NEHRU COLLEGE OF ENGINEERING AND RESEARCH CENTRE

(Accredited by NAAC, Approved by AICTE New Delhi, Affiliated to APJKTU)

Pampady, Thiruvilwamala(PO), Thrissur(DT), Kerala 680 588

DEPARTMENT OF MECHATRONICS ENGINERING

LAB MANUAL

MRL 333 INSTRUMENTATION LAB

VISION OF THE INSTITUTION

To mould true citizens who are millennium leaders and catalysts of change through excellence in education.

MISSION OF THE INSTITUTION

NCERC is committed to transform itself into a center of excellence in Learning and Research in Engineering and Frontier Technology and to impart quality education to mould technically competent citizens with moral integrity, social commitment and ethical values.

We intend to facilitate our students to assimilate the latest technological know-how and to imbibe discipline, culture and spiritually, and to mould them in to technological giants, dedicated research scientists and intellectual leaders of the country who can spread the beams of light and happiness among the poor and the underprivileged.

ABOUT DEPARTMENT

- Established in: 2013
- Course offered: B.Tech Mechatronics Engineering
- Approved by AICTE New Delhi and Accredited by NAAC
- Affiliated to the University of A P J Abdul Kalam Technological University.

DEPARTMENT VISION

To develop professionally ethical and socially responsible Mechatronics engineers to serve the humanity through quality professional education.

DEPARTMENT MISSION

1) The department is committed to impart the right blend of knowledge and quality education to create professionally ethical and socially responsible graduates.

2) The department is committed to impart the awareness to meet the current challenges in technology.

3) Establish state-of-the-art laboratories to promote practical knowledge of mechatronics to meet the needs of the society

PROGRAMME EDUCATIONAL OBJECTIVES

I. Graduates shall have the ability to work in multidisciplinary environment with good professional and commitment.

II. Graduates shall have the ability to solve the complex engineering problems by applying electrical, mechanical, electronics and computer knowledge and engage in lifelong learning in their profession.

III. Graduates shall have the ability to lead and contribute in a team with entrepreneur skills, professional, social and ethical responsibilities.

IV. Graduates shall have ability to acquire scientific and engineering fundamentals necessary for higher studies and research.

PROGRAM OUTCOMES (PO'S)

Engineering Graduates will be able to:

PO 1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSO'S)

PSO 1: Design and develop Mechatronics systems to solve the complex engineering problem by integrating electronics, mechanical and control systems.

PSO 2: Apply the engineering knowledge to conduct investigations of complex engineering problem related to instrumentation, control, automation, robotics and provide solutions.

SYLLABUS

CODE	INSRTUMENTATION LAB	CATEGORY	L	T	P	CREDIT
MRL333		PCC	0	0	3	2

Preamble: This course enables students to students to familiarize various instruments and practice them for applications in automation.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the calibration and use of different measuring instruments
CO 2	Evaluate the uncertainties involved in any measurement
CO 3	Understand and analyze construction and operational aspects of different electro-mechanical measuring instruments along with their application domains
CO 4	Explain the need of various modern measuring instruments and precision measurement techniques
CO 5	Develop knowledge on the fundamental concepts and principles of metrology
CO 6	Study the operating principle and analyse the output characteristics of different electronics instruments

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3											
CO 2	3	2							2			2
CO 3	3	2							2			
CO 4	3	2	2									2
CO 5	3	2							2			
CO 6	3		2						2			2

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance	:	15 marks
Continuous Assessment	:	30 marks
Internal Test (Immediately before the second series test)	:	30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	: 15 Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipment and trouble shooting)	: 25 Marks
(d) Viva voce	: 20 marks
(e) Record	: 5 Marks

General instructions: Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Mention some of the transducers.

2. The temperature coefficient of material should be high or low?

3. What is the value of excitationvoltage?

Course Outcome 2 (CO2)

1. Define Skin effect?

2. what are errors in this instrument?

3. Define self heating property of thermistor?

Course Outcome 3(CO3):

1. Give commonly used pressure sensitive devices?

2. What is the working principle of mercury in glass thermometer?

3. What is the nature of EMF induced in thermocouple?

Course Outcome 4 (CO4):

1. Why calibration is essential and how it is performed for a strain gauge?

2. What is Torque?

3. Are RTDs and thermocouples intrinsically safe?

Course Outcome 5 (CO5):

1. What is the relation between variation due to observation, manufacturing process and measuring process of a product?

2. What is the least count of clinometer which is used to check reading of column rotation used for setting of helix angles in universal micro meter?

3.What is the difference unilateral and bilateral system of tolerance? Discuss the least count of a verniercalliper?

Course Outcome 6 (CO6):

1.What do you meant by Basic size?

2. What is the sensitivity of Wheatstone bridge

3. The characteristics of thermistor in linear or non-linear?

LIST OF EXPERIMENTS (Minimum 12 experiments is mandatory)

1) Calibration of Bourdon tube pressure gauge using dead weight pressure gauge tester.

2) Calibration of strain gauge pressure cell

3) Measurement of temperature using Radiation pyrometer and infrared pyrometer

4] Time constant of temperature measuring device

5) Measurement of vibration using Piezoelectric Accelerometers

6) Measurement of vibration using vibrometers

7) Measurement of torque and force

Measurement of cutting force during turning, drilling and milling using tool force dynamometer

8) Acoustic measurement using Sound level meter and octave band filter

9) Preparation of noise Contours

10) Calibration of tachometers

11) Measurement of rotation speed using tachometer, tacho generator and stroboscopic tachometer

12) Metrology

Measurement of surface finish using stylus type surface roughness measuring device

13) Measurement of tool wear using tool makers microscope

14) Study and use of linear and angular measuring devices-verniercaliper, outside and inside micrometer, vernier depth gauge, vernier height gauge, feeler gauge, screw pitch gauge, sine bar, slip gauge- bevel protractor- profile projector

15) Measurements of gears and screw threads

16) Analysis of exhaust gases and flue gases with the help of orsats apparatus, Gas chromatograph, paramagnetic oxygen analyser, smoke meter etc.

Reference Books

1.Advanced laboratory manual of parasitology and immunopharmacology by MANNA

2. Electrical Measurements in the Laboratory Practice ByBartiromo, Rosario, De Vincenzi, Mario

3. Basic Theory and Laboratory Experiments in Measurement and Instrumentation:by Cataldo, A., Giaquinto, N., De Benedetto, E., Masciullo, A., Cannazza, G., Lorenzo, I., Nicolazzo, J., Meo, M.T., Monte, A.D., Parisi, G., Gaetani, F.

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Additional/Advanced Experiments				
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VERIFICATION BY HOD

INTERNAL EXAMINER **EXTERNAL EXAMINER**

STUDY - I

INTRODUCTION TO METROLOGY AND INSTRUMENTATION

Metrology is the science of measurement. It includes units of measurement and their standards, measuring instruments and their field of application, and all theoretical and practical problems relating to measurement.

Metrology is classified in three main fields:

Scientific Metrology,

Industrial Metrology,

Legal Metrology.

Scientific Metrology is that part of metrology which deals with problems common to all metrological questions irrespective of the quantity measured. It covers general theoretical and practical problems concerning units of measurement, including their realization and dissemination through scientific methods, the problems of errors and uncertainties in measurement and the problems of metrological properties of measuring instruments.

There are different specialist areas of metrology, for example:

• Mass metrology dealing with mass measurements;
• Dimensional metrology dealing with length and angle measurements;
• Temperature metrology dealing with temperature measurements;
• Electrical metrology dealing with electrical measurements;
• Chemical metrology dealing with measurements in chemistry.

Industrial metrology deals with measurements in production and quality control. It covers calibration procedures, calibration intervals, control of measurement processes and management of measuring instruments in industry to ensure that they are in a state of compliance with requirements for their intended use.

Legal metrology is that part of metrology which is subject to legal/regulatory control. It is defined in the International Vocabulary of Legal Metrology as that part of metrology relating to activities which result from statutory requirements and concern measurement, units of measurement, measuring instruments and methods of measurement and which are performed by competent bodies.

Theoretically, metrology, as the science of measurement, attempts to validate the data obtained from test equipment. Though metrology is the science of measurement, in practical applications, it is the enforcement, verification and validation of predefined standards for the Accuracy, Precision, Reliability and Traceability of measurements.

1.1GENERAL CONCEPT OF MEASUREMENT

Measurement is a comparison of a given unknown quantity with one of its predetermined standard values adopted as a unit. Measurement provides us with means of describing various phenomena in quantitative terms. It plays an important role in all branches of engineering and science.

There are two important requirements of the measurement:

i. The -standards used for comparison must be accurate and internationally *accepted*, and

ii. The apparatus or instrument and the process used for comparison must be provable.

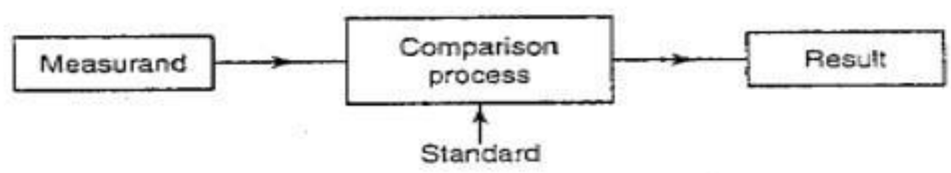


Fig. 1.1 Fundamental measuring process.

The word measurand is used to designate the particular physical parameter being observed ie. Unknown quantity which is to be measured. It is the input quantity to the measuring process.

This unknown quantity is compared with the available standard quantities such length, mass, time and it produces a result.

METHODS OF MEASUREMENTS

1. Direct comparison with primary or secondary standards
2. Indirect comparison with a standard through calibration of system.
3. Comparative method
4. Coincidence method
5. Fundamental method
6. Contact method
7. Transposition method
8. Complementary method
9. Deflection method.

1. Direct method

In direct comparison, the parameter to be measured is directly compared with either a primary standard or a secondary standard. In this method, the comparison is done with a standard with the help of calibrated systems. Direct methods are quite common for the measurement of physical quantities like length, mass and time. For example, if we want to measure the length of a steel rod, we would probably use a steel tape or scale.

We are comparing the length of the rod with the standard length, and finding the bar which is so many times long because that many units on the standard have the same length as the bar. Thus, we have determined the length by direct comparison. Generally, the direct comparison is not always the most accurate or the best, it is not sensitive enough also. Measurement by direct comparison is less common than the measurement by indirect comparison.

Measurements may be classified as primary, secondary and tertiary based on the complexity of the measurement system. In primary measurement, any physical parameters are measured by comparing directly with reference standards. For example

(i) Matching of two lengths when determining the length of an object with a meter rod.

(ii) Matching of two weights when determining the mass of the grossary items.

The *primary measurement* provides subjective information only Here, the observer indicates only that one rod is longer than the other rod One object contains more or less mass than the other. The primary measurement is under the category of direct measurement.

A *secondary measurement* involves only one translation to be don on the quantity under the measurement. For example, if we want b measure the pressure of a gas in a container, it may not be observable Therefore, it requires, (i) An instrument to convert pressure into displacement, and (ii) The change in displacement units equivalent to known change in pressure. Therefore, the primary signal is first transmitted to a transducer where it is effected to translate into a length change in pressure gauge Then the secondary signal of length change is transmitted to th observer's eye.

A *tertiary measurement* involves two translations. The measurement of static pressure by a bourdon tube pressure gauge is a typical example of tertiary measurement. During the measurement of pressure, the free end deflects slightly. This small deflection is made larger by using rac and pinion arrangement for better displaying and reading.

Prima Bourdon tube Secondary signal Flack and pinion Tertiary signal ---)— signal (Small cleMlestion) Pointer (Jinn: iceman] K. reacirl9) Arrangement

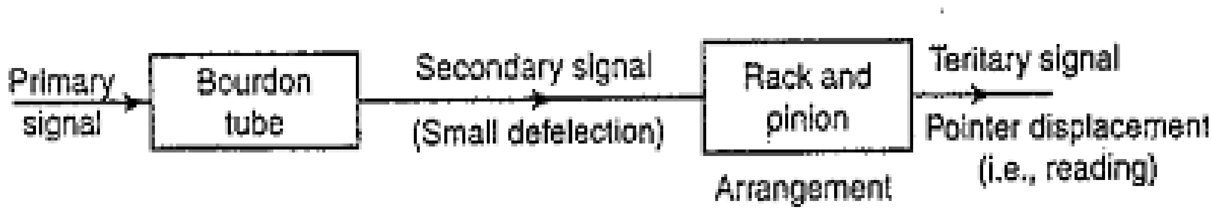


Fig. 1.2. Tertiary arrangement

2. Indirect method

Indirect comparison makes use of some form of transducing device which converts the quantity to be measured into an analogous signal. The analnaous signal is then processed by intermediate devices and displayed on the output device as known function of the input. Indirect methods for measurements are used in those cases where the direct measurement is difficult.

In this method, an empirical relationship is generally established between the measurement mode and result mode that are desired.

3. Comparative method

In this method, the quantity to be measured is compared with other known value. Example: Comparators.

4. Coincidence method

The value of the quantity to be measured and determined is coincided with certain lines and signals.

5. Fundamental method

Measuring a quantity is directly, related with the definition of that quantity.

6. Contact method

The sensor or measuring tip of the instrument touches the area (or) diameter (or) surface to be measured. Example: Vernier caliper.

7. Transposition method

In this method, the quantity to be measured is first balanced by a known value and then it is balanced by other new known value. Example: Determination of mass by balancing methods.

8. Complementary method

The value of quantity to be measured is combined with known value of the same quantity. Example: Volume determination by liquid displacement.

9. Deflection method

The value to be measured is directly indicated by a deflection of pointer. Example: pressure measurement.

1.2. GENERALIZED MEASURING SYSTEM

There are number of measuring instruments used in practice. Therefore, it is necessary to identify the common features or the basic elements of a generalized measuring system. A generalized measuring system consists of the following common elements:

(i) Primary sensing element
(ii) Variable conversion element
(iii)Variable manipulation element
(iv) Data transmission element
(v) Data processing element
(vi) Data presentation element

Fig. 1.3 indicates the functional elements of an instrument which are indicated by various blocks.

Physical variable to be measured

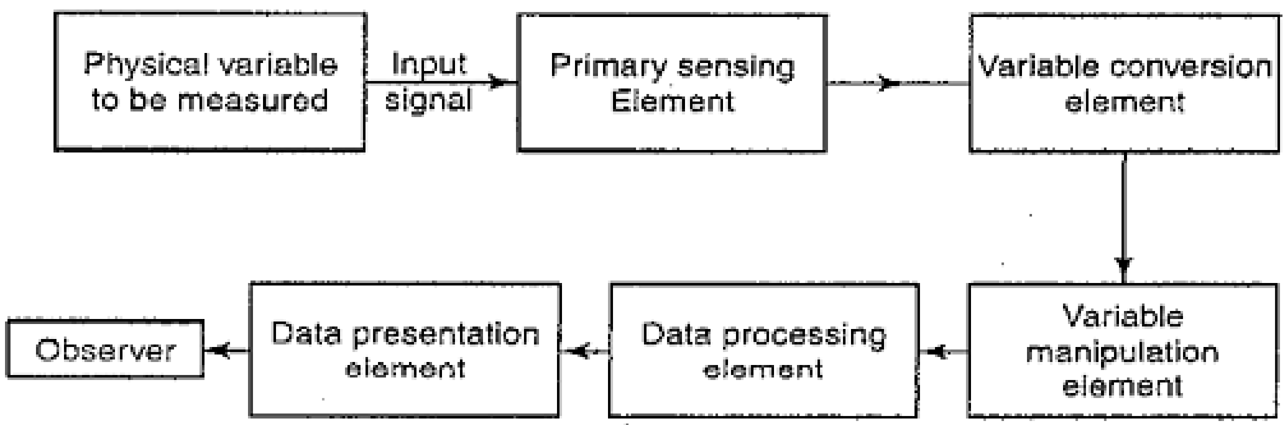


Fig 1.3 Functional elements of an instrument

1.2.1. Primary Sensing Element

It is the first element which receives energy from the measured medium and produces an output corresponding to the measurand. This output is then converted into an analogous electrical signal by transducer.

1.2.2. Variable Conversion Element

It converts the output electrical signal of the primary sensing element which may be a voltage, frequency or some other electrical parameter to a more suitable form without changing the information content of the output signal. In some instrument, there is no need of using variable conversion element while some other instruments require variable conversion element.

