STELLA MARY'S COLLEGE OF ENGINEERING

(Accredited by NAAC, Approved by AICTE - New Delhi, Affiliated to Anna University Chennai)

Aruthenganvilai, Azhikal Post, Kanyalumari District, Tamilnadu - 629202.

ME8491 ENGINEERING METALLURGY

(Anna University: R2017)

Prepared By

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DEPARTMENT OF MECHANICAL ENGINEERING

COURSE MATERIAL

REGULATION	**2017**
YEAR	**II**
SEMESTER	**04**
COURSE NAME	**Engineering Metallurgy**
COURSE CODE	**ME8491**
NAME OF THE COURSE INSTRUCTOR	**Dr. J. JENIX RINO**

SYLLABUS:

UNIT I ALLOYS AND PHASE DIAGRAMS 9

Constitution of alloys – Solid solutions, substitutional and interstitial – phase diagrams, Isomorphous, eutectic, eutectoid, peritectic, and peritectoid reactions, Iron – carbon equilibrium diagram. Classification of steel and cast Iron microstructure, properties and application.

UNIT II HEAT TREATMENT 9

Definition – Full annealing, stress relief, recrystallisation and spheroidising – normalising, hardening and Tempering of steel. Isothermal transformation diagrams – cooling curves superimposed on I.T. diagram CCR – Hardenability, Jominy end quench test - Austempering, martempering – case hardening, carburizing, Nitriding, cyaniding, carbonitriding – Flame and Induction hardening – Vacuum and Plasma hardening.

UNIT III FERROUS AND NON-FERROUS METALS 9

Effect of alloying additions on steel- α and β stabilisers– stainless and tool steels – HSLA, Maraging steels – Cast Iron - Grey, white, malleable, spheroidal – alloy cast irons, Copper and copper alloys – Brass, Bronze and Cupronickel – Aluminium and Al-Cu – precipitation strengthening treatment – Bearing alloys, Mg-alloys, Ni-based super alloys and Titanium alloys.

UNIT IV NON-METALLIC MATERIALS 9

Polymers – types of polymer, commodity and engineering polymers – Properties and applications of various thermosetting and thermoplastic polymers (PP, PS, PVC, PMMA, PET,PC, PA, ABS, PI, PAI, PPO, PPS, PEEK, PTFE, Polymers – Urea and Phenol formaldehydes)- Engineering Ceramics – Properties and applications of Al2O3, SiC, Si3N4, PSZ and SIALON –Composites- Classifications- Metal Matrix and FRP - Applications of Composites.

UNIT V MECHANICAL PROPERTIES AND DEFORMATION MECHANISMS 9

Mechanisms of plastic deformation, slip and twinning – Types of fracture – Testing of materials under tension, compression and shear loads – Hardness tests (Brinell, Vickers and Rockwell), hardness tests, Impact test lzod and charpy, fatigue and creep failure mechanisms.

TEXT BOOKS :

1. Avner, S.H., "Introduction to Physical Metallurgy", McGraw Hill Book Company,1997.
2. Williams D Callister, "Material Science and Engineering" Wiley India Pvt Ltd, Revised Indian Edition 2014

REFERENCES:

1. Kenneth G.Budinski and Michael K. Budinski, "Engineering Materials", Prentice Hall of India Private Limited, 2010.
2. Raghavan.V, "Materials Science and Engineering", Prentice Hall of India Pvt. Ltd., 2015.
3. U.C.Jindal : Material Science and Metallurgy, "Engineering Materials and Metallurgy", First Edition, Dorling Kindersley, 2012
4. Upadhyay. G.S. and Anish Upadhyay, "Materials Science and Engineering", Viva Books Pvt. Ltd., New Delhi, 2006.

Course Outcome Articulation Matrix

	Program Outcome												*PSO*		
Course Code / CO No	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***1***	***2***	***3***
ME8491 / C213.1	3	2	1	1	0	1	0	0	2	3	0	3	3	3	1
ME8491 / C213.2	3	3	2	1	2	1	2	0	2	3	0	3	3	3	1
ME8491 / C213.3	3	0	1	0	0	1	0	0	2	3	2	3	3	3	1
ME8491 / C213.4	3	1	1	0	0	1	1	0	2	3	2	3	3	3	1
ME8491 / C213.5	3	3	3	3	2	3	0	1	3	3	0	3	3	3	1
Average	3	2	2	1	1	1	1	0	2	3	1	3	3	3	1

Introduction :-

UNIT -I

The process or act of measurement consists of obtaining a quantitative comparision between a predefined standard and a measurand. The standard of comparision must be of the same character as the measurand, and usually but not always is prescribed and defined by the legal (or) recognized agency (or) organization.

Such quantities as temperature, strain and the parameters associated with fluid flow, acoustics and motion, in addition to the fundamental quantities of mass, length, time and so on, are typical of those further the scope of mechanical measurements.

"Measurements is also a fundametal element of any control process"

METROLOGY :-

Metrology is a science of measurements. Metrology may be defined depending upon the Quantity under consideration into Metrology of length, Metrology of time etc.... Depending upon the field of application it is divided into Industrial metrology. medical metrology etc.,

Need of metrology :-

Metrology is the process of inspection. Inspection means checking of all materials, Products (or) components at various stages during Manufacturing.

The Need of metrology are as follows

* To ensure that the part, material or a component conforms to the established standard.

* To meet the interchangeability of Manufacture

* To maintain customer relation by ensuring that no faulty Product reaches the customers.

* Provide the means of finding out shortcoming in manufacture

Principles of Measurement :-

Measurement is an essential part of the development of technology and as it becomes more complex the technique of measurement becomes more sophisticated. We must be able to express this difference in quantitative terms. (i.e) interms of numbers.

Process of measurement :-

There are three elements of measurement to be considered as important. They are.

Measurand :-

It is a physical quantity (or) property like length, angle, diameter, thickness etc. to be measured.

Reference :-

It is a physical quantity to which quantitative comparisons are made.

Comparator :-

It means of comparing measurand with some reference.

Methods Of Measurement :-

In Precision Measurement various methods of measurement are adopted depending upon the accuracy required and the amount of permissible error.

The Methods of Measurement can be classified as Follow

* Direct Method
* Indirect Method
* Absolute (or) fundamental Method
* Comparative Method
* Transposition Method
* Coincidence Method
* Defective Method
* Complementary Method
* Method of Measurement Substitution
* Method of Null Measurement
* Contact Method
* Contact less Method.

Direct Method of Measurement :-

This is a simple method of measurement in which the value of the Quantity to be Measured is obtained directly without any calculations. This method is mostly used in Production.

Indirect Method of Measurement :-

In Indirect Method, the value of Quantity to be Measured is obtained by measuring other Quantites which are fundamentally related to the required value

Absolute (or) fundamental Measurement :-

It is based on the Measurement of the base Quantities used to define the Quantity.

Comparative Method :-

In this Method, the value of the Quantity to be Measured is compared with known value of the same Quantity (or) other Quantity Practically related to it.

Transposition Method :-

It is a method of measurements by direct comparision in which the value of the Quantity measured is first balanced by an initial known value A of the same Quantity, then the value of the Quantity measured is put in place of this known value and is balanced again by another known value B.

Co incidence Method :-

It is a differential method of measurement in which a very small difference between the value of the Quantity to be measured and the reference is determined by the observation of the coincidence of certain lines signals.

