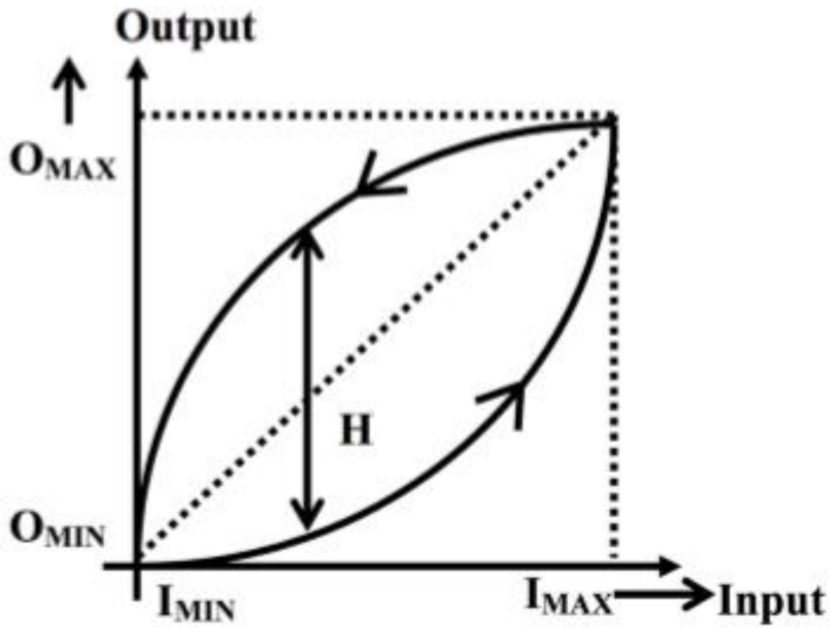
Span =Max-Min

SENSITIVITY

- The sensitivity of an instrument is the change of output divided by the change of the measurand (the quantity being measured).
- As an example, consider a pressure sensor that has a measurement range of 0-100 PSI and an output range of 0-5V. Its sensitivity is .05 Volt/PSI.
- It can be defined as the ratio of the incremental output and the incremental input. While defining the sensitivity, we assume that the input-output characteristic of the instrument is approximately linear in that range.

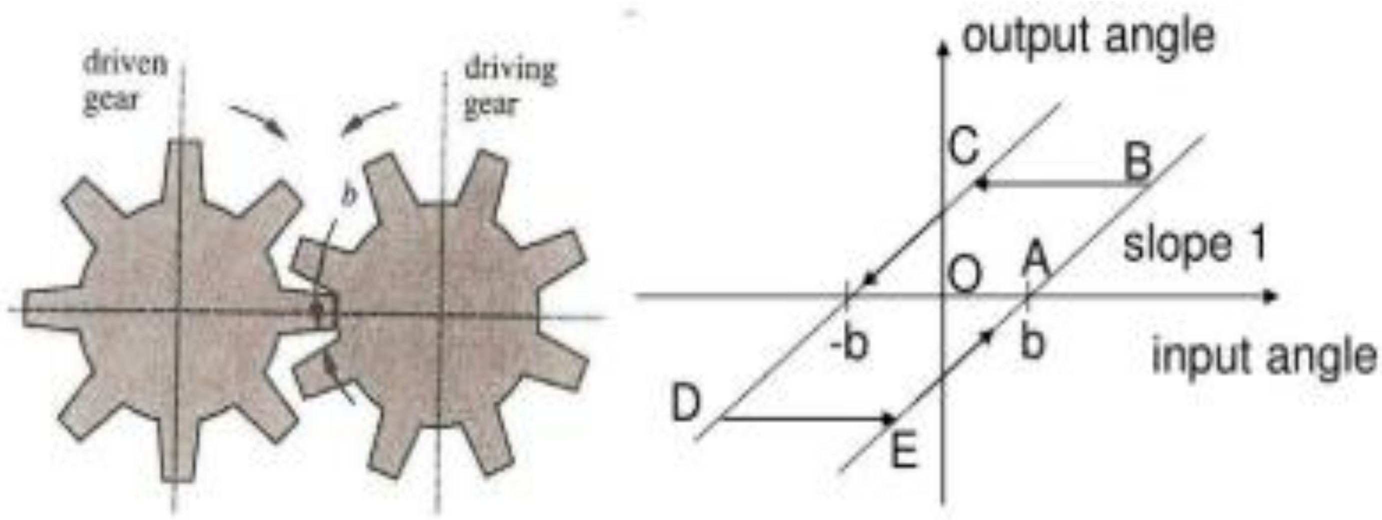
HYSTERESIS

Hysteresis exists not only in magnetic circuits, but in instruments also. For example, the deflection of a diaphragm type pressure gage may be different for the same pressure, but one for increasing and other for decreasing, as shown in Fig.



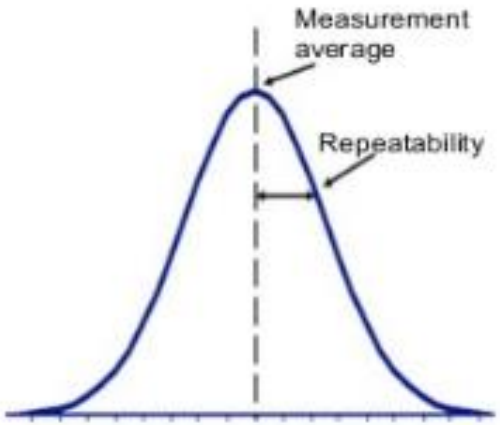
BACKLASH

It is defined as the maximum distance or angle through which any part of mechanical system may be moved in one direction without causing motion of next part.
Can be minimized if components are made to very close tolerances.