1.2.3. Variable Manipulation Element

This element is used to manipulate the signal presented to it and reserving the original nature of the signal. In other words, it amplifies he input signal to the required magnification. For example, an electronic voltage amplifier receives a small voltage as input and produces greater magnitude of voltage as output. A variable manipulation element does not necessarily follow a variable-conversion element, it may precede it.

1.2.4. Data Transmission Element

It transmits the data from one element to the other. It may be a simple as shaft and gear assembly system or as complicated as a telemetry system which is used to transmit signal from one place to another.

1.2.5. Data Processing Element

It is an clement which is used to modify the data before displayed or finally recorded. It may be used for the following purposes:

 To convert the data into useful form.

 To separate the signal hidden in noise.

 It may provide corrections to the measured physical variables to compensate for zero offset, temperature error, scaling etc.

1.2.6. Data Presentation Element

These are the elements that they finally communicate the information of measured variable to a human observer for monitoring, control or analysis purpose. The value of the measured variable may be indicated by an analog indicator (pointer and a scale), digital indicator (ammeter, voltmeter, etc) or by a recorder (magnetic taps, camera, T.V. equipment, storage type C.R.T.)

1.3. PERFORMANCE OF INSTRUMENTS

All instrumentation systems are characterized by the system characteristics or system response. The knowledge of the performance characteristics or system response of an instrument is essential for selecting the most suitable instrument for specific measuring jobs. It consists of two basic characteristics such as static and dynamic. If the instrument is required to measure a condition not varying with time, the characteristics arc called static while for a time-varying process-variable measurement, the dynamic characteristics are more important.

1.3.1. Static Response

The static characteristics of an instrument are considered for instruments which are used to measure an unvarying process conditions. All the static performance characteristics are obtained by one form or another of a process called calibration.

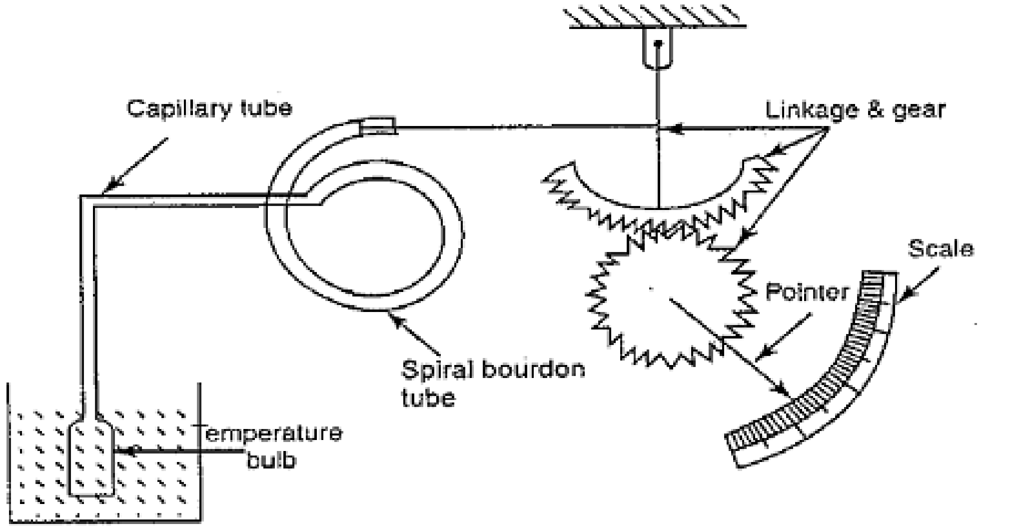
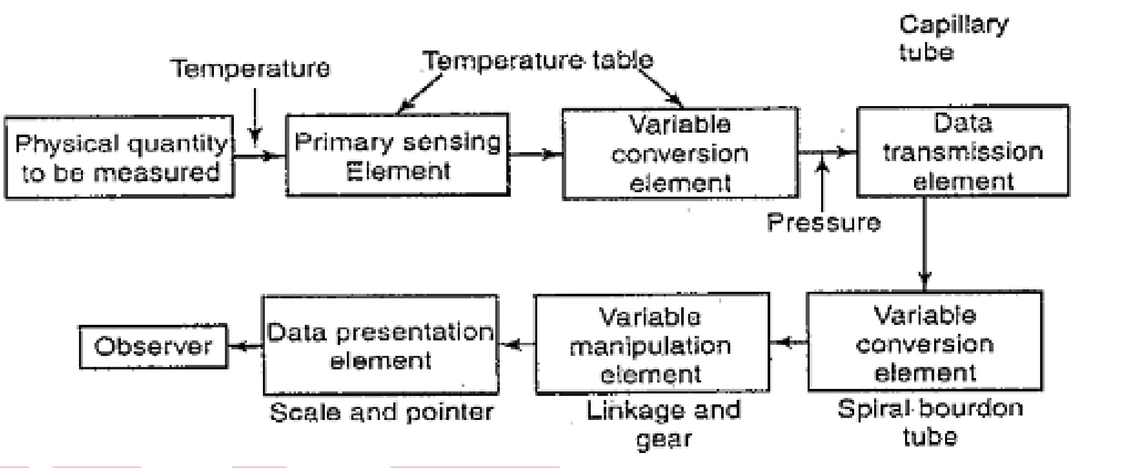


Fig. 1.4(a)



There are a number of related definitions such as accuracy, precision, repeatability, reproducibility, sensitivity, drift etc, which are described below:

1. Accuracy

The degree of closeness of a measurement compared to the expected value is known as accuracy.

2. Precision

A measure of consistency or repeatability of measurement, i.e. successive reading does not differ.

3. Resolution

It is the smallest change in a measured variable to which an instrument will respond

4. Sensitivity

The ratio of the change in output of the instrument to a change of input or measured variable is termed as sensitivity..

5. Threshold

The minimum value of input below which no output can be appeared is known as threshold.

6. Drift

The variation of change in output for a given input over a period of time is known as drift.

7. Error

The deviation of the true value from the desired value is called error.

8. Repeatability

Repeatability is the closeness of agreement among a number of consecutive measurements of the output for the same value of input under the same operating conditions.

9. Reproducibility

The closeness of agreement among the repeated measurements of the output for the same value of input under the same operating conditions over a period of time is called as reproducibility.

10. Dead zone

Dead zone is the largest range of values of a measured variable to which the instrument does not respond.

11. Backlash

Lost motion or free play of the mechanical elements such as gear linkage etc.

12. True value

The errorless value of the measured variable is known as true value.

13. Hysteresis

Maximum difference for the same measured quantity between th upscale and downscale readings during a full traverse in each direction.

14. Linearity

The ability to produce the input characteristics symmetrically an linearly is said to be linearity.

15. Range or span

Range is the minimum and maximum values of a quantity for which an instrument is designed to measure.

16. Bias

The constant error which exists over the full range of measurement of an instrument is known as bias.

17. Tolerance

It is a maximum allowable error in the measurement.

18. Stability

The ability of an instrument to retain its performance throughout it specified operating life and storage life is termed as stability.

1.3.2. Dynamic Response

Instruments In many practical cases, the parameters to be measured arc time varying i.e dynamic in nature. Thus, the output of an instrument is time varying. The behavior of an instrument tinder such time varying input - output conditions is called dynamic response of an instrument. The analysis of such dynamic response is called dynamic analysis of the measurement system.

Dynamic quantities are of two types (i) Steady state periodic (ii) Transient An output whose magnitude has a definite repeating time cycle is ailed steady stare periodic. An output whose magnitude does not repeat 'ith time is called as transient.

The number of parameter required to define the dynamic behavior f any instrument is decided by the group to which that system belongs. hen the systems can be classified into

(1) Zero - order systems

(2) First - order systems

(3) Second - order systems

(4) Higher - order systems

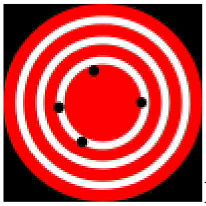
ACCURACY AND PRECISION

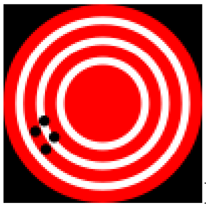
In the fields of science, engineering, industry and statistics, the Accuracy of a measurement system is the degree of closeness of measurements of a quantity to that quantity's actual (true) value. The Precision of a measurement system, also called reproducibility or repeatability, is the degree to which repeated measurements under unchanged conditions show the same results. Although the two words can be synonymous in colloquial use, they are deliberately contrasted in the context of the scientific method.

A measurement system can be accurate but not precise, precise but not accurate, neither, or both. For example, if an experiment contains a systematic error, then increasing the sample size generally increases precision but does not improve accuracy.

The end result would be a consistent yet inaccurate string of results from the flawed experiment. Eliminating the systematic error improves accuracy but does not change precision. A measurement system is designated *valid* if it is both *accurate* and *precise*.

Accuracy indicates proximity of measurement results to the true value, precision to the repeatability or reproducibility of the measurement


High **accuracy**, but low **precision**


High **precision**, but low **accuracy**

19. Correction

Correction is defined as a value which is added algebraically to the corrected result of measurement to compensate for an assumed iteMetiC error.

If a numerical value is multiplied with uncorrected results to ripenSate for an assumed systematic error, it is known as correction 'tor.

20. Calibration

In developing a measurement system, a user must make certain that instrumentation they are using is calibrated. Calibration is the process determining and adjusting an instrument's accuracy to make sure its :uracy is within the manufacturer's specifications. If the user does not Ice sure their instrumentation hardware or hardware components are ibrated, the user can potentially take false data. Why is taking false a bad? The obvious reason is that decisions to be made based on this a will now potentially be incorrect. Furthermore, in the manufacturing t environment, improperly calibrated measurement systems can pass J parts or fail pans that are good.

The result can be delivering bad parts the user's customers or throwing away usable product and investing :n more time to make additional product to make up for the shortage. ere is one simple way to know if the hardware in your measurement tern is calibrated.

Calibration offers a guarantee to the instrument that is operating with uired accuracy, under the standard environmental conditions. It also ates the confidence of using the calibrated instrument for the user. All instruments should be calibrated periodically.

The calibration procedure involves the various steps like visual pection for various defects, installation according to the specifications, o adjustment etc**.**

1.4. ERRORS IN MEASUREMENT

Error is the difference between the measured value and the true value.

Error in measurement = Measured Value — True value

The errors in measurement can be expressed either as an absolute error or an relative error.

1. **Absolute error**

The absolute error is classified into two types:

i). True absolute error

ii). Apparent absolute error

i) True absolute error:

Algebraic difference between the results of measurement to the true value of the quantity measured is called true absolute error.

ii) Apparent absolute error: \

While taking the series of measurement, the algebraic difference between one of the results of measurement

2. Relative error

Relative error is defined as the results of the absolute error and the value of comparison used for calculation of that absolute error. The comparison may be true value or conventional true value or arithmetic mean for series of measurement.

1.4.1. Types of Error

The errors can be classified into

1. Static errors

(i) Characteristic errors

(ii) Reading errors

(iii) Environmental errors

2. Loading errors

3. Dynamic error

1. Static error

It causes due to the physical nature of the various components of t measuring system. The static errors due to environmental effect and t other properties which influence the apparatus are also reasons for sad errors.

a) Characteristic error:

The deviation of the output of the measuring system from 0 nominal performance specifications is called characteristic error. The linearity, repeatability, hysteresis and resolution are part of tl characteristic error.

b) Reading error:

It is exclusively applied to the read out device. The reading ern describes the factors parallax error and interpolation error.

The use of mirror behind the readout indicator eliminates- the occurrence of parallax error. *Interpolation error* is a reading error resulting from the in extra evaluation of the position of index. The use of digital readout device eliminates the subjective error.

c) Environmental error:

Every instrument is manufactured and calibrated at one place and is used in some other place where the environmental conditions such temperature, pressure, and humidity change. So, the change in environment Influences the readings of the instrument. This change in environment is called environment error.

Following the below conditions, the environmental errors are eliminated.

1. Monitoring the atmospheric conditions.
2. By calibration of instrument at the place of use:
3. Automatic devices are used to compensate the effects.

2. Loading error

As the measured quantity looses energy due to the act of measurement, an error is introduced known as loading error.

Loading means the measuring instrument always taking the input om the signal source. Due to this, the signal source will always be entered by the act of measurement known loading.

Example: If steam flows through the nozzle, it is very difficult to and the perfect flow rate. This is called loading error. . Dynamic error This is due to time variations in the measurand. The dynamic errors re caused by inertia, friction and clamping action. The dynamic errors re mainly classified into

a) Systematic errors or Controllable errors

b) Random errors

a) Systematic error:

The systematic are constant and similar in form. These are controllable in both their sense and magnitude. The systematic errors are easily determined and reduced, hence these are also called as controllable errors.

Systematic errors includes

I. Calibration errors

2. Ambient or Atmospheric conditions

3. Avoidable errors, and

4. Stylus pressure

(1) Calibration error:

Calibration is a process of giving a known input to the measurement system and also taking necessary actions to see that the output of the Measurement system matches with Its input.. . If the instrument is not calibrated, the instrument will show very high degree of error. Calibration errors are fixed errors.

(2) Ambient error:

This is due to variation in atmospheric conditions (Example: Pressure, Temperature and moisture) • normally the instruments are calibrated at particular pressure and temperatures. Temperature will not be equal at all places.

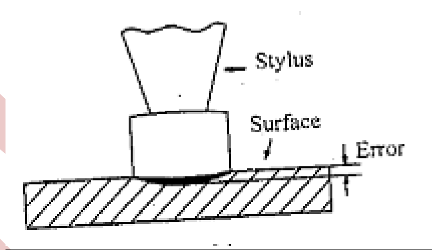
If the temperature and pressure vary, the ambient error will form. Standard temperature of 20°C and pressure of 760mm of Hg are taken as ambient conditions.

(3) Avoidable errors:

This type of error is due to parallax, non-alignment of work piece centers, and improper location of measuring instrument. For example placing a thennotneter in sunlight to measure air temperature will cause the instrument location error.

(4). Stylus pressure:

Whenever a component is measured under particular pressure, Surface the deformation of the work piece Error and surface deflection will occur. The pressure involved is generally Fig1.5. small but this is sufficient to cause appreciable deformation on stylus and the work piece.



b) Random error:

These types of errors occur randomly and reason for this type of errors cannot be specified.

Errors are due to unknown causes, not determinable in ordinary process of making measurements. Such errors are normally sn and follow the laws of probability. Random errors can thus be tree mathematically. The sources for this type of errors are

1. Displacement of level joints in the measuring instrument
2. Small variation in the position of settings.
3. Reading scale error due to operator.

1.4.2. Systematic and Random Errors

1. Systematic error

Systematic error is usually divided into two different categories**:**

(a) Instrumental errors

(b) Environmental errors

(a) Instrumental error:

These errors are due to shortcomings of the instrument. These arc errors inherent in measuring instruments because of their mechanical structure. For example, in the D'Arsonval movement friction in bearings of various moving components may cause incorrect readings.

Irregular spring tension, stretching of spring or reduction in tension due to improper handling or overloading of the instrument will result in errors. Other instrumental errors are calibration errors, causing the instrument to read high or low along its entire scale. These are many kinds of instrumental errors depending on the type of instrument used. Faults in instruments may be detected by checking for erratic behavior, stability and reproducibility of results.

(b) Environmental error:

These errors are due to conditions external to the measuring device such as effects of changes in temperature, humidity, barometric pressure. or of magnetic or electrostatic fields. For example, a change in ambient temperature at which the instrument is used to cause a change in elastic properties of the material of Vernier caliper and so affects the reading of the instrument. Corrective measures to reduce these effects should be taken accordingly.

2. Random error

These errors are due to unknown causes and occur even when all systematic errors have been accounted. Random errors are generally an accumulation of a large number of small effects and may be of r concern only in measurements requiring a high degree of accuracy. These errors are due to unknown causes, not determinable in ordinary process of making measurements. Such errors are normally and follow the laws of probability. Random errors can thus be tree mathematically. The sources for this type of errors are

1. Displacement of level joints in the measuring instrument
2. Small variation in the position of settings.
3. Reading scale error due to operator.