Deflection Method :-

In this method the value of the Quantity to be measured is directly indicated by a deflection of a pointer on a calibrated scale.

Complementary Method :

The Value of the Quantity to be measured is combined with a known Value of the same Quantity. The combination is adjusted that the sum of these two Values is equal to predetermined Comparison Value.

Method of Measurement by Substitution :

A direct comparison in which the Value of a Quantity to be measured is replaced by a known Value of the same Quantity, so selected that the effects Produced in the indicating device by these two Values are the same.

Method of Null Measurement

It is a method of differential measurement. The difference between the Value of the Quantity to be measured and the known Value of the same Quantity with which it is compared is brought to Zero.

Contact Method :-

It is a method the sensor (or) measuring tip of the instrument actually touches the surface to be measured.

Example :- Measurement by Micrometer.

Contact Less Method :-

In contact less method of measurement, there is no direct contact with the surface to be measured.

Measuring System :-

A measuring system is made of the basic elements. These are

* Standard
* Work piece
* Instrument
* Person and
* Environment

Accuracy of Measurement :-

The Purpose of measurement is to determine the true dimensions of a part. But no measurement can be made absolutely accurate. There is always some error. The amount of error depends upon the following factors.

* The accuracy and design of the measuring Instrument.
* The skill of the operator.
* Method adopted for measurement.
* Temperature Variations.
* Elastic deformations of the part or Instrument etc.,.

PRECISION AND ACCURACY

PRECISION :-

The terms Precision and accuracy are used in connection with the Performance of the instrument.

" Precision is the repeatablity of the measuring Process ".

It refers to the group of measurement for the same characteristics taken under identical conditions.

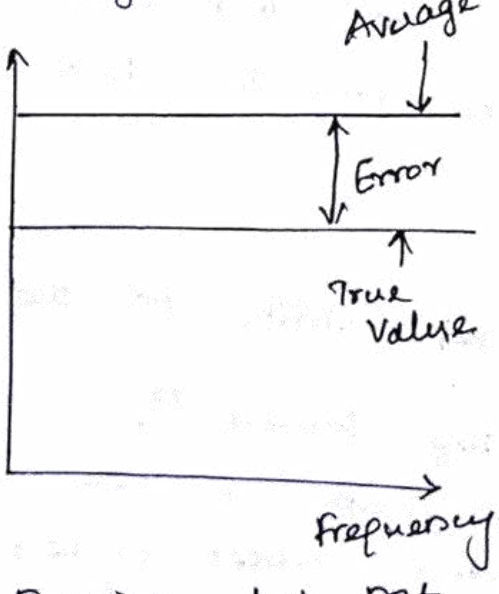
It indicates at what extent the identically performed measurements agree with each other.

Accuracy :-

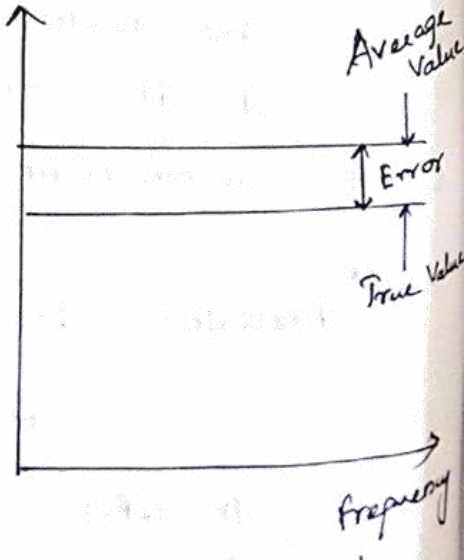
Accuracy is the degree at which the measured value of the quality characteristics agree with the true value. The difference between the true value and the measured value is known as the error of measurement.

Distinction between Precision and accuracy :-

Accuracy is very often confused with precision and though much different the distinction between the precision and accuracy will become clear by the following example.



(a) Precise but not accurate



(b) Accurate but not precise

factors affecting the accuracy of the measuring :-

The basic components of an accuracy evaluation are the two elements of a measuring system such as

* Factor affecting the calibration standards.
* Factor affecting the Workpiece.
* Factors affecting the inherent characteristics of the instrument.
* Factors affecting the person, who carried the measurements
* Factors affecting the enviorment.

SENSITIVITY :-

Sensitivity may be defined as the rate of displacement of the indicating device of an instrument, with respect to the measuring Quantity. In other words, sensitivity of an instrument is the ration of the scale spacing to the scale division value.

for example, if on an dial indicator, the scale spacing is 1.0 mm and the scale division value is 0.01 mm, then sensitivity is 100. It is called as "Amplification factor" or "gearing ratio"

Readability :-

It refers to the ease with which the readings of a measuring instrument can be read. It is the acceptability of a measuring device to have its indications correlated into meaningful number.

CALIBRATION :-

The calibration of any measuring instrument is necessary to measure the quantity in terms of standard unit. It is the process of framing the scale of the instrument by applying some standard signals. Calibration is a pre-measurement process, generally carried out by manufacturer.

The accuracy of the instrument depends upon the calibration constant use of the instruments affects their accuracy.

MAGNIFICATION :-

In order to measure a small difference in dimensions the movement of the measuring tip in contact with the work must be magnified. For this the output signal from a measuring instrument is to be magnified.

This magnification means increasing the magnitude of output signal of measuring instrument many times to make it more readable.

Repeatability :-

It is the ability of the measuring instruments to repeat the same results for the measurement for the same quantity, when the measurement are carried out.

* By the same observer.
* With the same instrument.
* Under the same conditions.
* Without any change in location.

Repeatability may be expressed quantitively interms of dispersion of the result.

Reproductability :-

It is the consistency of pattern of variation in measurement, (i.e) closeness of the agreement between the results of measurements of the same quantity, when individual measurement are carried out.

* By different observer.
* By different methods.
* Using different instruments.
* Using different conditions, location, etc.,

Errors in Measurement :-

It is never possible to measure the true value of a dimension, there is always some error. The error in the measurement is the difference between the measured value and the true value of the measured dimension.

Error in measurement = Measured Value − True Value

ABSOLUTE Error :-

True absolute error :-

It is the algebric difference between the result of measurement and the conventional true value of the Quantity measured.

Apparent absolute error :-

If the series of measurement are made then the algebric difference between one of the results of measurement and the arithmatical mean, is known as Apperent absolute error.

Relative error :-

It is the Quotient of the absolute error and the value of comparison used for calibration of the absolute error. This value of comparison may be the true value the conventional time value or the arithmatic mean for series of measurements.

* Calibration standard.
* Workpiece
* Instrument
* Person

Types of error :-

During measurement several types of error may arise. These are

1. Static errors which include
   (a) Reading errors.
   (b) Characteristics Errors.
   (c) Enviormental Errors.
2. Instrument loading errors.
3. Dynamic errors.

Static error :

These errors result from the physical nature of the various components of measuring system. These are three basic sources of static errors. The static error divided by the measurement range of measurement gives the measurement precision.

Reading errors :

Reading errors apply exclusively to the read out device. These do not have any direct relationship with other types (or) errors within the measurement system.

Reading error includes.

Parallax error

Interpolation error.

Characteristic Errors :-

It is defined as the deviation of the output of measuring system from the theoretical Predicted Performance or from Nominal Performance Specification.

Enviornmental Errors :-

These errors result from the effect of surrounding such as temperature, Pressure, humidity etc,.. on measuring system.