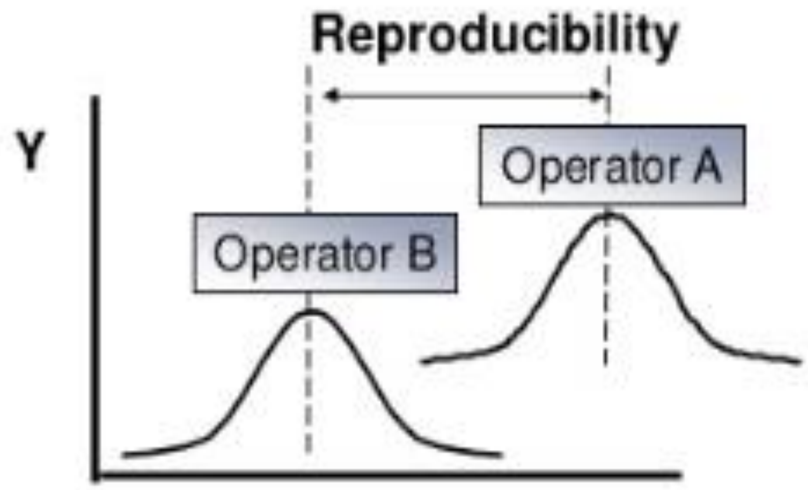
REPEATABILITY

- For repeatability to be established, the following conditions must be in place: the same location; the same measurement procedure; the same observer; the same measuring instrument, used under the same conditions; and repetition over a short period of time.
- What's known as "the repeatability coefficient" is a measurement of precision, which denotes the absolute difference between a pair of repeated test results.



REPRODUCIBILITY

- Reproducibility, on the other hand, refers to the degree of agreement between the results of experiments conducted by different individuals, at different locations, with different instruments. Put simply, it measures our ability to replicate the findings of others.

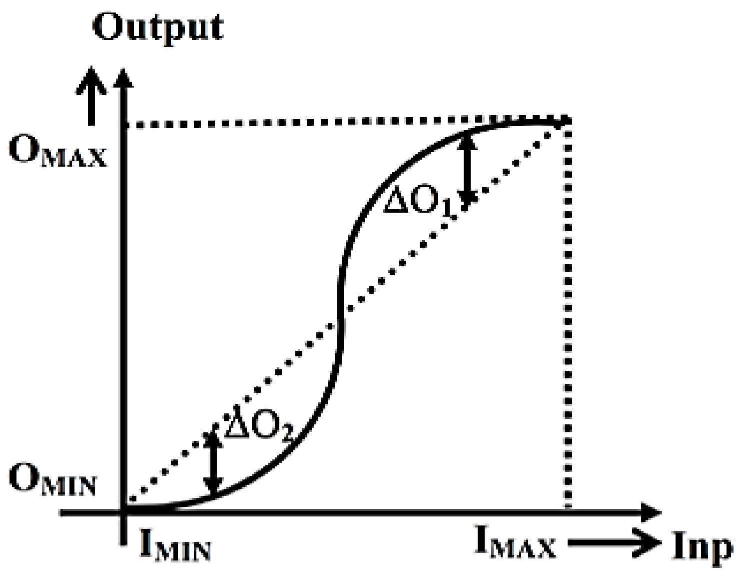


Linearity

- It is defined as the ability of an instrument to reproduce its input linearly.
- It is a measure of the maximum deviation of the calibration points from the ideal straight line.

$$Linearity = \frac{\Delta O}{O_{\max} - O_{\min}}$$

where, $\Delta O = \max(\Delta O_1, \Delta O_2)$.



Drift

- Drift is a departure in the output of the instrument over the period of time. An instrument is said to have no drift if it produces same reading at different times for the same variation in the measured variable. Drift is unrelated to the operating conditions or load. The following factors could contribute towards the drift in the instruments:

  i) Wear and tear

  ii) Mechanical vibrations

  iii) Stresses developed in the parts of the instrument

  iv) Temperature variations

  v) Stray electric and magnetic fields

Continued

- Drift may be of any of the following types;
- a) Zero drift: Drift is called zero drift if the whole of instrument calibration shifts over by the same amount. It may be due to shifting of pointer or permanent set.
- b)Span drift: If the calibration from zero upwards changes proportionately it is called span drift. It may be due to the change in spring gradient.
- c) Zonal drift: When the drift occurs only over a portion of the span of the instrument it is called zonal drift.

CALIBRATION

- Calibration is a comparison between a known measurement (the standard) and the measurement using your instrument.
- Calibration of your measuring instruments has two objectives. It checks the accuracy of the instrument and it determines the traceability of the measurement. In practice, calibration also includes repair of the device if it is out of calibration. A report is provided by the calibration expert, which shows the error in measurements with the measuring device before and after the calibration.

WHY CALIBRATION IS IMPORTANT?

- The accuracy of all measuring devices degrade over time. This is typically caused by normal wear and tear. However, changes in accuracy can also be caused by electric or mechanical shock or a hazardous manufacturing environment. Depending on the type of the instrument and the environment in which it is being used, it may degrade very quickly or over a long period of time. The bottom line is that, calibration improves the accuracy of the measuring device. Accurate measuring devices improve product quality.

A measuring device should be calibrated:

- According to recommendation of the manufacturer.
- After any mechanical or electrical shock.
- Periodically (annually, quarterly, monthly)

EXAMPLE

A Starrett-Webber gauge block is used to calibrate an electronic caliper.

THANK YOU