EXPERIMENT NO: 1

CALIBRATION OF BOURDON TUBE PRESSURE GAUGE USING DEAD WEIGHT PRESSURE GAUGE TESTER

INTRODUCTION

Dead weight pressure gauge tester is a testing instrument, which helps to calibrate and test the Pressure gauges. Here Dead weights are used to build the Pressure inside the Pressure chamber. Oil pump is fitted to the pressure chamber by which the oil is pumped to the pressure chamber. The pressure chamber has two outlets. One outlet is connected to oil tank through a control valve. The other outlet is connected to connect any pressure gauge which has to be tested or calibrated. The pressure chamber is fitted with a plunger arrangement also. By closing the control valve and by pumping the oil inside the pressure chamber the pressure increases inside the chamber and the plunger starts moving out. The dead weight calibrated for known pressure is kept on the plunger which will build the pressure inside the pressure chamber proportion to the weight on the plunger. By adding the weights on the plunger the pressure inside the chamber can be increased accordingly. The plunger is made to lift the weight till the mark on the plunger by pumping the oil into the pressure chamber by using oil pump.

SPECIFICATION

DEAD WEIGHT PRESSURE GAUGE TESTER

CAPACITY : 1 to 10 Kg/cm2

AREA : 0.196 Cm2

DEAD WEIGHTS : 1Kg -2Nos.,2 Kg -1 No.,5 Kg -1No.,

PLUNGER WEIGHT : 1 Kg

ACCURACY : 0.5%

LINEARITY : 0.5%

MAX. OVER LOAD : 150 %

TEST GAUGE : 14 Kg/cm2 Bourdon Pressure gauge

The Dead weight pressure gauge tester comprises of the following :

Hydraulic Pump: The pump fitted is of Single Cylinder reciprocating type oil pump

Oil Reservoir : Acrylic tank with metal cover to store oil to build the pressure.

Piston : Piston to load the dead weight. It is of 5mm diameter shaft. So the pressure built can be calculated as follows.

$$P = \frac{W}{A}$$

Where P is pressure built due to weight Kg / cm^2
W is the weight in Kg and
A is the area of the piston in cm^2

Speciman calculation : Weight required for 1 Kg/cm^2

$$\text{Area of the piston} = \frac{\pi \times D^2}{4}$$

D = diameter of the piston = 0.5 cms

$$A = \frac{\pi \times 0.5^2}{4} = 0.196 \text{ cm}^2$$

$$\text{So} \quad \text{Weight} = \frac{0.196}{1} = 0.196 \text{ Kg} = 196 \text{ Grams.}$$

So the Dead weight required to build 1 Kg/cm^2 Pressure is 196 Grams.

1/8" BSP Port : Pressure Port to connect Test gauge to the deadweight tester.

Control valve : Stainless steal Needle valve to control the pressure and to release the pressure.

OPERATING PROCEDURE

1. Fill the Oil tank with sufficient Oil. **(Hydraulic oil SERVO/CASTROL 40 grade)**
2. Release the AIR RELEASE VALVE provided at the bottom till the oil starts dripping
3. Continuously about 10 to 12 drops and tighter the release valve.

4. Release the control valve and pump the oil so that the oil circulates through the tubes. Pump for a wile about a minute so that all the tubes will be filled with oil and any air bubble inside the tube will be removed.
5. Now close the Control valve, and Pump the oil the plunger starts floating. Rotate the plunger gently. The plunger should rotate smoothly without any friction pump a little if the plunger is not rotating smoothly. The pressure is built inside the chamber proportion to the weight on the plunger. The Test Gauge fixed will starts showing the pressure.
6. Add 1 Kg dead weight on the plunger and pump once again till the mark on the plunger is visible. The pressure inside the chamber increases by 1Kg/cm2.
7. Add the weights on the plunger and pump till the line on the plunger is clearly visible.
8. The bourdon pressure gauge will read the pressure corresponding to the dead weights on the plunger.
9. Not down the readings on the pressure gauge and tabulate the readings with the corresponding readings to the dead weight. Plot the graphs for actual pressure (dead weights v/s pressure gauge reading. Calculate the accuracy, linearity and hysteresis of the pressure gauge.
10. Release the control valve slowly and remove the dead weights from the plunger.

NOTE: - Rotate the plunger along with the weights while taking the readings.

- Maintain sufficient quantity of oil in the oil tank.

- Do not pump when the AIR RELEASE VALVE IS loosened.

TABULAR COLUMN

1. SL No.	2 LOAD APPLIED (ATA)	3 ACTUAL PRESSURE IN Kg/CM^2	4 TEST GAGE READING IN Kg/CM^2	5 DEVIATION (3 – 4)
1				
2				
3				
4				
5				

$$\%\ \text{Linearity} = \frac{\text{Max error} \times 100}{\text{max. pressure}} \qquad = \frac{0.2}{5} \times 100 = 40\%$$

To calculate Linearity: Plat the graph for actual Pressure V/s Test gauge. Max. % error is the linearity of the Test gauge.

To calculate the Hysteresis of the Test gauge :- Tabulate the readings for Ascending and descending of loading and calculate the hysteresis for the test gauge

1. SL No.	2 LOAD APPLIED (ATA)	3 ASSENDING TEST GAUGE READING Kg/CM^2	4 DESENDING TEST GAGE READING IN Kg/CM^2	5 DEVEIATION (3 – 4)
1				
2				
3				
4				
5	4	4	4	4

$$\% \text{ Hysteresis} = \frac{\text{Max. Deviation} \times 100}{\text{max. pressure}}$$

Plot the Graph for both Assending and decending V/s Actual pressure to get the hystersis curve.
Area = 0.196 cm^2
Actual pressure = Load /Area = kg/cm^2
Load applied = atm = kg

RESULT

EXPERIMENT NO: 2

MEASUREMENT OF VIBRATION USING PIEZO ELECTRIC ACCELEROMETERS

INTRODUCTION

Many methods have been developed to measure linear and angular displacements, velocities, and accelerations. Displacements and accelerations are usually measured directly, while velocities are often obtained by integrating acceleration signals. The definitions of velocity and acceleration suggest that any convenient quantity can be measures and the other can be obtained by integrating or differentiating the recorded signal. Since the integration process is an error -smoothing process, while the differentiation process is an error-amplifying process, only the integration process is widely used for practical application. Displacement measurements are most frequently made in manufacturing and process-control applications, while acceleration measurement is made in vibration, shock, or motion-measurement situations. Piezo-electric material, an electric potential; appears across certain surfaces of a crystal if the dimension of the crystal are changed by the application of a mechanical force. This potential is produces by the displacement of charges. This effect is reversible and is known as *piezo-electric effect.* Elements exhibiting piezo-electric quality are often refered as electro-resistive effects.

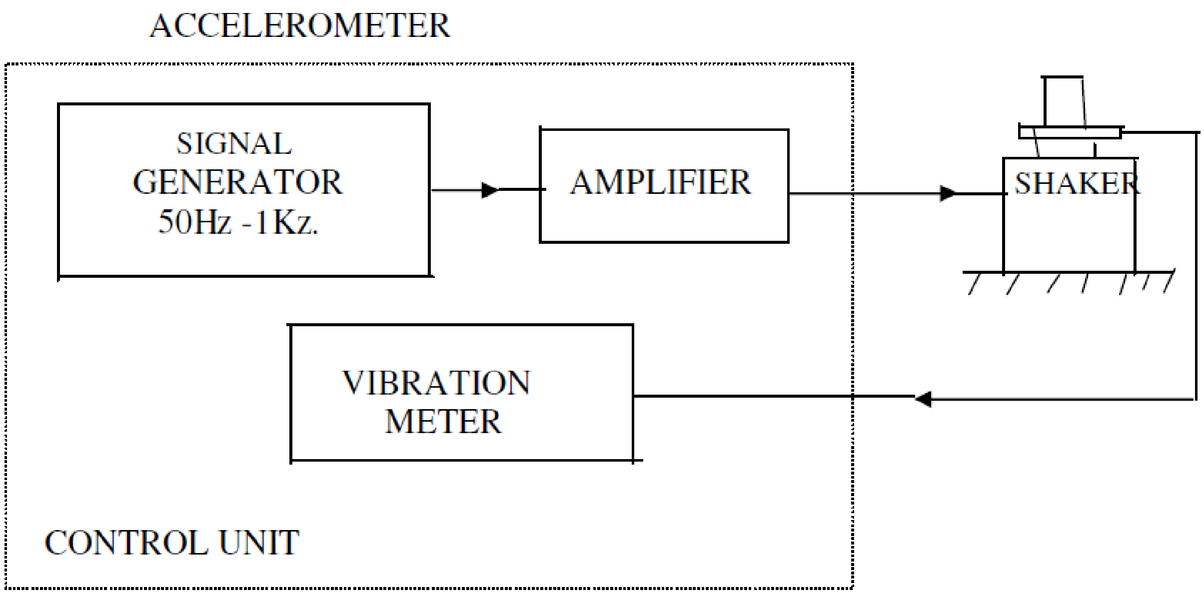
When a force F is applied to a piezo-electric crystal it develops a charge Q = d * F coulomb where is the charge sensitivity of the crystal in N/C. By incorporating a mass M in direct contact with the crystal, we get essential components of an accelerometer. By applying varying acceleration to the mass-crystal assembly, the crystal experiences a varying force which according to Newton's second law is given by Where ***a*** is the acceleration. This force produces a varying charge given by $Q = d\ X\ F = d\ Ma$ If the crystal has a capacitance C, the no load output voltage is $V_o = Q/C = (d\ X\ F)/C = d\ (Ma/C)$ Thus the output voltage is a measure of the acceleration.

The accelerometer is quit small in size and weight. The natural frequency is high of the order 100 kHz and hence can be used for any vibration and shock.

THE SETUP

Vibration Demo is designed as a laboratory set up which can be used to demonstrate the principles of Vibration measurement. It consists of a shaker and control unit. (Ref Block Diagram Fig.1.). The shaker is of the Electro-magnetic type; The control unit consist of a signal generator, power amplifier and vibration-meter.

The sinusoidal output from the signal generator is amplified by the amplifier and applied to the shaker, which generates vibrations on the spindle. The Accelerometer may be attached to the spindle through the M-5 stud. (supplied with the accelerometer). Signal output from the accelerometer is connected to the bivration meter, which gives direct read out of acceleration velocity or displacement.



BLOCK DIAGRAM FIG-1

SPECIFICATIONS

01.SHAKER :-
Force rating : 5 Newton (maximum)
Frequency Range : 50Hz to 1KHz.
(Max. Static load on shaker spindle : 100gm)
02. CONTROL UNIT :-
POWER OSCILLATOR:-
Frequency range : 50Hz to 1000Hz.
Output Voltage : 0-10V (p-p)
Distortion : <2%.
Measurement Range
Acceleration : 0.1-199.0 m/s2 (peak), (10Hx to 10 KHz).
Velocity : 0.01-19.99cm (rms), (10Hz to 3 KHz).
Displacement : .03-1.999mm (pp),(10Hz, to I KHx)
Output : Analog AC output 2V pK F.S.
(Minimum load 10 K ohms).
Operating Temperature : 0 degree to 40 degree C.
Accuracy : A - +/- 5% +/-1 LSB.
: V - +/- 5% +/-1 LSB
: D - +/- 5% +/-1 LSB

ACCELEROMETER:-
Charge sensitivity : 45 pC/ g -55pC/g.
Frequency range : 2-2000 Hz (5%).
Dynamic range : +/- 200 g.

Maximum shock : 1000g.
Maximum ambient : 60 degree Centigrade.
Temperature
Capacitance : 1000 pF.
Leakage Resistance : > 10,000 M ohms.
Construction : C.M.C.
Weight : 40 gms.
Type of Connection : Side.
Mounting Thread : M5.
Height : 35mm.
spanner Size : 18mm.

ACCESSORIES STANDARD.

1. Threaded steel studs M5 : 1No.
2. Co axial Cable 1m long with BNC Connector and crimped tags.

INSTALLATION

For Test Purpose the Shaker and Control Unit may be on a laboratory table. The Accelerometer should be mounted on the shaker spindle using the M-5 stud supplied with the accelerometer. Connect the accelerometer output to the input connector on the control unit using the 1mtr long low noise cable supplied. Connect the co-axial cable attached to the socket to the amplifier output connector on the control unit, and the power cable to a 230 V, 50 Hz outlet.

OPERATING PROCEDURE

1. Connect the sensor to the instrument through the BNC socket provided on the Back Panel mentioned SENSOR.

2. Connect the Vibration generator to the instrument through the cable provided at the rear panel of the instrument marked EXCITER.

3. Connect the instrument to the 230V 50Hz. Supply through cable provided at the rear panel.

4. Keep the FREQ. Pot and the VOLT pot in the minimum position.

5. Switch on the instrument, the display glows to indicate the power is on. In this Position Press the Tare button to make the readings Zero.

6. Turn the VOLT pot to the max position.

7. Now turn the FREQ pot in steps of 100 Hz. And note down the readings of Acceleration, Velocity, Displacement.

8. Tabulate the readings in the tabular column. Experiment can be repeated for different voltage levels settable through VOLT knob provided.

TABULAR COLUMN

Output (measurement parameters**):**

Acceleration : +/-5% of the reading value.

Velocity : +/-5% of the reading value

Displacement : +/-5% of the reading value

SAMPLE READINGS:

S.NO	Freq in Hz	Indicator Readings		
		Acc in M/s^2	Vel In cm/s	Display In mm

NOTE: The sample readings above tabulated are taken for a vibration sensor supplied with the vibration instrument with voltage set at max. level. The readings differ from one sensor to anther as the mass weight varies and the variation on the excitation given to the vibration exciter

GRAPHS

Graph can be plotted for Frequency V/s Acceleration, Velocity and displacement.

RESULT

EXPERIMENT NO: 3

MEASUREMENT OF VIBRATION USING VIBROMETERS

INTRODUCTION

Many methods have been developed to measure linear and angular displacements, velocities, and accelerations. Displacements and accelerations are usually measured directly, while velocities are often obtained by integrating acceleration signals. The definitions of velocity and acceleration suggest that any convenient quantity can be measures and the other can be obtained by integrating or differentiating the recorded signal. Since the integration process is an error -smoothing process, while the differentiation process is an error-amplifying process, only the integration process is widely used for practical application. Displacement measurements are most frequently made in manufacturing and process-control applications, while acceleration measurement is made in vibration, shock, or motion-measurement situations. Piezo-electric material, an electric potential; appears across certain surfaces of a crystal if the dimension of the crystal are changed by the application of a mechanical force. This potential is produces by the displacement of charges. This effect is reversible and is known as *piezo-electric effect.* Elements exhibiting piezo-electric quality are often refered as electro-resistive effects.

When a force F is applied to a piezo-electric crystal it develops a charge Q = d * F coulomb where is the charge sensitivity of the crystal in N/C. By incorporating a mass M in direct contact with the crystal, we get essential components of an accelerometer. By applying varying acceleration to the mass-crystal assembly, the crystal experiences a varying force which according to Newton's second law is given by Where ***a*** is the acceleration. This force produces a varying charge given by $Q = d X F = d Ma$ If the crystal has a capacitance C, the no load output voltage is $V_o = Q/C = (d X F)/C = d (Ma/C)$ Thus the output voltage is a measure of the acceleration.

The accelerometer is quit small in size and weight. The natural frequency is high of the order 100 kHz and hence can be used for any vibration and shock.

THE SETUP

Vibration Demo is designed as a laboratory set up which can be used to demonstrate the principles of Vibration measurement. It consists of a shaker and control unit. (Ref Block Diagram Fig.1.). The shaker is of the Electro-magnetic type; The control unit consist of a signal generator, power amplifier and vibration-meter.