External influences like magnetic or electric fields, nuclear radiation Vibrations or shocks etc.,. also leads to environmental error.

Loading error :-

Loading error results from the change in measrand itself when it is being measured (i.e) after the measuring system (or) instrument is connected for measurement.

Dynamic Error :-

Dynamic error is the error caused by time Variations in the measurand. It results from the inability of the system to respond faithfully to a time varying measurement. It is caused by Inertia, friction and other physical constraints in the sensing or readout or display system.

* systematic errors.
* Random error.

Systematic Error :-

Systematic errors are regularly repetitive in Nature. They are of constant and similar form. They results from improper Conditions (or) Procedures that are Consistant in action. Out of the systematic errors all except the personal error varies with individual to individual depending on the Personality of the Observer.

Calibration Error :-

These are caused due to the Variation in the calibrated scale from its normal value. The actual lengths of standards such as slip gauge and engraved scales will vary from the nominal value by a small amount.

Random errors :-

Random errors are non-consistant. They occur randomly and are accidental in nature. Such errors are inherent in the measuring system. It is difficult to eliminate such errors.

The Possible source of Random errors are

* Small variations in the position of setting standard and workpiece
* slight displacement of lever joints of measuring instrument.
* Operator error in scale reading
* Fluctuations in the friction of measuring Instrument etc.,.

Comparision between systematic errors and Random errors.

Systematic Error	Random error
These errors are repetative in nature and are of constant and similar form.	These are non-consitent. The source giving rise to such errors are random
These errors result from improper conditions of producers that are consistent in action.	Such errors are inherent in the measuring system (or) measuring instrument.
Except Personal errors, all other systematic errors can be controlled in magnitude and sense	specific causes, magnitudes and sense of these errors cannot be determined from the knowledge of measuring system or condition.

Direct Measurement :-

Let us consider a gauge block being measured directly by interferometry. Here the effect of using a non-standard temperature produces a proportional error.

$$E = la(t - t_s)$$

Where l = Nominal length.

a = Coefficient of expansion

$(t - t_s)$ = Deviation from standard temperature.

t = Temperature during measurment

t_s = standard temperature.

Comparative Measurement :-

If we consider two gauges whose expansion coefficients are respectively a_1 and a_2, then the error due to non-standard temperature will be error

$$E = l(a_1 - a_2)(t - t_s)$$

control of error in measurement :-

* Against the primary cause (Planning, design, calibration, filtering)

* Against the secondary cause (Disturbance error and Load error)

Types of Standard :-

Primary Standard

Secondary Standard

Working Standard.

Primary Standard :-

for Precise defination of the unit there shall be one and only one material standard which is to be preserved under most careful conduction it is called Primary standard.

Ex :-

International Metre

International Yard

Secondary Standard :-

Secondary standard are made as nearly as possible exactly similar to Primary standard as regards to design material and length. They are compared with Primary standard after long interval and the records of deviation are noted.

Tritary Standard :-

The Primary and Secondary standards are applicable only as ultimate control. Tertiary standard are the first standard to be used for reference purpose in laboratories and workshops. They are used for comparision at internal with working standards.

Working Standard :

Working Standard are used more frequency in laboratories and workshop. They are usually made of low grade of material as compared to Primary Secondary and tertiary standards for the sake the economy. They are derived

from fundmental standard. Both line and working standard are used. Line - standards are made from H - cross sections.

Most of the precision measurement envolve the distance between two surface and not with the length between two lines.

Other standards :-

Reference standard - for reference purpose.

Calibration standard - Inspection, working.

Inspection standard - Inspection.

Working standard - Operation.

Line and end measurements :-

Line standard.

End standard.

Line standard :-

When the length is measured as the distance between the centre of two engraved line.

Ex :-

The line measurement is the rule with divisions shown at line that works on it.

End standard :-

When length is expressed as the distance between two flat parallel face, it is known as end standards.

ex :-

Vernier caliper, slip gaye, end bar.

X ——— X ———

Unit - II

Linear and angular measurment

1. Introduction :-

Linear measurment applied to measurment of length, diamiter, height and thickness includes internal and internal measurment.

The dimension to be measured is aligned with the graduation of the scale. Linear measuring instrument are designed either for line (or) end measurment.

2. Classification of the instruments :-

The instruments used for the linear measurment are classified as

1. Direct — Graduated / Non graduated
2. Indirect

The graduated instrument includes rules, Vernier caliper, height gauge, depth gauge micrometers, dial gauge etc.

The Non graduated instruments includes Telescopic gauge, surface gauge, wire gauge etc.

They are also classified as,

a) Precision instrument (vernier, dial gauge)

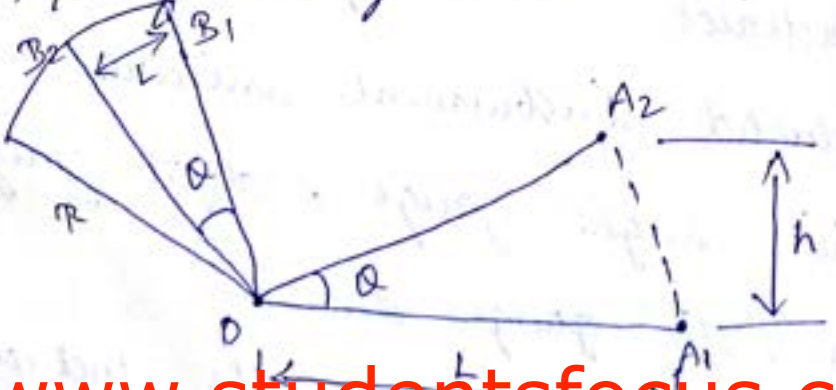
b) Non Precision instrument (steel rule)

3. Spirit level:-

Spirit level are used for

1. Measuring small angle (or) inclination
2. To determine the position of surface
3. To establish a horizontal datum.

The spirit level consist of a sealed glass tube mounted on a base. The inside surface of the tube is ground to a convex barrel shape having large radius. The precision of the level depend on the accuracy of this radius of the tube. A scale is engraved on the top of the glass tube.



The tube is nearly filled with either ether (or) alcohol except a small air (or) vapour in the form of a bubble.

Principle:-

The bubble always tries to remains at the highest point of the tube. If the base of the spirit level is horizontal, the centre point is the highest point of the tube.

If the base of the level is tilted through a small angle, the bubble will move relative to the tube, a distance along its radius corresponding to the angle. (OA_1 & OA_2) are two position of the base of the level. (B_1 & B_2) are the bubble positions

Let l be the distance travelled by the bubble along the tube and "h" the difference in height between the end of the base,

$l = R\theta$ and $h = L\theta$

$R \rightarrow$ Radius of curvature

4. Sine bar:-

Sine bar is a precision inst
used along with slip gauge for mea
of angle. Sine bar is used to measu
the angle very accurately and it
used to locate the work to a gi
angle within very close limits.

It consist of a steel bar a
two roller. The sine bar is made
high carbon and high chromium
corrosion resistant steel, suitable harde
The roller are of accurate and eq
diameter. They are attached to bar
at two end. The axis of the
roller is 100 mm, 200 mm (or) 300 mm

When the roller are brought
in contact with a flat surface, the
top of the bar is parallel to the
surface. The various parts are harden
and stabilized before grinding and
lapping.