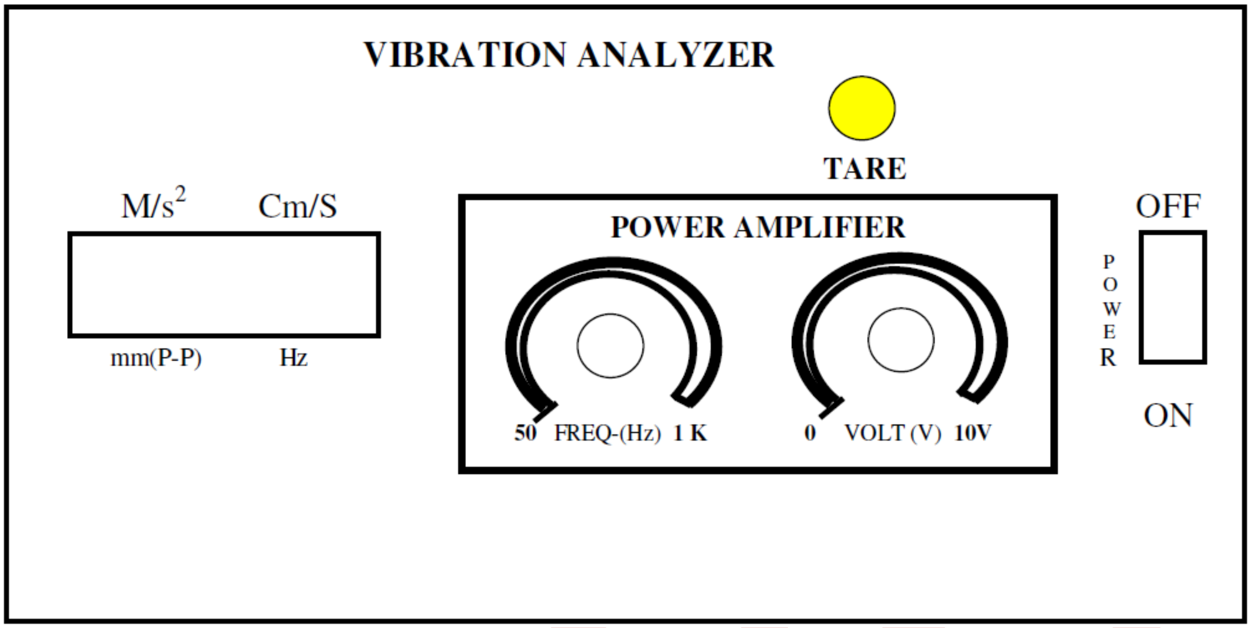
The sinusoidal output from the signal generator is amplified by the amplifier and applied to the shaker, which generates vibrations on the spindle. The Accelerometer may be attached to the spindle through the M-5 stud. (supplied with the accelerometer). Signal output from the accelerometer is connected to the bivration meter, which gives direct read out of acceleration velocity or displacement.

SPECIFICATIONS

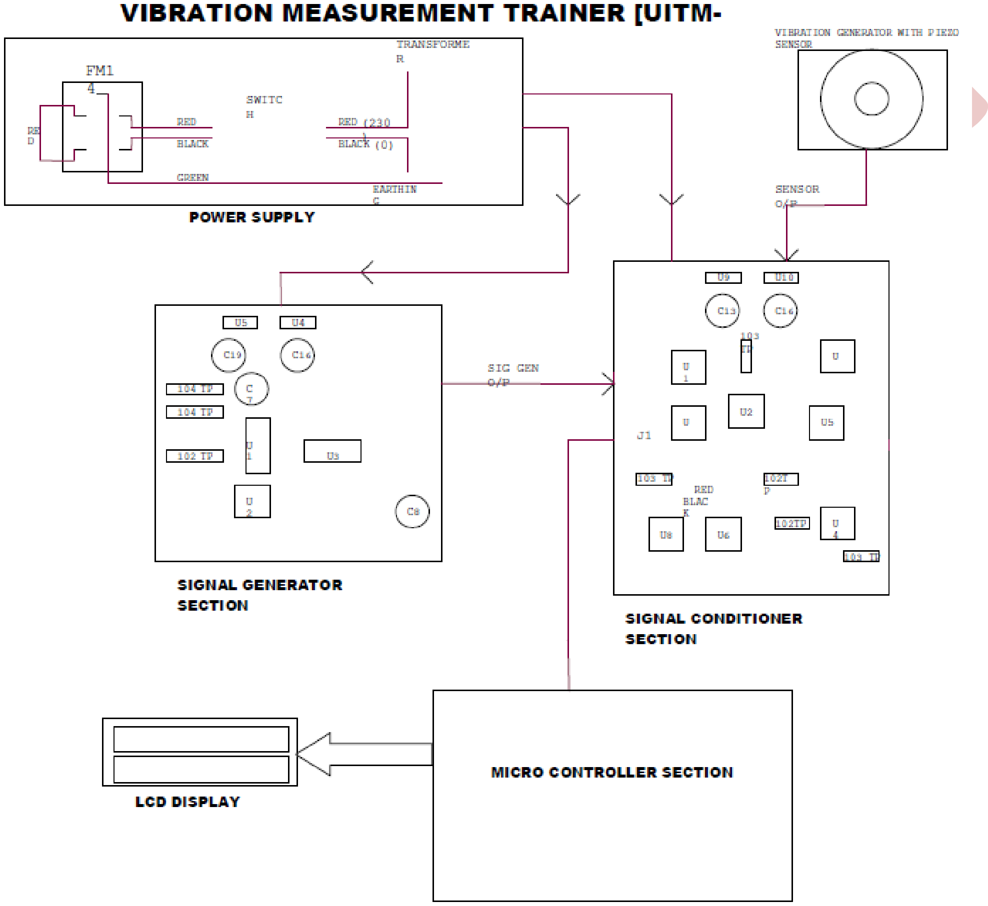
01.SHAKER :-
Force rating : 5 Newton (maximum)
Frequency Range : 50Hz to 1KHz.
(Max. Static load on shaker spindle : 100gm)
02. CONTROL UNIT :-
POWER OSCILLATOR:-
Frequency range : 50Hz to 1000Hz.
Output Voltage : 0-10V (p-p)
Distortion : <2%.
VIBRATION METER:-
Frequency Range : 10Hz to 10KHz.
Input impedance : > 10,000 M ohms.
Display : 3.5 digit LCD.
Source Capacitance : 30,000 pF.
Measurement Range
Acceleration : 0.1-199.0 m/s2 (peak), (10Hx to 10 KHz).
Velocity : 0.01-19.99cm (rms), (10Hz to 3 KHz).
Displacement : .03-1.999mm (pp),(10Hz, to I KHx)
Output : Analog AC output 2V pK F.S.
(Minimum load 10 K ohms).
Operating Temperature : 0 degree to 40 degree C.
Accuracy : A - +/- 5% +/-1 LSB.
: V - +/- 5% +/-1 LSB
: D - +/- 5% +/-1 LSB

INSTALLATION

For Test Purpose the Shaker and Control Unit may be on a laboratory table. The Accelerometer should be mounted on the shaker spindle using the M-5 stud supplied with the accelerometer. Connect the accelerometer output to the input connector on the control unit using the 1mtr long low noise cable supplied. Connect the co-axial cable attached to the socket to the amplifier output connector on the control unit, and the power cable to a 230 V, 50 Hz outlet.



VIBRATION MEASUREMENT TRAINER [UITM-



OPERATING PROCEDURE

1. Connect the sensor to the instrument through the BNC socket provided on the Back Panel mentioned SENSOR.

2. Connect the Vibration generator to the instrument through the cable provided at the rear panel of the instrument marked EXCITER.

3. Connect the instrument to the 230V 50Hz. Supply through cable provided at the rear panel.

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6. Turn the VOLT pot to the max position.

7. Now turn the FREQ pot in steps of 100 Hz. And note down the readings of Acceleration, Velocity, Displacement.

8. Tabulate the readings in the tabular column. Experiment can be repeated for different voltage levels settable through VOLT knob provided.

TABULAR COLUMN

Output (measurement parameters)**:**

Acceleration : +/-5% of the reading value.

Velocity : +/-5% of the reading value

Displacement : +/-5% of the reading value

SAMPLE READINGS:

S.NO	Freq in Hz	Indicator Readings		
		Acc in M/s^2	**Vel In cm/s**	**Display In mm**

NOTE: The sample readings above tabulated are taken for a vibration sensor supplied with the vibration instrument with voltage set at max. level. The readings differ from one sensor to anther as the mass weight varies and the variation on the excitation given to the vibration exciter

GRAPHS

Graph can be plotted for Frequency V/s Acceleration, Velocity and displacement.

RESULT

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EXPERIMENT NO: 4

ACOUSTIC MEASUREMENT USING SOUND LEVEL METER

THEORY

Human ears are most sensitive to frequencies between about 500Hz and 6kHz and less sensitive to frequencies above and below these. To allow the sound level meter or noise dosimeter to measure and report noise levels that represent what we hear, **Frequency Weightings** are used. These are electronic filters within the the instrument that are used to adjust the way in which the instrument measures the noise.

The most commonly used Frequency Weightings that you will see on a modern sound level meter or noise dosimeter are 'A', 'C' and 'Z' and below is a brief explanation of each of these.

'A' Frequency Weighting

'A' Weighting is standard weighting of the audible frequencies designed to reflect the response of the human ear to noise. At low and high frequencies, the human ear is not very sensitive, but between 500 Hz and 6 kHz the ear is much more sensitive.

The 'A' weighting filter covers the full frequency range of 20 Hz to 20 kHz, but the shape approximates to the frequency sensitivity of the human ear. So the A-weighted value of a noise source is an approximation to how the human ear perceives the noise.

Measurements made using A-weighting are usually shown with dB(A) to show that the information is 'A' weighted decibels or, for example, as LAeq, LAFmax, LAE etc where the A shows the use of A-Weighting.

'C' Frequency Weighting

'C' Weighting is a standard weighting of the audible frequencies commonly used for the measurement of Peak Sound Pressure level.

Measurements made using 'C' weighting are usually shown with dB(C) to show that the information is 'C' weighted decibels or, for example, as LCeq, LCPeak, LCE etc where the C shows the use of 'C' Weighting.

'Z' Frequency Weighting

Z weighting is a flat frequency response between 10Hz and 20kHz ±1.5dB excluding microphone response.

Measurements made using 'Z' weighting are usually shown with dB(Z) to show that the information is 'Z' weighted decibels or, for example, as LZeq, LZFmax, LZE

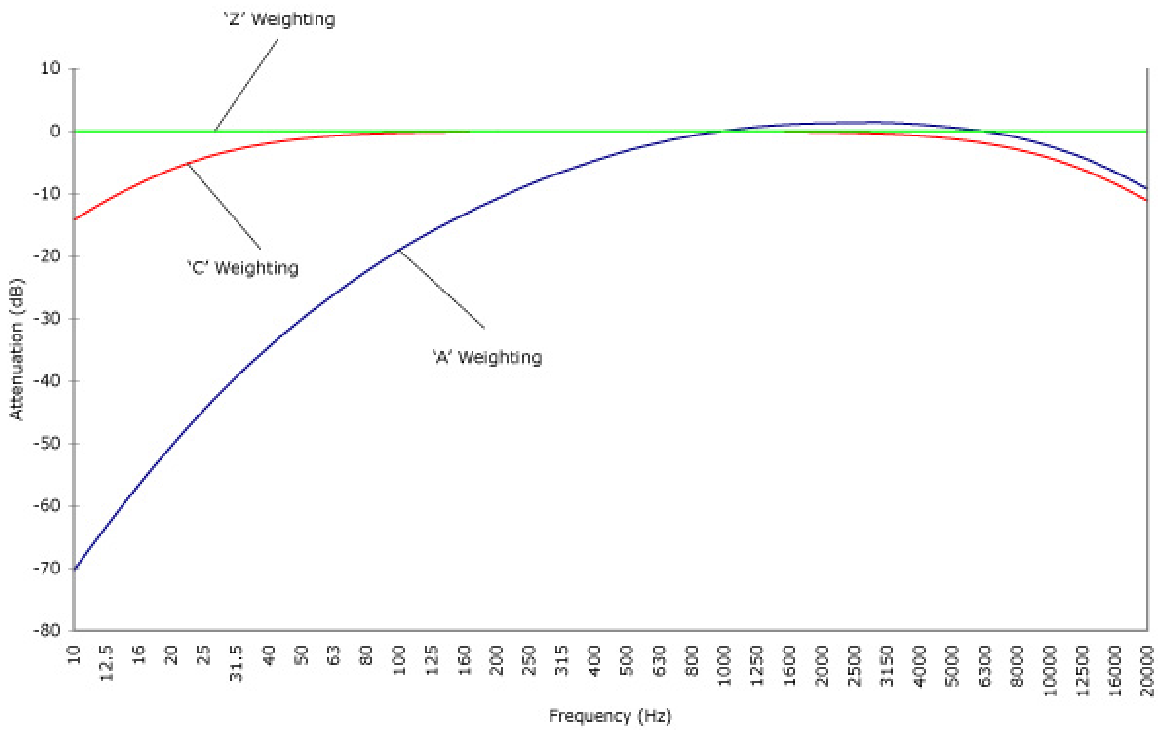


Figure: Frequency Weighting Curves – 'A', 'C' & 'Z'

SOUND PRESSURE LEVEL MEASUREMENTS

The object of this experiment is to measure and record the sound pressure levels (in dB) created by as many different types of sound sources as you can during your lab period.

PROCEDURE

Make the measurements suggested below using A weighting and then C weighting. Record all the data indicated by the Table headings below, including Source of Sound, Estimated Distance from Meters, dB (A weighting), dB (C weighting), and your subjective judgments of the loudness of the sounds (such as "very quiet", "medium", "loud", "very loud", etc.).

SOURCE OF SOUND	ESTIMATED DISTANCE FROM METER	SPL (dB) A-Weighting	SPL (dB) C-Weighting	COMMENTS ON SUBJECTIVE LOUDNESS

In general, what differences do you find between your measurements made with A and C weighting? Why do such differences exist?

RESULT

EXPERIMENT NO: 05(A)

STUDY AND USE OF LINEAR AND ANGULAR MEASURING DEVICES-VERNIER CALIPER

AIM :

To calibrate and measure the given component by using vernier caliper.

APPARATUS REQUIRED:

Slip gauges and Vernier Calliper.

THEORY:

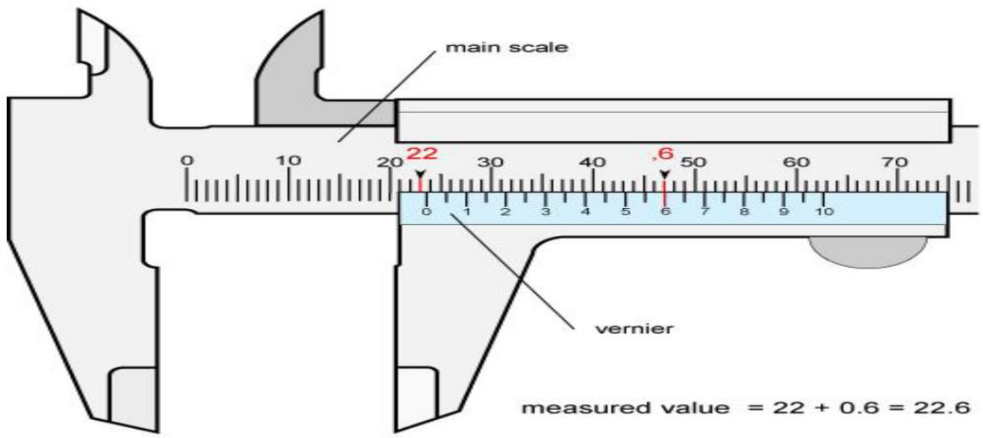
The Vernier Caliper is a precision instrument that can be used to measure internal and external distances extremely accurately. Measurements are interpreted from the scale by the user. This is more difficult than using a digital vernier caliper which has an LCD digital display on which the reading appears. Manually operated vernier calipers can still be bought and remain popular because they are much cheaper than the digital version. Also, the digital version requires a small battery whereas the manual version does not need any power source. The main use of the vernier caliper is to measure the internal and the external diameters of an object. To measure using a vernier scale, the user first reads the finely marked "fixed" scale (in the diagram). This measure is typically between two of the scale's smallest graduations. The user then reads the finer vernier scale which measures between the smallest graduations on the fixed scale providing much greater accuracy.

Example: On decimal measuring instruments, as in the diagram below, the indicating scale has 10 graduations that cover the same length as 9 on the data scale. Note that the vernier 10th graduation is omitted.

The method to use a vernier scale or caliper with zero error is to use the formula: actual reading = main scale + vernier scale − (zero error). Zero error may arise due to knocks that cause the calibration at the 0.00 mm when the jaws are perfectly closed or just touching each other.

When the jaws are closed and if the reading is 0.10mm, the zero error is referred to as +0.10mm. The method to use a vernier scale or caliper with zero error is to use the formula 'actual reading = main scale + vernier scale − (zero error)' thus the actual reading is 19.00 + 0.54 − (0.10) = 19.44 mm

Positive zero error refers to the fact that when the jaws of the vernier calip r are just closed, the reading is a positive reading away from the actual reading of 0.00mm. If the reading is 0.10mm, the zero error is referred to as +0.10 mm.



CALIBRATION OF VERNIER CALIPER:

S.NO	Slip gauge in mm	MSD	VSD	Output value in mm	Actual value in mm	Error in mm
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

When the jaws are closed and if the reading is −0.08mm, the zero error is referred to as −0.08 mm. The method to use a vernier scale or caliper with zero error is to use the formula 'actual reading = main scale + vernier scale − (zero error)' thus the actual reading is 19.00 + 0.36 − (−0.08) = 19.44 mm

Negative zero error refers to the fact that when the jaws of the vernier caliper are just closed, the reading is a negative reading away from the actual reading of 0.00mm. If the reading is 0.08mm, the zero error is referred to as −0.08mm.

PRINCIPLE:

Vernier Calipers is the most commonly used instrument for measuring outer and inner diameters. It works on the principle of Vernier Scale which is some fixed units of length (Ex: 49mm) divided into 1 less or 1 more parts of the unit(Ex: 49mm are divided into 50 parts). The exact measurement with up to 0.02mm accuracy can be determined by the coinciding line between Main Scale and Vernier Scale. Total Reading = M.S.R + L.C X V.C

Where:

M.S.R – Main Scale Reading

L.C – Least Count

V.C – Vernier Coincidence

PROCEDURE:

Calibration

1. With the help of slip gauges as standard, calibrate the gauges.
2. Plot a graph of (i) STD Input vs Output and (ii) Standard Input vs Error .

Measurement

1. Place the work piece and the gauge appropriately and carry out the measurement of the job.
2. Prepare a report of the measurement and indicate the characteristics of the work pieces.

RESULT

EXPERIMENT NO: 05(B)

STUDY AND USE OF LINEAR AND ANGULAR MEASURING DEVICES- OUTSIDE AND INSIDE MICROMETER

AIM:

To calibrate the micrometer using slip gauges

APPARATUS:

Micrometer, slip gauges

OBJECTIVES:

Students will be able to know 1. To know the use and working of slip gauges 2. To know the classification and working of slip gauges

THEORY:

Slip gauges are end standards used in linear measurements. They are used in workshop for work where a tolerance as low as 0.001mm is needed. Slip gauges were invented by Swedish engineer, C.E. Johnson, so they are also called Johnson gauges. Slip gauges are rectangular blocks, made of high grade steel, having cross section about 30mm X10mm. These blocks are made into required sizes and hardened to resist wear and allowed to stabilize so as to relieve internal stresses. This prevents occurrence of size and shape variations. After hardening the blocks, measuring faces are carefully finished to fine degree of surface finish, flatness and accuracy. This high grade surface finish is obtained by super finishing process known as lapping.

Wringing of slip gauges:

The measuring face of the gauges is flat and it possesses high surface finish. If two slip gauges are forced against each other on measuring faces, because of contact pressure, gauges stick together and considerable force is required to separate these blocks. This is known as wringing of slip gauges. Thus, wringing refers to condition of intimate and complete contact and of permanent adhesion between measuring faces. Slip gauges are wrung to build desired dimension. Slip gauges are wrung together by hand and no other external means. Figure shows 1) Parallel wringing of slip gauges and 2) Cross wringing of slip gauges. **In cross wringing** – the two slip gauges are first cleaned to remove dirt and then they are placed together at right angles in the form of cross and then rotated through 90o, while being pressed together. This method causes less rubbing of surfaces. Almost any dimension may be built by suitable combination of gauges. Wringing phenomenon is purely due to surface contact and molecular adhesion of metal of blocks. Hence, **―wringing** is **defined** as the property of measuring faces of gauge blocks of adhering, by sliding or pressing the gauge against measuring faces of other gauge blocks or reference faces or datum surfaces without the use of external means.

Uses/Applications of slip gauges

1. as a reference standard.
2. for verification and calibration of measuring apparatus.
3. for adjustment of indicating devices.
4. for direct measurement.
5. for setting of various types of comparators.
6. Micrometres are used to measure the small or fine measurements of length, width, thickness and diameter of the job.

Observation table:

Range: Least count: Make:

Sr. No	Slip gauges in combination	Micrometer reading in mm				
		Increasing	Decreasing	Average	Error	Correction
1						
2						
3						
4						
5						
6						

Determining the dimension of 29.758mm by M45 slip gauge set:

Rule 1:-Minimum number of slip gauges should be used to build dimension.

Rule 2:- Always start with the last decimal place.

Hence to build the dimension of 29.758 we need slip gauges of 20mm, 6mm, 1.7mm, 1.05mm and 1.008mm.

Procedure	Last decimal	Calculation
a) Write the required dimension		
b) Starting with last decimal place i.e. 0.008 But we can use 1.008 as to follow rule 1.		
c) After subtraction the value remaining is 28.75. Here the last decimal place is 0.05 but we can use 1.05 slip gauge set so as to follow rule 1		
d) Value remaining is 27.7 i.e last decimal place is 0.7 But we can use 1.7mm slip gauge so as to follow rule 1.		
e) Now the value remaining is 26 mm and we have 6mm gauge block available.		
f) Final value is 20mm and this gauge is available. Remainder should always be zero		

PROCEDURE OF PERFORMING EXPERIMENT:

(1) Clean the fixed vice and micrometer

(2) Clamp the micrometer in vice putting cushioning material between micrometer and jaws of vice to protect the micrometer from probable damage due to clamping force.

(3) Make pile of gauge blocks and insert between two anvils of the micrometer and take reading.

(4) Increase the value of gauge blocks pile and take next few readings.

(5) Then decrease the value of gauge blocks pile and take same readings in decreasing order.

(6) Tabulate the readings

(7) After cleaning the place the gauge blocks should be placed in their respective places.

Particulars of M87 and M45 slip gauge set

M87 is a special set of slip gauges

Range (mm)	Steps	Pieces

M45 is a normal set of slip gauges

Range (mm)	Steps	Pieces

RESULT

EXPERIMENT NO: 05(C)

STUDY AND USE OF LINEAR AND ANGULAR MEASURING DEVICES- SINE BAR

AIM:

To determine the taper angle of the given work piece and compare it with theoretical value by using sine bar.

APPARATUS:

Surface plate, sine bar, slip gauge sets, Vernier calliper, cleaning agent, tapered work piece, clean dry soft cloth, clamping devices etc.

THEORY:

Sine bar is a precision instrument used along with slip gauges for accurate angle measurements or angle setting. Sine bar consists of an accurate straight bar in which two accurately lapped cylindrical plugs or rollers are located with extreme position. **The straight bar** are made of high carbon, high chromium, corrosion resistant steel and the surfaces are hardened, grounded and lapped. Ends of the straight bar are stepped so that the plugs can be screwed at each step. Plugs are the two rollers of same diameter fixed at a distance L between them and is called as length of the bar. This distance L is the centre to centre distance of plugs is which is generally 100, 200 and 300 mm and so on.

Use of Sine bar: The work piece whose angle is to be measured is placed on sine bar. Below one roller of sine bar, slip gauges are placed. Slip gauges are added till the work piece surface is straight. Dial indicator is moved from one end of work piece till another end. Slip gauges are added till dial pointer does not move from zero position. The use of sine bar is based on the laws of **trigonometry**. When sine bar set up is made for the purpose of angle measurement, sine bar itself forms hypotenuse of right angle triangle and slip gauges form the side opposite to the required angle**. Sin θ= (h/L),** Therefore θ= sin-1(h/L), Angle θ is determined by an indirect method as a function of sine so this device is called as sine bar. Sine bar is always used in conjunction with slip gauge and dial indicator for the measurement of angle.

The angle is defined as the opening between the two lines or planes, which meet at a point. So angle is a thing which can be generated very easily requiring no absolute standard. Sine bars are used in junction with slip gauges constitute a very good device for the precision measurement of angles. Since sine bars are used either to measure angle very accurately or for locating any work to a given angle within very close limit. Sine bars are used only for measuring and setting any angle of the object having flat surface. Sine bars are also used to measure or set angle of the object not larger than the 450, if higher accuracy is demanded.

OBSERVATIONS:

1. Least count of vernier calliper = ____________ mm
2. Least count of dial gauge = ____________ mm
3. Distance between the centre of rollers & side bar L =   mm
4. Length of specimen (taper length), l = ____________ mm

Tabular Column

SL No	Taper length of the specimen 'l' mm	Height for one side of the work piece 'h'1 mm	Height for another side of the work piece 'h2' mm	Diff. of height dh = $(h_2 - h_1)$	App. Ht. of slip gauge Read. H_{app}.	Actual Ht. of slip gauge Read. H_{act}	Theoretical taper angle, θ_{th}	Actual taper angle, θ_{act}	Error
1									
2									

Calculations:

7) Height for one side of the work piece $'h_1' =$ -------------- mm

8) Height for another side of the work piece $'h_2' =$ -------------- mm

9) Difference in height $dh = (h_2 - h_1) =$ -------------- mm.

10) Approximate height of slip gauge used = $H_{app.}$

$$H_{app.} = \frac{dh \times L}{\sqrt{dh^2 + l^2}} \quad \text{-------------- mm}$$

11) Theoretical taper angle, $\theta_{th} = \tan^{-1}(dh/l) =$ ------------- Degrees

30

12) Actual taper angle, θact = [sin-1 (Hact)] /L = ----------- Degrees

0.5

13) Error θact - θthe =--------------- Degrees

APPLICATIONS:

1. To measure and/ or set the angle accurately using a sine bar, the main requirement is that it must be accurate.

2. To check the flat surfaces in industry machine tools like lathe beds, milling machines columns, tables, apron & also saddle in lathe.

3. Rolling mills housing can be checked by sine bars.

PROCEDURE:

1. Set the sine bar on the surface plate.

2. Measure the distance between rollers of center of sine bar.

3. Mark the position of the rollers on the surface plate which is advantage if the position of sine bar is changed.

4. The axial length of taper under test is noted by use of vernier calliper.

5. The work piece whose taper is required to be known is fixed on the upper surface of the sine bar by means of clamp and so positioned that easily access whole length of the taper to the dial gauge.

6. The dial gauge is fixed on its stand which in term is fixed on the slide way.

7. Note down the least count of the dial gauge used.

8. Adjust the slip gauge height on the taper to be measure in such a way that it easily takes slip on the smaller end and note down dial gauge reading at the entry end.

9. By sliding the dial gauge across the work piece length take reading of the dial gauge on other end.

10. Calculate approximate height of slip gauge required at smaller dimension end in order to become an upper surface of the work piece parallel to the reference plane.

11. Without altering the position of the roller place the slip gauge pile under the roller of small size end of the sine bar set up to equal approximate height.

12. Then test with dial gauge for null deflection. If there is any slight deflection in dial gauge then alter slip gauges pile until getting null deflection.

13. With the help of formulas given in, calculate the actual angle and theoretical angle of taper and error in taper.

RESULTS:

EXPERIMENT NO: 6

MEASUREMENT OF TEMPERATURE USING RADIATION PYROMETER AND INFRARED PYROMETER

Non-contact temperature measurement-Radiation pyrometer and infrared pyrometer-Time constant of temperature measuring device

AIM:

To measure the temperature of a hot body using pyrometers

THEORY:

The optical pyrometer principle is based on Planck's Radiation Law. The law is given below:

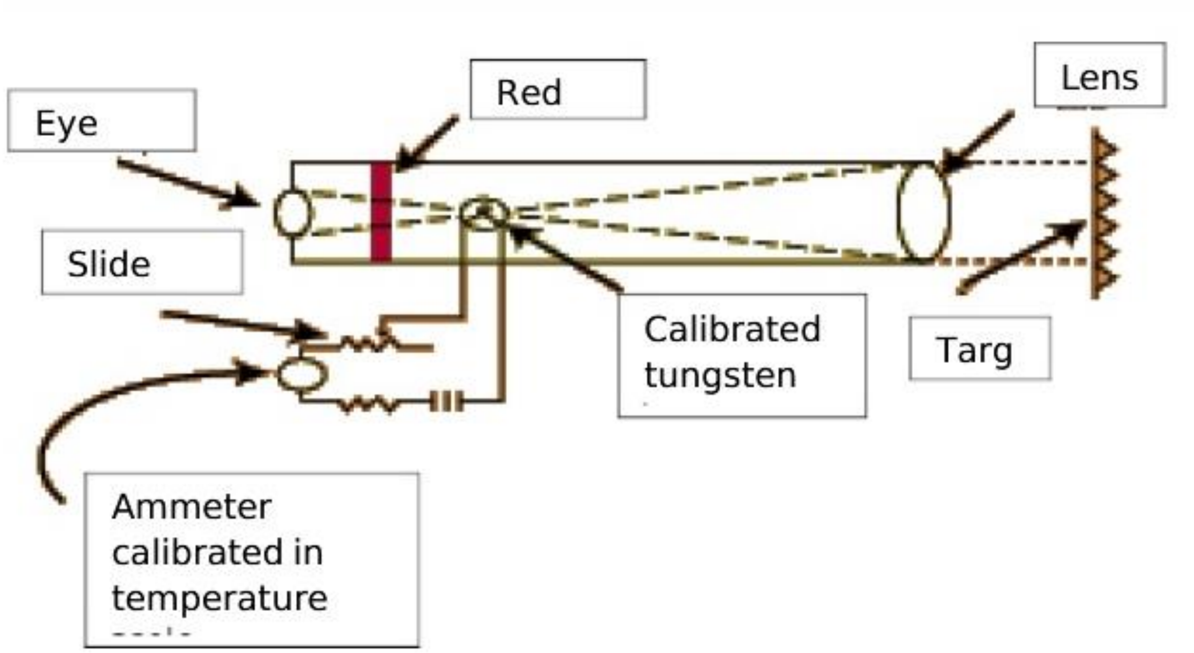
The primary law governing blackbody radiation is the Planck Radiation Law. This law governs the intensity of radiation emitted by unit surface area into a fixed direction (solid angle) from the blackbody as a function of wavelength for a fixed temperature.

The Planck Law can be expressed through the following equation.

$$I_b(\lambda,T) = \frac{2hc^2}{\lambda^5}\frac{1}{e^{\frac{hc}{\lambda kT}}-1} Wm^{-2}sr^{-1}\mu m^{-1}$$

h = 6.625 X 10^{-27} erg-sec (Planck Constant)
K = 1.38 X 10^{-16} erg/K (Boltzmann Constant)
C = Speed of light in vacuum
λ = Wavelength of the emission
T = Absolute temperature of the body.

Optical pyrometers are narrow-band or two-color radiation pyrometers that operate in the visible spectrum around the 0.65-μm point. The human eye, acting as the detector in the manually balanced type, compares a source of known radiant energy generated within the instrument by a calibrated tungsten lamp to the incoming unknown source. A filter interposed between the eye and both sources of energy cuts out the shorter wavelengths. This serves a dual purpose: (1) it minimizes the difference between eyes, permitting an easier color match, and (2) it permits an extension of the temperature range beyond the point where the eye could no longer tolerate the amount of energy if viewed directly. The instrument is shaped to be held in the hand and up to the eye so that it may be sighted on the target. An adjustable focus permits the operator to focus an image of the source whose temperature is to be determined. The filament of the standard source is placed on the same plane as this image so that the two appear superimposed on one another when viewed through the eyepiece. A null type of balance is usually used where a rheostat, moving against a calibrated dial, is manually rotated to vary the current through the standard source until it just disappears into the field of the unknown. A slight modification of this principle maintains the standard source constant and varies the amount of interposing absorbing gate opening in the optical path. The range of the manual optical pyrometer is limited on the low end to a minimum of 1400°F(760°C), since there is insufficient emission of visible light for an accurate comparison below this figure. At 2400°F (1316°C), the image would become too bright to look at directly, but filters are usually interposed to permit readings as high as 6300°F (3500°C). The use of the human eye as the detector restricts accuracy somewhat. This is because the eye responds to both color and brightness rather than directly to energy and no two eyes area like. However, it is possible to detect both a color and a brightness match by adjusting to the minimum difference between known and unknown. The schematic diagram of an optical pyrometer is given below:



A bridge circuit can be used to detect the temperature. As, changing the slide wire the current through tungsten wire is controlled, the temperature of the wire is directly proportional to the slide wire resistance. Using Wheatstone bridge arrangement we can detect the resistance change and thereby the temperature. In this case the null detecting voltmeter must be calibrated in temperature scale as its deflection is the measure of temperature.

TABULAR COLUMN RADIATION PYROMETER

SL NO	VOLTAGE	TEMPERATURE

TABULAR COLUMN INFRARED PYROMETER

SL NO	SPECIMEN	TEMPERATURE

RESULTS:

EXPERIMENT NO: 7
STARIN GAUGE PRESSURE CELL

AIM:

To calibrate the strain gauge pressure cell.