Sine bar are graded as A Grade (or) B grade sine bar. A grade sine bar are made with an accuracy of 0.01 mm/m of length and B grade sine bar with an accuracy of 0.02 mm/m of length

Type of sine bar:-

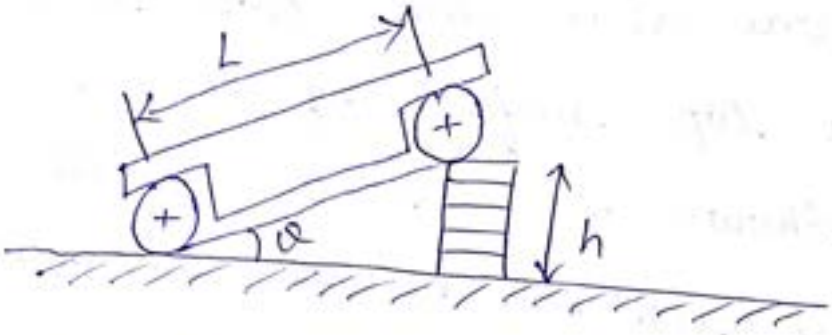
a) Form in which the roller are so arranged that their outer surface on one side are lied with the plane top surface of the sine bar.

b) Shows a sine bar with hollow roller which outside diameter equal to the width of sine bar. It is useful in instance where the width of the inter into calculate of work height

c) Shows a sine bar with pins on both side. This is used where the ordinary sine bar cannot be used on the top surface due to interruption.

Principle of Sine bar:-

The principle of operation a sine bar is based on the laws of trigonometry. To set a given angle, one roller of the bar is placed on the surface plate and the combination of slip gauge is inverted under the second roller.



h → Height

L → Distance b/w roller

$$\sin\theta = \frac{h}{L} \quad (\text{or}) \quad \theta = \sin^{-1}\left(\frac{h}{L}\right)$$

Thus the angle to be measured or to be set is determined by indirect method as a function of sine for this reason, the device is called "Sine bar".

Angle Gauge:-

The Angle gauge enable any angle to be set to the nearest 3". These are pices of hardend and stainless steal. The measuring face are lapping and polished to a high degree of accuracy and flatness.

They are 75 mm long and 15mm wide and are available in two sets. One set consists of 12 pices and a square block in three series of value of angle.

1°, 3°, 9°, 27° and 41°

1', 3', 9' and 27'

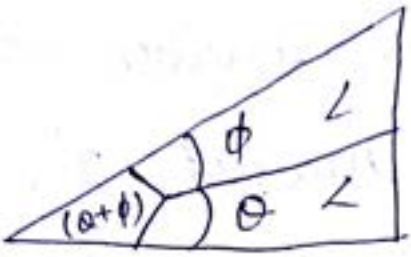
6', 8", and 30"

Another set contain 13 pices

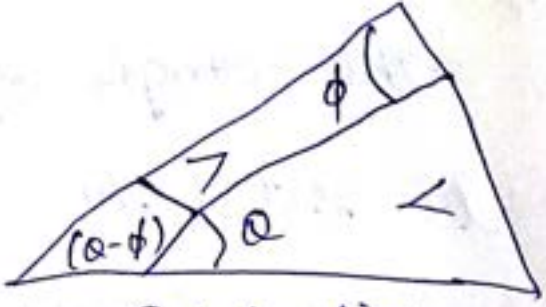
1°, 3°, 9°, 27° and 41°

1', 3', 9' and 27'

3", 6", 12" and 30"



Addition



Substraction

Each angle gauge is accurate to which one second and is marked with engraved "V" which indicate the direction of indicated angle.

These gauge together with a square block can be so wrong that any angle between 0° to 360° can be set.

Each angle gauge is a wedge thus two gauge with their narrow ends together provide an angle which is the sum of the angle of the individual gauges. Subtraction of angle is obtained when the narrow end are opposed.

Clinometer :-

A Clinometer is a spirit level mounted on a rotary member. The angle of inclination of the rotary member relative to its base can be measured by circular scale.

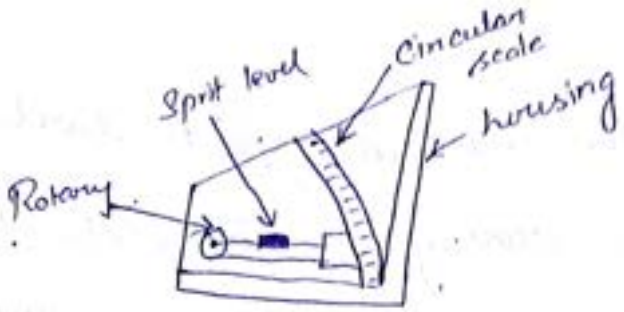
Types of clinometer

1. Vernier
2. Micrometer
3. Dial
4. Optical

Vernier Clinometer :-

It consist of a spirit level mounted on a rotary member carried in a housing. One face of the housing forms the base can be measured by a circular scale. The scale may cover the whole circle (or) only part of it.

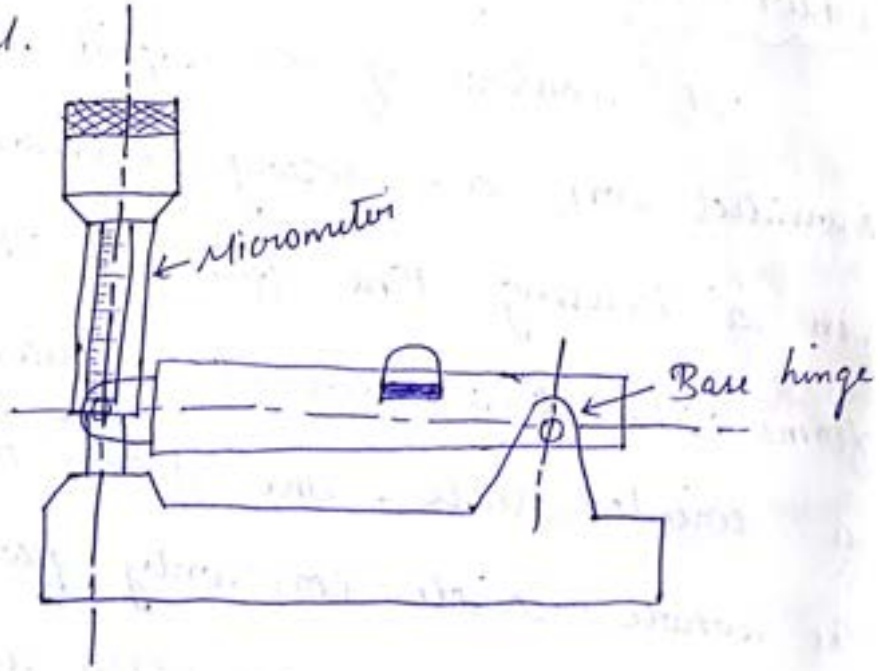
Clinometer are generally used to determined the angle included between two adjacent face of a workpiece.



$$\alpha = 180 - (\theta - \phi)$$

Micrometer clinometer :-

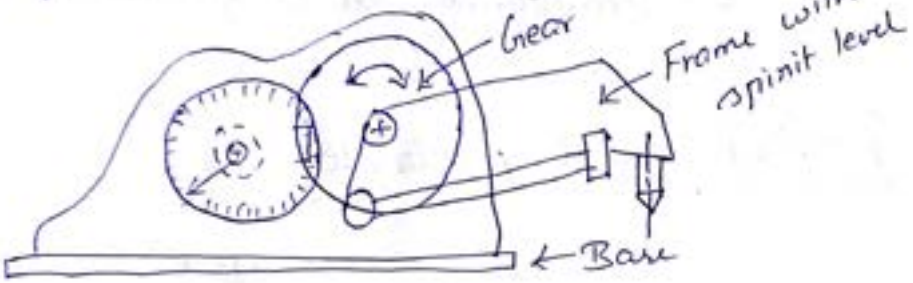
In this type spirit level is attached at one end of the beam of a micrometer. The other end of the spirit level is hinged on the base. The base is placed on the surface whose inclined is to be measured.