APPARATUS REQUIRED:

Strain Measurement Trainer

THEORY:

When a material is subjected to any external load, there will be small change in the mechanical properties of the material. The mechanical property may be, change in the thickness of the material or change in the length depending on the nature of load applied to the material. This change in mechanical properties will remain till the load is released. The change in the property is called strain
in the material or the material get strained. So the material is mechanically strained, this strain is defined as ' The ratio between change in the mechanical property to the original property'. Suppose a beam of length L is subjected to a tensile load of P Kg the material gets elongated by a length of Δl So according to the definition strain S is given by
$S = \Delta l / L$ ....Eq 1
Since the change in the length of the material is very small it is difficult to measure ıl. So the strain is always read in terms of microstrain. Since it is difficult to measure the length Resistance strain gauges are used to measure strain in the material directly. Strain gauges are bonded directly on the material using special adhesives. As the material get strained due to load applied, the resistance of the strain gauge changes proportional to the load applied. This change in resistance is used to convert mechanical property in to electrical signal which can be easily measured and stored for analysis.The change in the resistance of the strain gauge depends on the sensitivity of the strain gauge. The sensitivity of strain gauges is usually expressed in terms of a gauge factor SgwhereSg is given as
□R / R = Sg ....Eq 2
Where ı is Strain in the direction of the gauge length. The output □R / R of a strain gauge is usually converter in to voltage signal with a Whetstones bridge, If a single gauge is used in one arm of whetstones bridge and equal but fixed resistors is used in the other arms, the output voltage is
Eo = Ei / 4 (□Rg / Rg) .....Eq 3
Substituting Eq 2 into Eq 3 gives
Eo = 1/4 (EiSgı) .....Eq 4
The input voltage is controlled by the gauge size (the power it can dissipate) and the initial resistance of the gauge. As a result, the output voltage Eo usually ranges between 1 to 10 microV / microunits of strain.

SPECIFICATIONS:

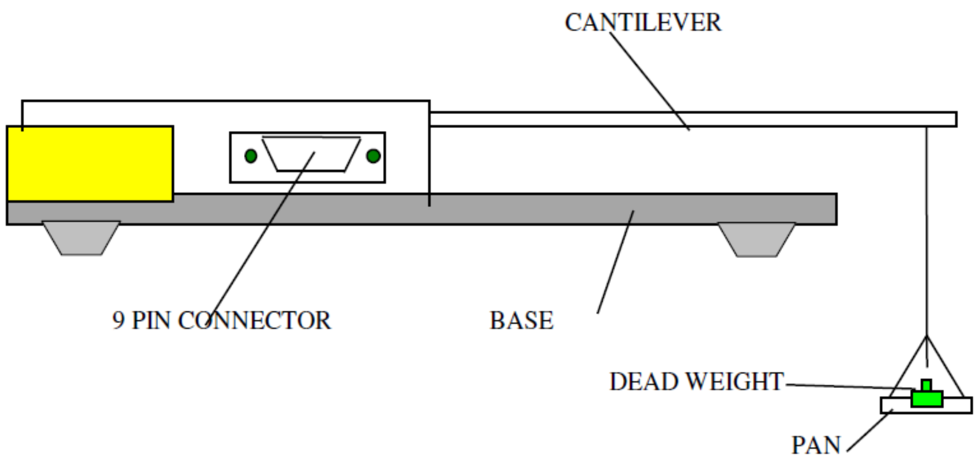
DISPLAY RANGE : 31/2 digit RED LED display of 200 mV FSD to readup to +/-1999 microstrain .
GAUGE FACTOR SETTING : 2.1
BALANCE : Potentiometer to set zero on the panel.
BRIDGE EXCITATION : 10V DC
BRIDGE CONFIGURATIONS : Full Bridge.

MAX. LOAD : 1Kg.
POWER : 230 V +/- 10% at 50Hz. with perfect grounding.
All specifications nominal or typical at 230 C unless noted.

CANTILEVER BEAM SPECIFICATION

MATERIAL : Stainless Steel
BEAM THICKNESS (t) : 0.25 Cm.
BEAM WIDTH (b) : 2.8 Cms.
BEAM LENGTH (Actual) : 22 Cms.
YOUNGS MODULUS (E) : 2 X 106 Kg / cm2.
STRAIN GAUGE : Foil type gauge
GAUGE LENGTH (l) : 5 mm
GAUGE RESISTANCE (R) : 300 Ohms.
GAUGE FACTOR (g) : 2.01

CANTLIVER BEAM SETUP



PHYSICAL DIMENTIONS

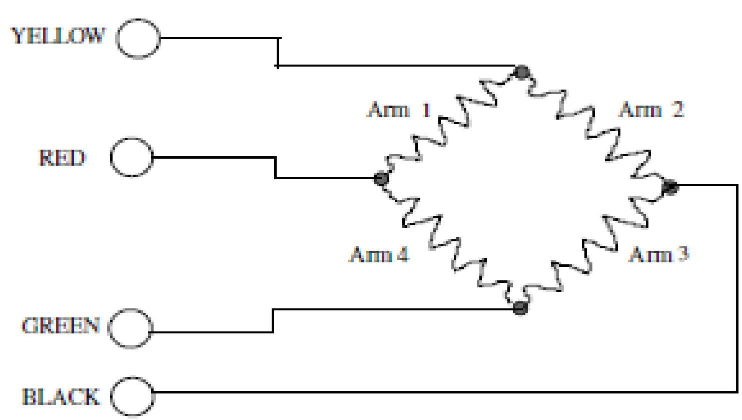
Over all BEAM Length (X) : 300 mm
Actual Length (L) : 220.0 mm (Middle of the Strain Gauge Grid to loading point)
Width of the Beam (b) : 28.0 mm
Thickness of the Beam (t) : 2.5 mm

PROCEDURE

1. Check connection made and Switch ON the instrument by toggle switch at the back of the box. The display glows to indicate the instrument is ON.

2. Allow the instrument in ON Position for 10 minutes for initial warm-up.
3. Adjust the ZERO Potentiometer on the panel till the display reads ‘000’.
4. Apply 1 Kg load on the cantilever beam and adjust the CAL potentiometer till the display reads 377 micro strains. (as per calculations given below) Remove the weights the display should come to ZERO in case of any variation adjust the ZERO pot again and repeat the procedure again. Now the Instrument is calibrated to read micro-strain.
5. Apply load on the sensor using the loading arrangement provided in steps of 100g up to 1Kg.
6. The instrument displays exact micro strain strained by the cantilever beam
7. Note down the readings in the tabular column. Percentage error in the readings, Hysteresis and Accuracy of the instrument can be calculated by comparing with the theoretical values.

CONNECTION DETAILS



Specimen calculation for cantilever beam

$$S = (6\,P\,L) / BT^2E$$

P = Load applied in Kg. (1 Kg)
L = Effective length of the beam in Cms. (22 Cms)
B = Width of the beam (2.8 Cms)
T = Thickness of the beam (0.25Cm)
E = Youngs modulus (2×10^6)
S = Microstrain

Then the microstrain for the above can be calculated as fallows

$$S = \frac{6 \times 1 \times 22}{2.8 \times 0.25^2 \times (2 \times 10^6)}$$

$$S = 3.77 \times 10^{-4}$$

S = 377 microstrain.

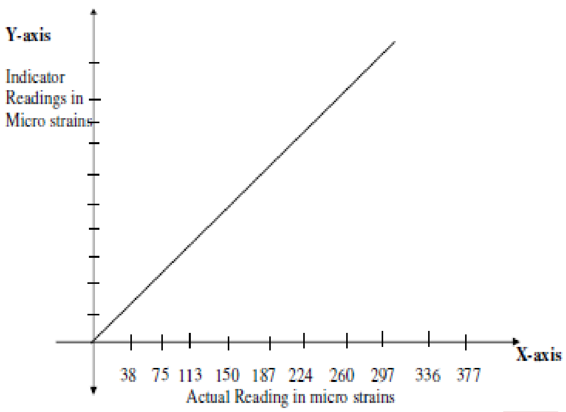
TABULAR COLUMN

S.NO	**Weight**	**Actual readings (using formulae) S =(6PL)/BT²E**	**Indicator readings (in micro strains)**	**ERROR in %**

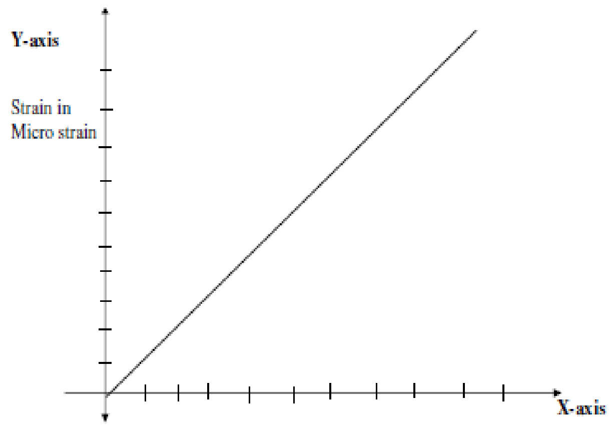
$$\% \text{ ERROR} = \frac{[(\text{Actual Reading (C)} - \text{Indicator Readings (D)}] \times 100}{\text{Max. Weight in gms}}$$

GRAPH

Graph : Graph Plotted Actual Readings (X-axis) Vs Indicator Readings (Y-axis)



Load Vs Strain



RESULT AND DISCUSSION

EXPERIMENT NO: 8

METROLOGY

MEASUREMENT OF SURFACE FINISH USING STYLUS TYPE SURFACE ROUGHNESS MEASURING DEVICE

TIME 3100 SURFACE ROUGHNESS TESTER

Product Description:

Portable Surface Roughness Tester - TIME3100 is a pocket-sized economically priced instrument for measuring surface texture conforming to traceable standards. It can be used on the shop floor in any position, horizontal, vertical or anywhere in between.

The large LCD display shows either roughness parameter Ra or Rz at the touch of a button, combined with the selected cut-off length. External calibration of roughness values is possible by means of a special CAL button, which makes adjustment of this instrument very easy. A beep signal informs the user of each individual measurement status when ready

OBJECTIVE

To study the effects which variations in the parameters of the primary machining process of turning have on the surface finish of a work piece.

EQUIPMENT

TIME 3100 SURFACE ROUGHNESS TESTER, Lathe, mild steel work piece, hand tachometer, and safety glasses.

DISCUSSION

Primary machining uses heavy roughing cuts to remove large amounts of material. Secondary machining follows primary machining taking lighter cuts to improve surface finish and dimensional accuracy. The allowable surface roughness of a part to be machined depends on factors such as functions and size of the part, fit and dimensional accuracy required, loading requirements, and required motion and wear characteristics.

In most cases the character of a machined surface depends upon the process used to produce it. For example, there are several sources of roughness when machining with a single point tool: (1) feed marks left by the cutting tool; (2) built-up edge fragments embedded in the surface during the process of chip formation; (3) chatter marks from vibration of the tool, work piece, or machine tool itself. When a surface is turned at high speed without chatter present, the primary surface roughness lies in an axial direction and may be computed quite accurately from the feed and the tool geometry. (The average roughness expressed in micro-inches for a turned surface is approximately equal to feed/60.)

PROCEDURE

1. Understand the operating instructions for the lathe as presented to you by the instructor.
2. Observe the cutting edge of the carbide insert under a microscope to assure that the cutting edge is free from flaws and defects.
3. Divide the surface of the work piece into nine 1.5" segments. Machine these segments at the various combinations of feeds (0.004, 0.007, 0.010 ipr) and speeds (150, 300, 450 rpm), using a constant .020 inch depth of cut.
4. After turning the surface of the given workpiece, clean off the workpiece (i.e., remove chips and oil from it) measure the surface roughness of the workpiece using the portable surface analyzer.

Take four readings for each segment by rotating the workpiece 90° after each reading. Record all data on the "Data Sheet" below. Calculate the average surface roughness.

DATA SHEET FOR SURFACE FINISH EVALUATION

Cutting Speed (sfpm)	Feed (ipr)	Surface Roughness (µin.)				Average Roughness (µin.)
		1	2	3	4	

RESULT

EXPERIMENT NO: 9

MEASUREMENT OF TOOL WEAR USING TOOL MAKERS MICROSCOPE

AIM :-

Experiment on tool maker's microscope

APPARATUS :-

Tool maker's microscope, specimen

THEORY :-

INTRODUCTION:-

The tool maker's microscope is a versatile instrument that measure by optical means with no pressure being involved, thus very useful for measurement on small and delicate parts.

It is designed for:

a) Measurement on parts of complex form e.g. - profile of external thread, tool, templates, gauges, etc.

b) Measuring centre to centre distance of holes in any plane.

c) A variety of linear measurements.

d) Accurate angular measurements.

Tool maker's microscope is shown in fig. The optical head can be moved up or down the vertical column and can be clamped at any height by means of clamping screw. The table which is mounted on the base of the instrument can be moved in two mutually perpendicular horizontal directions (longitudinal and lateral) by means of accurate micrometer screw having thimble scale and venires.

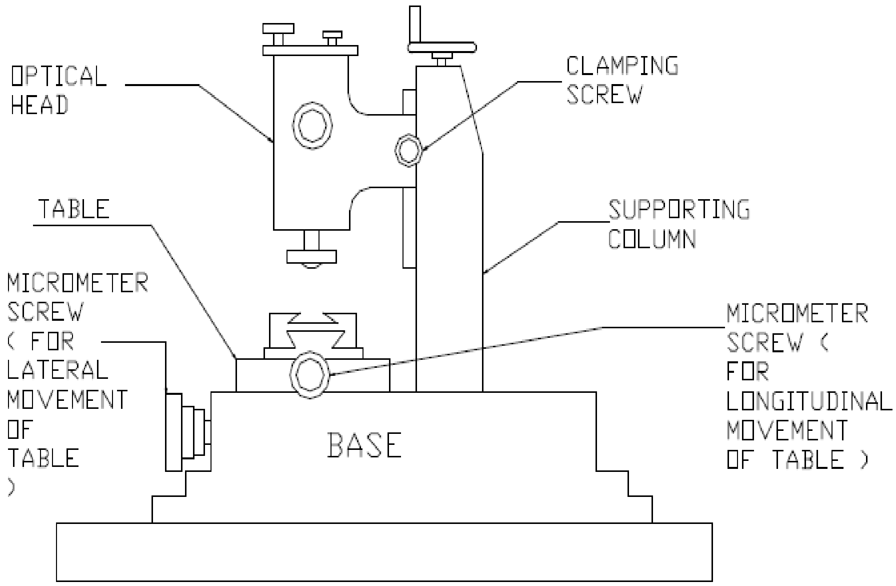


Fig. Tool Maker's Microscope

PRINCIPLE OF MEASUREMENT:

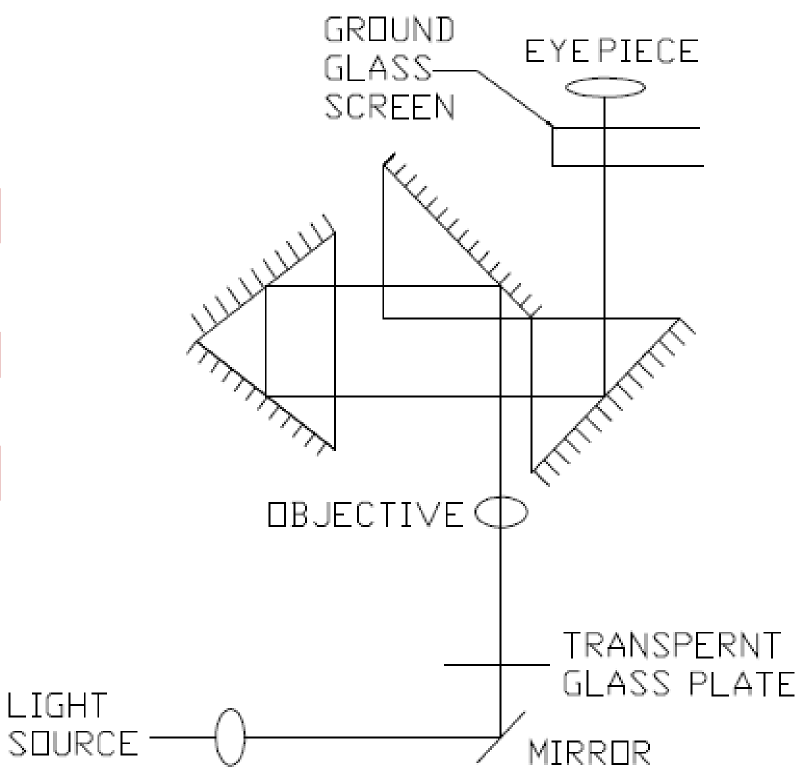


fig. Principle of operation.