The micrometer is adjusted till the level is horizontal. This type of clinometer is used for measuring small angles.

Dial clinometer :-

The dial clinometer is similar in principle to the bural prismatic. The spirit level is attached in a gear and a dial gauge. The whole angle can be observed through an opening in the dial on the circular scale on the gear and the fraction of the angle can be readed on the dial gauge.



Optical Clinometer :-

It consist of rotatable turret which is mounted on a base. Spirit level is provided in the turret. The reading are taken by measuring microscope on a graduated scale provided on a fixed circular glass disc concentric with the [illegible] measured.

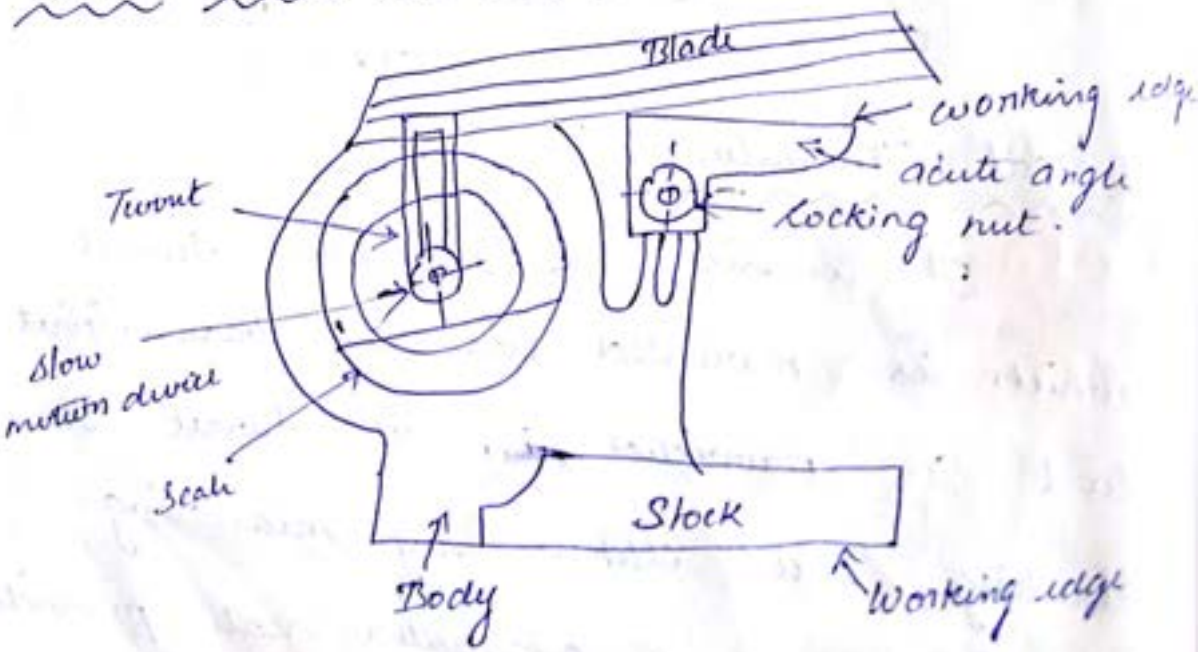
7. Angular Measurements:

To obtain these fine angu
for high precision work, use is m
of sine bar, angle gauge and optic
instrument. The spirit level and the
divided head are also employed.

8. Bevel Protector:-

a) Vernier bevel protractor
b) Optical bevel protractor
c) Universal bevel protractor

Vernier bevel protractor:-



The bevel protractor are used to find the flatness, squareness, parallelism, e

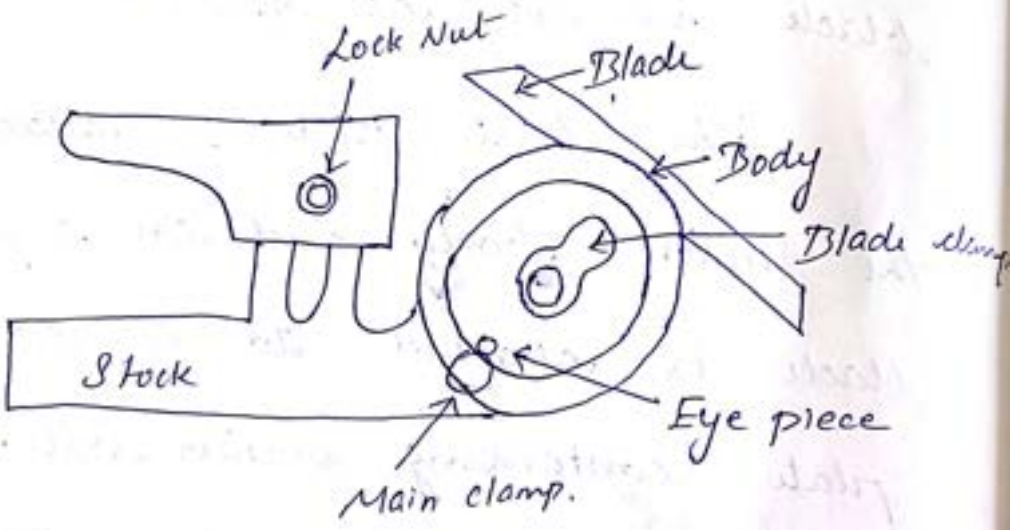
The Vernier bevel protractor with acute angle attachement. The body of "V" bevel protractor is designed is such a way that is back is flat and there are no projections beyond its back The features of the body is tested by checking the squarness of blade with respect to base plate when the blade is set at 90°.

The base plate is attached to the main body and an adjustable blade is attached to a circular plate containing vernier scale. The main scale graduated in degree is provided on the main scale.

The blade can be moved along throughout its length and can also be reversed. It is about 150 (or) 300 m long, 13mm wide and 2mm thick. Its ends are bevelled at an angle of 45° and 60°.

Optical bevel protractor:-

Optical bevel protractor is a recent development of the vernier bevel protractor. By using this instrument it is possible to take reading upto approximately 2 mins of an arc. The internal circular scale is graduated in division of 10 mins of arc.



Reading are taken against a fixed index line (or) Vernier by means of optical magnifying system which is integral with the instrument.