A ray of light from a light source fig. b is reflected by a mirror through 90' It then passes through a transparent glass plate (on which flat parts may be placed). A shadow image of the outline or counter of the workspaces passes through the objective of the optical head and is projected by a system of three prisms to a ground glass screen. Observations are made through an eyepiece. Measurements are made by means of cross lines engraved on the ground glass screen. The screen can be rotated through 360'; the angle of rotation is read through an auxiliary eyepiece.

PROCEDURE: -

PITCH MEASUREMENT: -

1) Take the hacksaw blade and mount on the moving blade of tool maker's Microscope in horizontal position.

2) Focus the microscope on the blade.

3) Make the cross line in the microscope coincided with one of the edge of the blade.

4) Take a reading on ground glass screen, this is the initial reading.

5) The table is again moved until the next edge of the blade coincides with the cross-line on the screen and the final reading takes.

6) The difference between initial and final reading gives pitch of the blade.

TEETH ANGLE :-

1) Place the blade on the table in same position.

2) Rotate the screen until a line on the angle of screen rotation is noted.

3) Take the angular reading, the initial one.

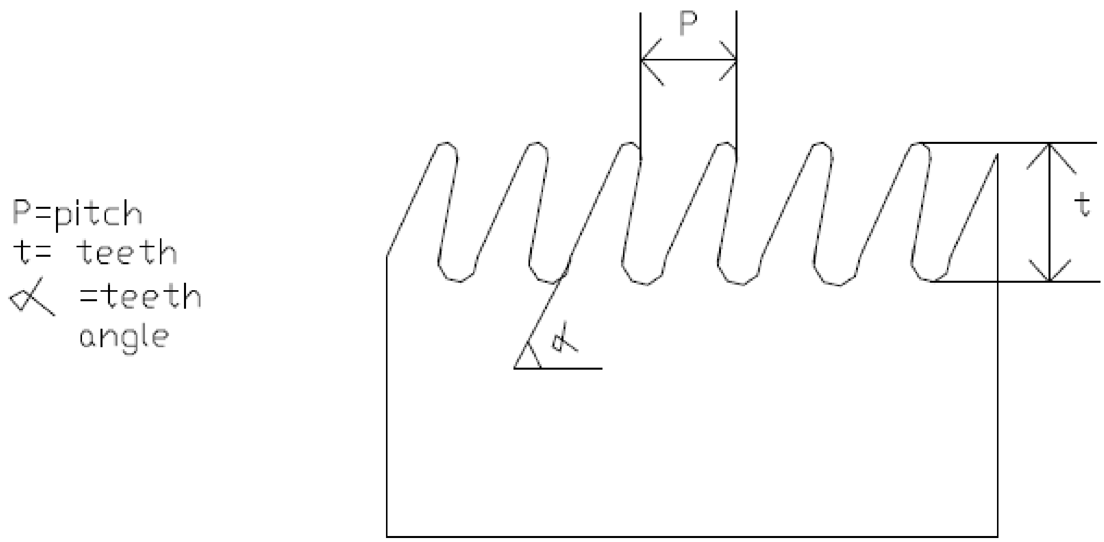
4) Again rotate the screen until the same line coincides with the other flank of the tooth.

5) Take the final angular reading.

6) The teeth angle of blade in the difference between the two angular readings.

OBSERVATION TABLE

For Measurement	Sr No.	Initial reading	Final reading	Difference	Mean
PITCH					
TEETH ANGLE					



Hacksaw Blade Tooth

RESULT

A) Pitch of blade =

B) Teeth angle =

EXPERIMENT NO: 10

MEASUREMENT OF GEARS AND SCREW THREADS

AIM:

To measure major diameter, minor diameter and pitch of screw thread using Profile Projector.

APPARATUS:

Profile Projector, threading job.

PROFILE PROJECTOR:

A profile projector projects a magnified profile image of an area or feature of a workpiece onto a screen, most commonly using diascopic illumination. Dimensions can be measured directly on the screen or compared to a standard reference at the correct magnification. For accuracy, it is important that the magnification does not change with perspective, i.e. its position or the view point of the operator. Telecentric lenses are, therefore, highly desirable. The screen often has a grid and this grid can often be rotated through 360 degrees to align with an edge as displayed on the screen. Point positions, measurements, and calculations may also be performed using a simple digital read out device. Episcopic lighting is used to measure features such bores, bosses, pockets, pads etc., which would not be revealed on a profile view. A computer may be added to a profile projector system for edge determination, thereby eliminating some human error.

APPLICATIONS:

Profile projectors are robust measuring tools commonly used in machine shops, quality assurance departments and occasionally on assembly shop floors. They are suitable for measuring and quality control for a wide range of size and weights of objects. The most basic use of a profile projector is to identify a point or edge on the shadow and from this point to calculate a length. By magnifying the image, the operator is less likely to make a mistake when deciding where the edge or point starts. Profile images can also be used to make simple stop / go decision by, for example, matching an image against a standard to determine whether a part has been made correctly.

PROCEDURE:

The use of Profile Projector for the taking the various measurements is explained below:

1) For taking linear measurements, the work piece is placed over the table. Then it is focused and one end of the work piece is made to coincide with cross line on the screen (by operating micrometers screws). The table is again moved until the other end of the work piece coincide with the cross line on the screen and the final reading taken. From the final reading, the desired measurement can be taken.

2) To measure the screw pitch, the screw is mounted on the table. Then it is focused (by adjusting the height of the optical head) until a sharp image of the projected contour of the screw is seen of the ground glass screen. The contour is set so that some point on the contour coincides with the cross line on the screen. The reading on the thimble of the longitudinal micrometer screw is noted. Then the table is moved by the same screw until a corresponding point on the contour (profile) of the next thread coincides with the cross line. The reading is again noted and the difference in two reading gives the screw pitch.

3) To determine pitch diameter the lateral movement to the table is given.

4) To determine the thread handle, the screen is rotated until a line on the angle of screen rotation is noted. The screen is further rotated until the same line coincides with the other flank of the threads. The angle of thread on the screen will be difference in two angular readings. Different types of gradated and engraved screens and corresponding eye piece are used for measuring different elements.

RESULTS:

1) External diameter = R2 - R1 = -------------- mm.

External diameter = R2 - R1 = -------------- mm.

External diameter = R2 - R1 = -------------- mm.

External diameter = R2 - R1 = -------------- mm.

2) Internal diameter = R2 - R1 = -------------- mm.

Internal diameter = R2 - R1 = -------------- mm.

Internal diameter = R2 - R1 = -------------- mm.

Internal diameter = R2 - R1 = -------------- mm.

3) Pitch of threads = R2 - R1 = --------------- mm.

Pitch of threads = R2 - R1 = --------------- mm.

Pitch of threads = R2 - R1 = --------------- mm.

Pitch of threads = R2 - R1 = --------------- mm.

4) Threads angle = R2 - R1 = --------------- mm.

Threads angle = R2 - R1 = --------------- mm.

Threads angle = R2 - R1 = --------------- mm.

Threads angle = R2 - R1 = --------------- mm.

Major diameter, minor diameter, pitch and thread angle of screw thread using profile projector is measured.

For Measurement	SL NO	Initial Reading	Final Reading	Difference	Mean
Pitch	1.				
	2.				
	3.				
Teeth angle	1.				
	2.				
	3.				
External diameter	1.				
	2.				
	3.				
Internal diameter	1.				
	2.				
	3.				

EXPERIMENT NO:11

MEASUREMENT OF ROTATION SPEED

MEASUREMENT OF ROTATION SPEED USING TACHOMETER, TACHO GENERATOR AND STROBOSCOPIC TACHOMETER –CALIBRATION OF TACHOMETERS

AIM

Measurement of rotation speed using tachometer, tacho generator and stroboscopic tachometer –calibration of tachometers.

APPARATUS REQUIRED

Tachometer, Tacho generator and Stroboscopic tachometer

THEORY

A **stroboscope** is an instrument that emits a series of brief, intense flashing lights at specific intervals.
When the flashing light from a stroboscope is directed onto an object rotating at high speed (e.g., a cooling fan inside a PC), the moving fan appears to stand still.
The stroboscope makes the fan rotating at high speed appear to stand still due to the visual persistence of the human eye.
When the frequency of the flashing lights from the stroboscope is adjusted to synchronize with the fan rotating speed, the number of apparently stationary fan blades you see corresponds to the actual number of fan blades.

A **tachometer** (revolution-counter, tach, rev-counter, RPM gauge) is an instrument measuring the rotation speed of a shaft or disk, as in a motor or other machine. The device usually displays the revolutions per minute (RPM) on a calibrated analogue dial, but digital displays are increasingly common.

Tachometer generators (or tachogenerators) are electromechanical devices which output a voltage proportional to their shaft speed. They are used to power tachometers and to measure the speed of motors, engines, and other rotational devices.

PROCEDURE

DIGITAL TACHOMETER

Caution: Use minimum pressure_needed to register the actual shaft speed, in order to minimize the loading error and to avoid damage to the equipment. Set the motor speed to the desired rpm. Check and note down how the speed varies while machining process is in progress. Each member of the team should record at least 10 readings from the digital tachometer. At least 50 data should be taken per group.

STROBOSCOPE

Set motor speed to desired rpm and record the electronic frequency counter reading. Set the stroboscope frequency to approximately the electronic frequency counter reading. Fine-adjust the stroboscope frequency until the timing mark appears stationary; record this stroboscope reading, and sketch the mark on the gear face. Without changing the motor speed, increase the stroboscope frequency until it is doubled. Record the stroboscope frequency. Sketch the timing mark pattern.

Repeat above measurements for a stroboscope frequency of 3 times true shaft speed.

Repeat above measurement for a stroboscope frequency of ½ times true shaft speed.

RESULT

EXPERIMENT NO: 12

MEASUREMENT OF TORQUE AND FORCE

MEASUREMENT OF CUTTING FORCE DURING TURNING, DRILLING AND MILLING USING TOOL FORCE DYNAMOMETER

INTRODUCTION

Tool Dynamometers are basically a strain gauge based sensors, which senses cutting forces in different direction. The cutting force dynamometer like Lath tool dynamometer, Drill tool dynamometer, Mill tool dynamometer, Grinding tool dynamometer are specially designed cutting force sensing devises which can be mounted directly on the particular machines and conduct experiment. The sensors are designed to take all the three directional forces minimizing the cross sensitivity of load from one direction to other. Strain gauges are used as sensing element. Suppurate strain gauge whetstones bridge are used for each direction force. there are different Tool Dynamometer for different type of machines like:

- LATHE TOOL DYNAMOMETER
- DRILL TOOL DYNAMOMETER
- MILLING TOOL DYNAMOMETER
- GRINDING TOOL DYNAMOMETER

LATHE TOOL DYNAMOMETER

Lathe Tool Dynamometer is a cutting force measuring instrument used to measure the cutting forces coming on the tool tip on the Lathe Machine. The sensor is designed in such a way that it can be rigidly mounted on the tool post, and the cutting tool can be fixed to the sensor directly. This feature will help to measure the forces accuratly without lose of the force. The sensor is made of single element with three different whetstones straingauge bridge. Provision is made to fix 1/2" size Tool bit at the front side of the sensor. The tool tip of the tool bit can be grind to any angle required.

DRILL TOOL DYNAMOMETER

The Drill tool dynamometer is a cutting force measurement transducer specially designed to measure the cutting forces on the coming on the tool tip on the drilling machine. The dynamometer has two directional force measurement such as TORQUE and THRUST. The sensor is mounted on the machine table of the drilling machine. Self centering vice is fixed on the sensor. The job held with the vice and the job is drilled with a drill bit. The sensor mounts the torque and thrust force generated between the job and the tool bit.

MILLING AND GRINDING TOOL DYNAMOMETER

The Milling and Grinding Tool Dynamometer are a rigid straingauge based sensor which senses the cutting forces in all three X, Y and Z direction. The difference between the two is the forces developed in the grinding machine are very low, hence it is made sensitive when compared to Milling Tool Dynamometer. The sensor is mounted directly on the machine table. Self-centering vice is fixed on the sensor and a job is held rigidly. The sensor has three whetstones straingauge bridge to measure the force in all the three direction. The cutting forces coming on the job is transferred to the sensor directly. all the three directional forces will be sensed simultaneously and measured.

TOOL FORCE INDICATOR

Tool Force Indicators are mainly a Strain gauge signal conditioner and amplifier specially designed to connect cutting force dynamometers and to display the forces. The instrument has suppurate signal conditioner and amplifier with individual display unit for each forces. The instrument provides also the power supply to the sensor. 3.5 digit LED display is used to indicate the load. Front panel zero balancing facility is provided for each directional load through single turn potentiometers. Course potentiometer is provided for any large variations and fine potentiometer for fine tuning. The instrument is calibrated internally to read the load directly in Kg force. The instrument will also provide Analog output through terminals at the back side of the instrument. X-Y plotter or a Recorder can be connected across the terminals and the readings can be plotted.

The digital indicators comprises of four parts.

1. Power Supply 2. Signal conditioning 3. amplifier 4. Analog and digital converter.

The inbuilt regulated power supply used will provide sufficient power to electronic parts and also excitation voltage to the strain gauge bridge transducers. The signal conditioners Buffers the output signals of the transducers. Amplifier will amplifies the buffered output signal to the required level where it is calibrated to required unit. Analog to digital converter will convert the calibrated analog out put to digital signals and display through LED’s.

SPECIFICATION

LATHE TOOL DYNAMOMETER

SENSOR : Straingauge based Three axis force sensor

CAPACITY : X - Force 500 Kg

Y - Force 500 Kg

Z - Force 500 Kg

STRAIN GAUGE RESISTANCE : 350 ohms ± 1%

CONNECTION : Through Twelve core shielded cable with the connector attached.

TOOL BIT : 20mm Square of 50 mm length HSS bit.

EXCITATION : 10V DC

ACCURACY : 2%

LINEARITY : 2%

CROSS-SENSITIVITY : 5%

OUTPUT : Analog out put to connect Recorder or X-Y Plotter.

200mV for FSD

MAX. OVER LOAD : 150 %

INDICATOR:

DISPLAY : 31/2 digit seven segment LED individual display for X, Y & Z direction.

EXCITATION : 10 V DC

ACCURACY : 1%

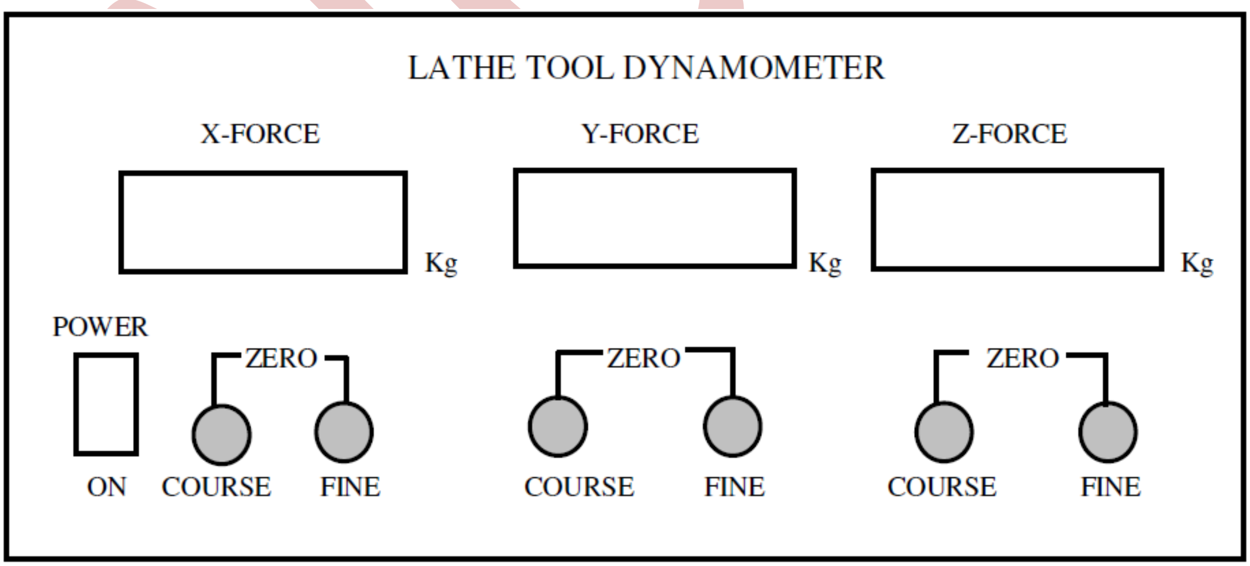
TARE : Front panel Course & Fine Zero adjustment through Potentiometers.