The scale is graduated as a full circle marked 0-90-0-90. The zero position corresponding to the condition, when the blade is perpendicular to the

Auto collimator:-

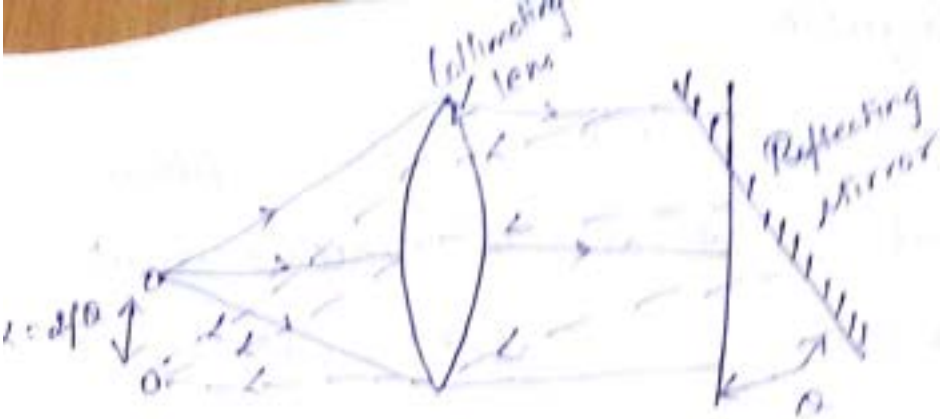
Auto collimator is an optical instrument used for the measurement of small angular deflection, changes (or) deflection, plane surface inspection etc.

Principle:-

If a light source is placed in the focus of a collimating lens, it is projected as a parallel beam of light. If this beam is made to strike a plane reflector kept normal to optical axis, it is reflected back along its own path and its brought to the same focus. If the reflection is tilted to the small angle θ the parallel beam is deflected twice that angle and is brought to a focus in the same plane as the light source, but a one side at a distance $x = 2f\theta$

where, f = focus length of lens

θ = angle of inclination (Reflecting mirror)



The image seen after reflection in the external reflector whose angular variation are being measured formed by the light from the objective lens. This light passes through the beam splitter and the image is picked up by the microscope

Application :-

1. Measurement of straightness and flatness of surface
2. Finds angular widening
3. Comparative measuring using master angle.
4. Assessment of squareness, & II^{el}
5. Small linear dimension measuring

Limit gauge:-

The main requirement of using interchangeability in the manufacturing component is to attain the close achieve value.

Types:-

Plug gauge

Ring gauge

Snap gauge

Position gauge

Application:-

→ Thread gauge

→ Form gauge

→ Screw Pitch gauge

→ Feeler gauge

→ Air gauge

→ Indicating gauge

Device used for linear measurement

1. Vernier
2. Micrometer
3. Slip gauge
4. Comparators

Vernier caliper:-

→ Main scale
→ Vernier scale

Principle:-

Two scale of different size are used to measure dimension in high accuracy.

Steps:-

→ Check for zero error
→ Fine adjustment of movable jaw
→ Both jaw should touch the part
→ Final adjustment depend on experience

Type:-

1. Type A
2. Type B
3. Type C

Micrometer:-

1. Has an accurate screw
2. 10 to do threads
3. End of screw act as measuring tip
4. While measuring diminion the lock nut is arrested.

Parts:-

→ Frame, Anvil, spindle, Ratchet, adjustment nut.

UNIT - III

ADVANCES IN METEOROLOGY

Light is considered as an electro magnetic wave of sinusoidal form. The high point of wave is called the crest and the low point is called trough. The distance between two crests or two troughs is called the wavelength. The time taken by light in covering one wavelength is called time period.

The amplitude of a wave is the distance from the still position to the top of a crest or to the bottom of a trough. The frequency of a wave is the Number of waves passing a point in a certain time (i.e) the velocity of transmission.

Light is produced by any two methods

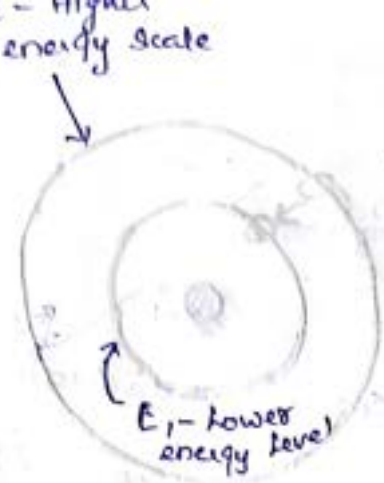
* Incandescence is the emission of light from hot matter (Temp $\geq$ 800K)
* Luminescence is the emission of light when excited electrons fall to lower energy level.

Monochromatic Light is a narrow band of spectrum of visible light having the same wave length or colour.

LASER :

In Coherant beam, all the waves have the same frequency and phase. Lasers have greater coherent length of a light beam refers to the distance over which the beam stays in phase with itself.

* An electromagnetic radiation is emitted whenever a charged particle such as an electron drops from a higher energy state, E_2 to a lower energy state E_1.



The difference in energy level across which an excited electron drops determines the wavelength of emitted light. The wavelength or frequency of light determines its colour.

According to Quantam Mechanics, light is made up of Particles called photons. Which exhibit both particle like and wave like properties.

$$E = h\nu$$

ν is the frequency of light and h,

$$\lambda \nu = c$$

λ is the wavelength of light and c is the speed of light in vacuum.

$$E = \frac{hc}{\lambda}$$

From the above operation we see that longer the wavelength of light lower the energy of photon. So the Ultraviolet light is more energetic than infrared light.

When an electron is an excited energy state, it must eventually decay to a lower level giving off a photon or radiation. This event is called spontaneous emission.

A photon strikes an exicted atom

The atom emits a New photon Just like the first one.

There is a probability that the passing photon will cause the electron to decay in such a manner that a photon is emitted at exactly the same wavelengths, in exactly the same direction and with exactly the same phase as the parity photon. This process is called as 'stimulated emission'.

The Normal thermal population in any material will have most of the electrons in the steady state ground level. But it is preferred to have most of the electrons in the excited state. So that we can get more photons through stimulated emission. Thus a population inversion.

The condition of having enough excited or higher energy states distributed in a material, that a chain-reaction of stimulated emission can occur is called population inversion.

Comparision between Laser light and light from an incandecent lamp.

LASER LIGHT	ORDINARY LIGHT
Has single wavelength (i.e) spectrally pure or Monochromatic.	Has a mixture of various wavelength i.e Polychromatic.
Coherent radiation i.e all photons are in Phase	Incoherent radiation.
High directionality	No Directioality.
Prevails over long distance	Does not Prevail long.

Types of Laser.

There are Vaious kinds of lasers like solid state, gas, liquid and semiconductor lasers. The different lasers and their applications are given below

* Types of laser :

Solid state :

Ruby laser

YAG laser

Liquid laser:

Dye laser

He-Ne laser

Gas laser :

Argon ion laser

CO_2 gas laser

Semi conductor laser :-

GaAlAs laser

InGaAsP laser

InGaAlP laser

There are the types of laser are available.

Advantages of Laser :-

* Lasers are More intensive than any other Monochromatic source.

Metrology lasers are Low Power Instruments.

Lasers have wide dynamic range, low optical cross talk and high contrast.

Lasers are highly Precise, accurate and can Prevail over long distance.

Lasers are allow fabrication of fine structure with high Quality avoidy mechanical stress.

Lasers facilitate rapid non-Contact gauging of soft, delicate or hot moving parts.

Applications :-

Manufacturing :-

for high Quality cutting, drilling, welding and surface treatment etc.,.

Metrology :-

for Contact measurement of Parts, for long distance range finding and Navigation, for scanning bar codes etc.,.

Medical :-

for surgery, kidney stone, treatment, eye treatment, in dentistry, for diagonosis like holes Microscopy.

Data storage :-

for optical data storage eg (compact disks, CD, DVD, etc) for holography.

Communication :-

for optial fibre communication, for free space communication, (eg Inter satellite communications).

SCANNING LASER GAUGE :-

A scanning laser gauge is used for non-contact dimensional Measurements.