CALIBRATION : 500 Kg load in X, Y, Z direction.

POWER SUPPLY : 230 V +/- 10% 50 Hz

PANEL DETAILS

FRONT PANEL

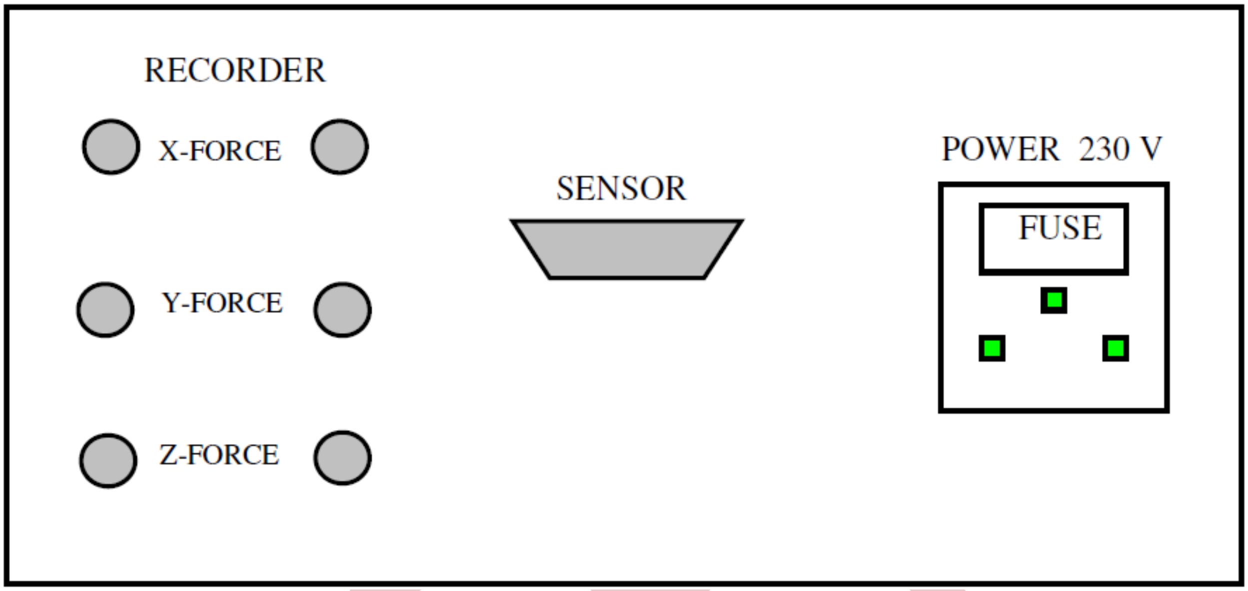


DISPLAY : 31/2 Digit LED Display of 200 mV FSD

ZERO : Single turn potentiometers for Course and Fine adjustment of tare load coming on the sensor and bridge balancing set the display to read “000”.

POWER ON : Rocker switch to control power supply to the instrument.

REAR PANEL

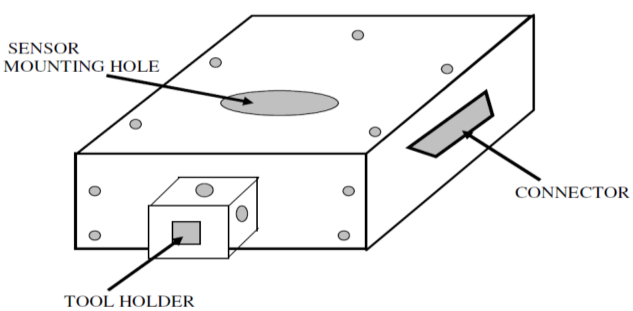


Power Socket : Power socket to connect the Instrument to AC 230 V 50 Hz. Supply through the chord supplied. It also has FUSE attached with it. To replace fuse remove the cap slowly only after disconnecting the power chord.

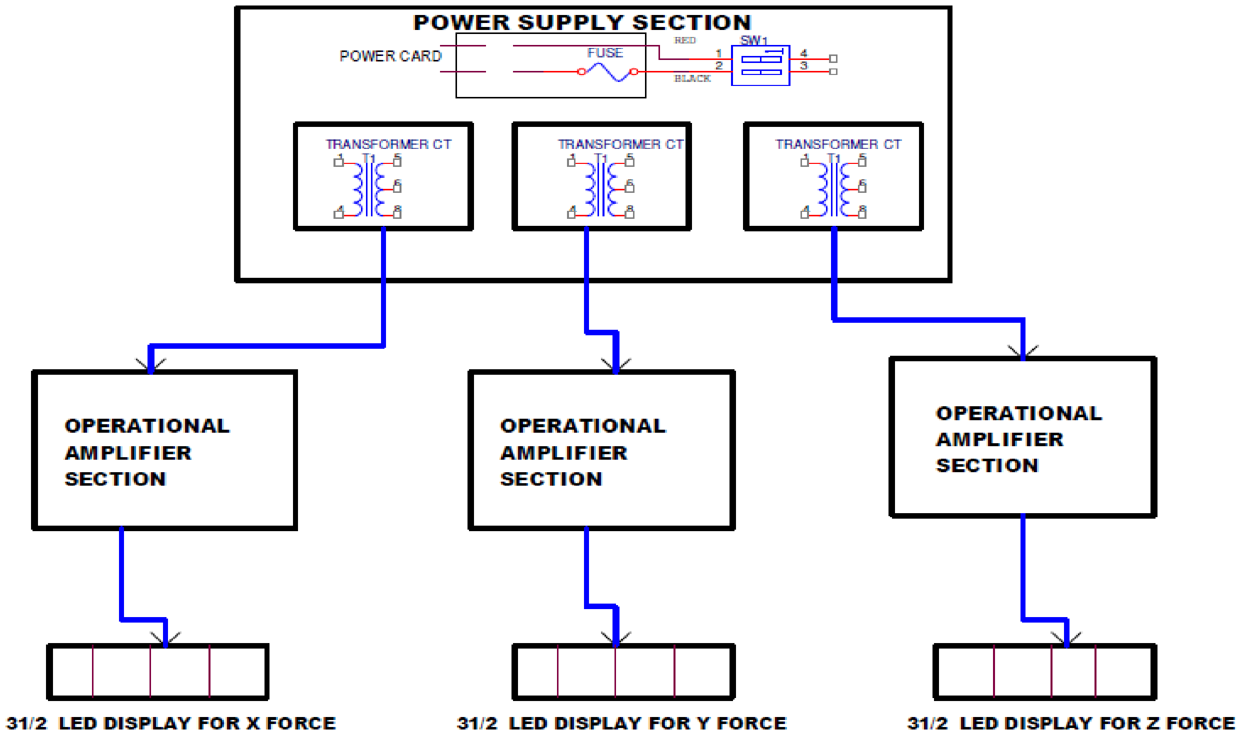
15 Pin socket : To Connect the sensor through 12 core shielded cable attached with connector.

RECORDER : Analog output to connect X-Y Plotter or Recorder.

LATHE TOOL DYNAMOMETER



BLOCK DIAGRAM



CONNECTION DETAILS

SENSOR MOUNTING

The Sensor is mounted directly on the tool post of the Lathe Machine.

- Remove the tool holder from the tool post of the lathe machine.

- The Dynamometer is provided with 1" hole at the center. Mount the sensor in the place of tool holder on the tool post. Fix the sensor rigidly using the fastener nut used to mount the tool Holder.

- Fix 1/2" HSS tool bit provided firmly inside the square hole at the front of the sensor.

CONNECTING SENSOR TO THE INSTRUMENT

To the right side of the instrument 15 pin D-Connector is provided. Connect the one end of the cable provided to the sensor and the other end of the cable to the connector provided at the rear panel of the instrument.

POWER SUPPLY

Connect one end of the 3 core cable to the connector at the rear panel of the instrument, and the other end to the 230V 50 Hz supply.

OPERATING PROCEDURE

- Check the connections made to the instrument. Switch ON the power to the instrument through rocker switch at the front panel.

- Allow the instrument in ON position for 10 minutes for initial warm-up.

- Adjust the Potentiometer in the front panel till the display reads "000". Now the instrument is ready for use.

- Mount the job on the lathe machine. Adjust the line of cut and the center-line of the job by giving packing below the sensor.

- Adjust the speed of the machine and switch ON the machine.

- Give a light cut on the job throughout the length of the job so that the surface of the job is even.

- Adjust the cut and the feed required. Put the machine into auto feed.

- The instrument will start showing the force coming on the sensor in Kg as soon as the tool starts removing the metal from the job. Not down the reading and tabulate on the tabular column for various depth of cut keeping feed and speed constant.

- Experiment can be conducted for different combinations of feed, speed and depth of cut and also the material of the job, by varying one component (material, speed, feed) and keeping the other constant.

- Conclusions can be drawn for the following :

• Optimum speed, feed and depth of cut for the various materials.

• Optimum cutting & release angle of the tool tip for various materials.

• Optimum utilization of the machine power by optimizing cutting fed, speed and depth of cut.

RESULT

ADDITIONAL EXPERIMENT -1

MEASUREMENT OF AIR FLOW USING ANEMOMETER

AIM:

To study the air velocity measurement using Anemometer

APPARATUS REQUIRED

Digital Anemometer

SPECIFICATION

Display : 18mm Liquid Crystal Display

Measurements : m/s (meters per second)

km/hr (kilometers per hour)

ft/min (feet per minutes)

knots (nautical miles per hour)

Operating Temperatures : 0°C to 50°C

Operating Humidity : Less than 80% RH Air Velocity

Sensor

Structure : Conventional twisted vane arms and

Low-friction ball-bearing design

Power Supply : 006p DC 9V battery (heavy-duty type)

Power

Consumption : Approx. DC 9 mA

Weight : 325gm

Dimensions : Instrument 168x80x35 mm

Sensor Head Round, 72 mm Dia.

THEORY

Anemometer is an instrument to measure the speed or velocity of gases either in a contained flow, such as air flow in a duct or in un con fined flow s such as atmospheric wind. To determine the velocity, an anemometer detects change in some physical property of the fluid or the effect of the fluid on a mechanical device inserted in to the flow.

 1.Velocity anemometers

- Cup anemometers
- Windmill anemometers
- Hot-Wire anemometers
- Laser Doppler anemometers
- Sonic Anemometers
- **2.Pressure anemometers**
- Plate anemometers
- Tube anemometers

An anemometer can measure the total velocity magnitude, the velocity magnitude in a plane or the velocity component in a particular direction. The cup anemometers for example measures the velocity in a plane perpendicular to the axis of its rotation cups If the cup anemometers mounted with the shaft perpendicular to the horizontal ,it will measure only the component of the wind that is parallel to the ground. Other anemometers are usually measures the total velocity vector. Before using an anemometer, it is important to determine how it should be positioned and what component of the total velocity its measurement represents.

An anemometer usually measures the gas flows that are turbulent. The Cup anemometer,Pitot-static tube and thermal anemometer are mostly used to measure the mean velocity, while the hot wire, laser Doppler and sonic anemometers are usually used when the turbulence characteristics are being measured. The term "Thermal Anemometer" is often used to mean any anemometer that uses a relationship between heat transfer and velocity to determine the velocity.

Pressure tube anemometer (Dines anemometer) is an instrument which derives wind speed from measurement of the dynamic wind pressures. Wind blowing into the tube develops a pressure greater than the static pressure, while the wind blowing across the tube develops a pressure less than the static pressure. This pressure difference is proportional to the square of the wind speed.

PROCEDURE:

1) Select the “Off/On/Hold switch” to the “On” position.

2) Select the “Function Switch” to the position according to the measuring requirement.

3) Hold the “Vane probe Handle” by hand and let the “Vane Probe Head” is opposite to the measuring airflow source, and then the display will show air velocities directly.

4) During the measurement, it will hold the display values if select the “Off/On/Hold Switch” to the “Hold” position

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RESULT

ADDITIONAL EXPERIMENT-2

CALIBRATION OF LINEAR VARIABLE DIFFERENTIAL TRANSFORMER [LVDT]

AIM:-

To calibrate the given LVDT.

APPARATUS:-

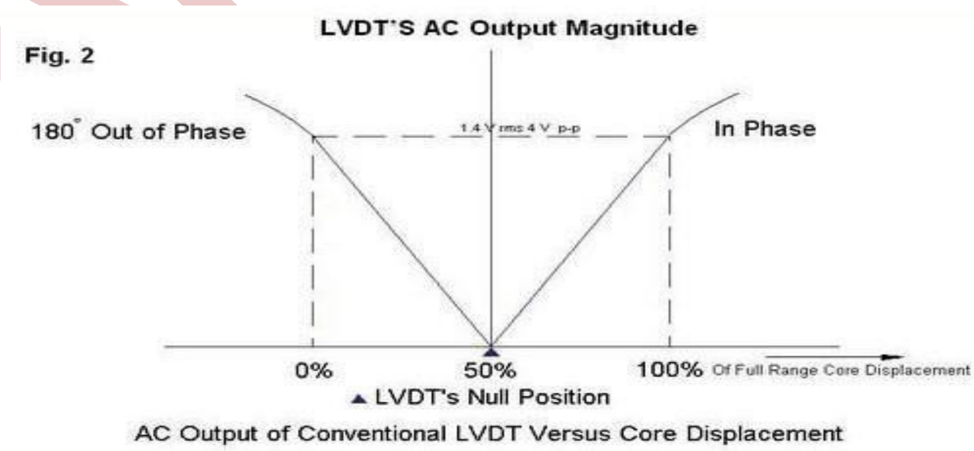
1. LVDT
2. Micrometer

PRINCIPLE:-

LVDT is a variable reluctance type displacement transducer, where a moving coil is used to vary the magnetic flux coupling the two coils. It consists of a primary winding, two secondary windings and a movable core. When the core is in the null position, the voltage in the two secondaries will be equal and the output voltage will be zero.

LVDT is constructed with an iron core with a non magnetic rod moving freely inside the windings. The iron core is responsible for the flux linkage.

With the two identical secondary coils, sinusoidal voltages of same frequency are produced the amplitude varies with the position of the iron core when the secondary coils are connected. In series opposition null output is obtained at the null position motion of the core from the null position causes a large mutual inductance for one coil and a small mutual inductance for another coil and the amplitude of the output voltage becomes a linear function of the core position.



P R O C E D U R E:-

- Connect the power supply chord at the rear panel to the 230V 50Hz supply. Switch on the instrument by pressing down the toggle switch. The display glows to indicate the instrument is ON.
- Allow the instrument in ON position for 10 minutes for initial warm-up.
- Rotate the micrometer till it reads “20.0”.
- Adjust the CAL potentiometer at the front panel so that the display reads “10.0”
- Rotate the core of micrometer till the micrometer reads “10.0” and adjust the ZERO potentiometer till the display reads “00.0”.
- Rotate back the micrometer core upto 20.0 and adjust once again CAL Potentiometer till the display read

  Now the instrument is calibrated for +/- 10.0 mm range. As the core of LVDT moves the display reads the displacement in mm.
- Rotate the core of the micrometer in steps of 1 or 2 mm and tabulate the readings. The micrometer will show the exact displacement given to the LVDT core the display will read the displacement sensed by the LVDT. Tabulate the readings and Plot the graph Actual V/s indicator readings.

E X P E R I M E N T & T A B U L A R C O L U M N:-

- Measurement of displacement through LVDT is well accepted method in process control instrumentation. In measurement Repeatability, Linearity. Accuracy are important factors. So the experiment to test the LVDT for all these factors.
- EXPERIMENT is the known displacement is given to the LVDT core through micrometer and the displacement sensed by the micrometer can be noted down. Graph of Micrometer reading versus LVDT reading can be Plotted. Accuracy and the linearity of the LVDT can be calculated by the graphs. Repeatability can be calculated by repeating the experiment 3 to 4 times and tabulating the readings both for ascending and descending of displacement

TABULAR COLUMN:-

SL.NO.	ACTUAL MICROMETER READINGS (mm)	INDICATR READINGS LVDT (mm)	ERROR B.C.	% ERROR

RESULT:-