The main component in a scanning laser gauge are

Transmitting Unit

Photo Cell (receiver)

Microprocessor a Control Unit.

Signal from the light entering the photocell is process by a microprocessor to provide display of the dimension.

The scanning laser gage is used to measure the roundness and diameter of hot steel bars. It provides an accuracy of 0.025 mm for ϕ 25 mm diameter objects and above.

Laser Telemetric System :-

Laser telemetric system is used for high speed, Non contact dimensional and positional Measurement and Control. The system Measures Outside diameters, multiple dimensions or part positions of either opaque or transparent Object.

The laser telemetric system consist of three component : Transmitter, reciever and Processor eletronics

Photo Diode Array Imaging :-

This system consist of a laser source, Image optics, photodiode array, Signal Processor and display Unit. Here, the shadow of a stationary part is Projected on a solid state diode array image sensor.

INTERFERENCE :-

The phenomenon in which two waves of greater or lower amplitude is called Interference.

Principle of Superposition :-

When two or more waves of the same type are incident at the same point, then the total displacement at that point is equal to the vector sum of the displacement of the individual waves.

On the other hand, if they are out of phase, the resultant wave amplitude is the difference of the individual amplitudes which results in decreased brightness.

If the amplitude of both the waves are same, than they nullify each other. and other will react in darkness.

The conditions necessary for the interference of light waves at a place are

The source should continuously emit waves of the same wavelength or frequency

The amplitudes of the two interfering waves should be equal or nearly for obtaining interference fringes.

The surfaces must be reflective

The source should be narrow.

INTERFEROMETRY :-

Metre was defined as the distance between two finely spaced lines on the Platinum Iridium bar.

In order to reduce the dependence on the physical standard, the process which was prone to errors, the wave length of pure monochromatic light is used as the Natural standard of length.

Interferometer :-

It is an instrument which generate and compares the difference between two light waves which are reflected off two different surface. It utilizes the effect of interference.

Applications of Interferometers :-

Measurements of lengths and small changes in lengths.

Optical testing.

Studies of surface structure.

Wavelength measurement.

AC laser Interferometry :-

A D.C Interferometer system mixes out of phase light beams of the same frequency where as the a.c system mixes beams of two slightly different frequencies, permitting the distance information to be carried on a.c wave form.

The envelope frequency is given by the difference of the two frequency component $(F_1 - F_2)$ of the source radiation.

So, an A.C Laser interferometer measures mirror displacement by measuring the phase change due to the doppler effect. It gives a much improved signal to noise ratio over amplitude modulation.

Description of A.C Laser Interferometer.

1. Two frequency laser source.
2. Optical Elements.
   (i) Beam splitters.
   (ii) Beam Benders.
   (iii) Retro reflectors.
3. Laser head's measurements reciver.
4. Measurement display.

Advantages of ACLI :

It is more tolerant to environmental factors like dust, smoke, air turbulence, etc that attenuate laser beam intensity.

It has high repeatability and resolution of displacement measurement.

It has high accuracy of measurement.

It facilitates to maintain long Range optical path (60 m).

It is easy to Install.

Alignment is good.

Laser Interferometry :

Conventional light source emit waves of differing frequencies and at different time from different point in the source. Hence they are not suitable for obtaining interference fringes. Laser device produce intense beam of light which are monochromatic coherent and have collimation.

Types of Laser Interferometer :-

Homodyne or Single - frequency (or) DC Laser

Heterodyne (or) Dual - frequency or AC laser Interferometer.

Single frequency DC Interferometer :-

For two beams of light to interfere, the beams must have same Polarization state. A Polaroides transmit only a simple Polarization state.

The orientation of the transmitted Polarization state is based on the angle of the Polarizer.

Wave plates (or) retarders Change the Polarization state of light. eg :- from horizontal to Vertical

A Polarization beam splitter separates the source into beams with opposite polarization stated referred to as the reference and measurement legs.

The homodyne or simple frequency DC interferometer is an improved version of the Michelson Interferometer.

Co ordinate Measuring Machine :-

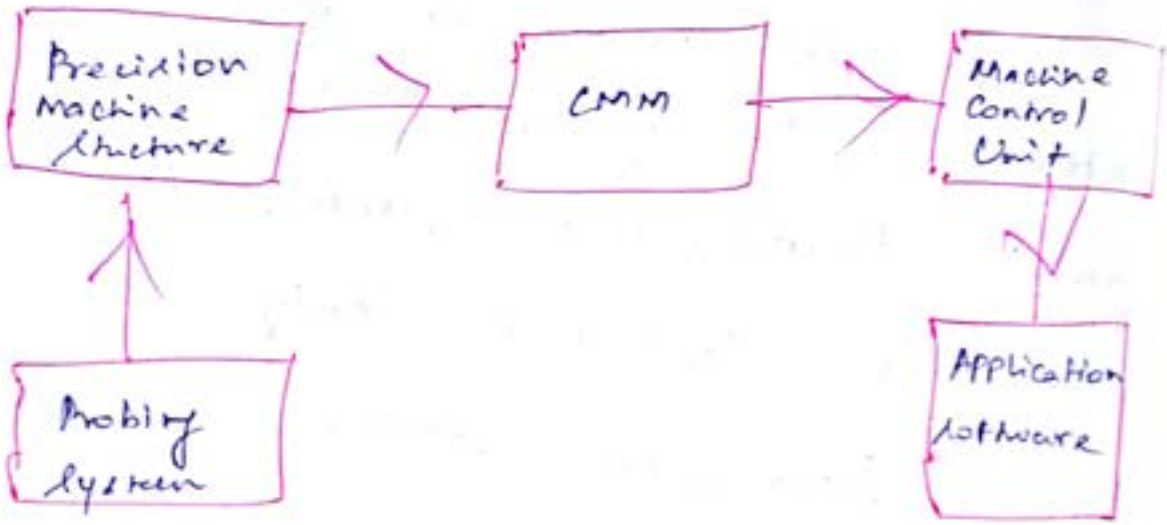


Diagram of Coordinat measuring System.

A Coordinate measuring system Machine consist mainly of four elements. They are,

* The Main structure including the area of motion.

* The Probing system,

* The Machine controller and computer hardware.

* Suitable Application software

Types of CMM :-

Cmm are classified as follows :-

1. According to Control system

   (i) Manual Cmm's or free Floating Cmm

   (ii) Computer Numerical Control (CNC)

   (or) Direct Computer Control (DCC)

2. According to design of Main structure or Orientation of Probe arm

   (i) Bridge type

   (ii) Cantilever type.

   (iii) Column type

   (iv) Gantry type.

   (v) Horizontal type

Accordy to Mounting Speed.

(i) Bench top.

(ii) Free standing.

(iii) Portable and Hand Held.

Advantage of CMM :-

* Reduced inspection cycle time.
* Flexiability.
* Reduce operator error
* Improved accuray and Precisions.
* Improved Productivity.

PROBES :-

CMM Measure work place dimensions by moving a sensing device, called a Probe

The Probes convert Physical measurement into electrical signals by using various means of hybrid within the Probe structure.

Common Probes Fall into two general Categories.

* Tactile (or) Contact Probes.
* Non-Contact Probes.

Contact Probes :

In many Applications, gather data by physically touching the workpiece as the acquisition of the measuring point takes place by probe with Stylus. Contact Probes are classified.

* Hard (or) fixed Probes.
* Touch Trigger Probes.
* Analog type (or) displacement

Non - Contact Probes :

Non Contact probe also called Proximity Probes are used when fast, accurate measurements are required with no physical contact with the part.

These probes enable the measurement of flexible parts that, soft material and geometry might be distorted with a contact probe.

Applications of CMM :

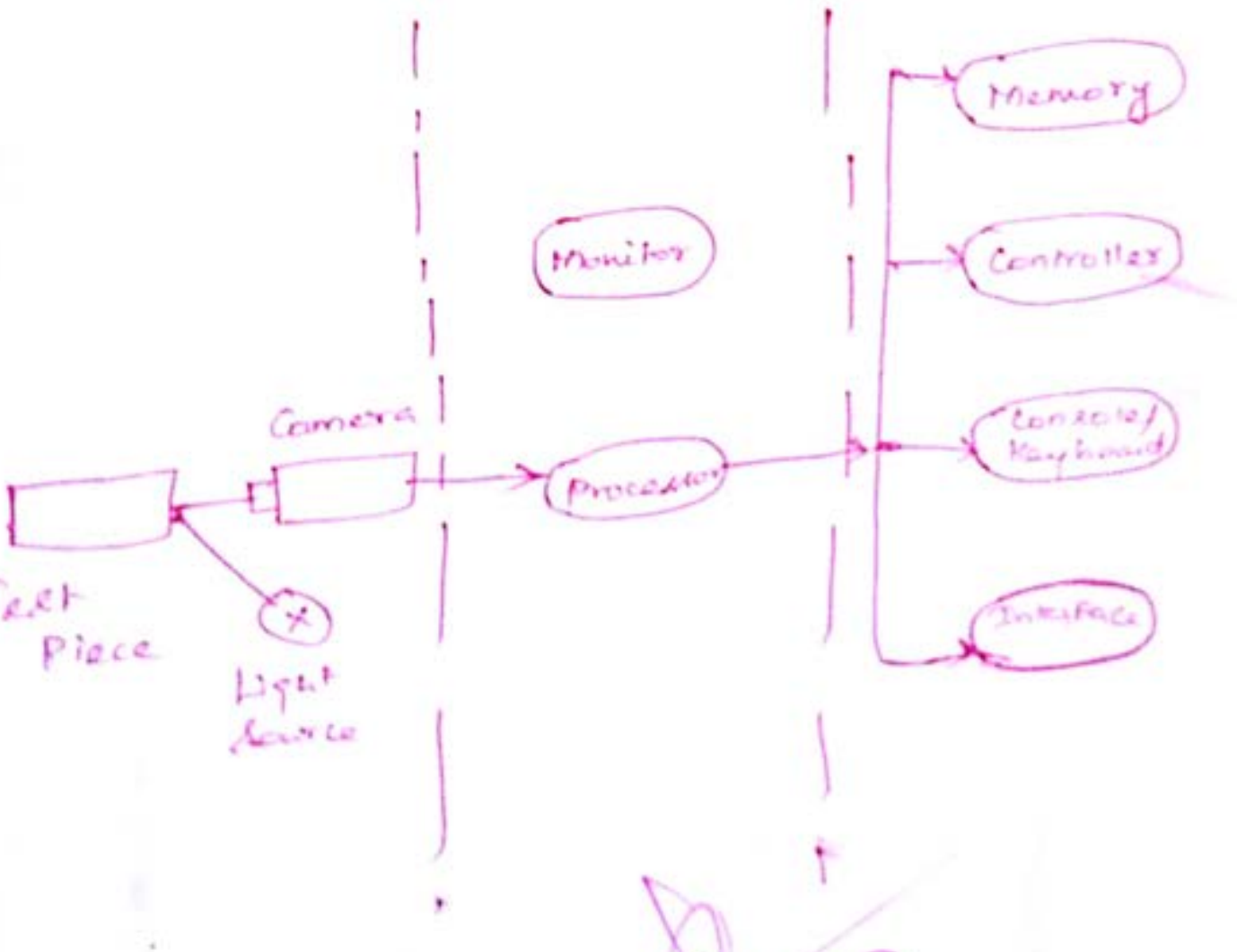
To check dimensional Accuracy of parts in various steps of production and of parts supplied by vendor.

To inspect test equipment, gauges and tools.

To determine shape and position, Minimum metal condition, linkage of results, etc., which conventional manual Gauging Devices

Machine Vision :-

Machine Vision is the ability of a computer to 'see'. Machine Vision is also called as 'Artificial Vision' (or) Computer Vision. It is defined as a Techn/l which allow a sensor to view a scene and drive a numerical or logical decision without further human intervention.



UNIT - IV

FORM MEASUREMENT

PRINCIPLES and Methods OF straightness - Flatness Measurement - Thread Measurement ; gear measurement, Surface Finish Measurement ; Roundness Measurement - Applications.

Introduction :

If the components of a machine have to function properly, accurate measurements of any dimensions to a specific length and other geometric feature must be considered. Geometrical features of a measurement include measurement of straightness, Flatness, squareness, Parallelism, roundness. Circularity, Cylindricity, Co-axiality., etc.,. Vaious methods and Techniques are discussed here to measure these geometrical features.

STRAIGHTNESS MEASUREMENT :-

Straightness is an important geometrical parameter of the surface on the part of machine. In case of shaping machine, tool must move on a straight path to perfectly cut the material by having the surface of Guideways being straight.

A straight line is defined by the shortest distance between two lines. But it is very difficult to define straightness exactly. A ray of light is straight. also, the liquid level is straight and flat.

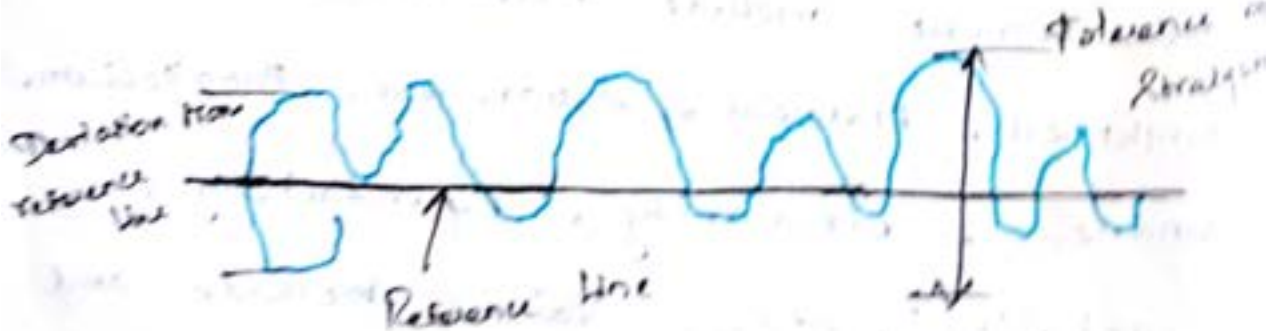


Fig. Exaggerated View of a surface showing Undulations - ups and downs

METHODS OF STRAIGHTNESS MEASUREMENT

1. SPIRIT LEVEL :-

Straightness can be measured by using spirit level. Spirit level is used in the shape of a bubble tube mounted on a cast-iron base.

Also autocollimeter is used to test the straightness. While the sprit levels are used only to measure (or) test straightness of horizontal surface, the auto collimeter are used on a surface in any plane.

STRAIGHT EDGES :-

With help of surface plates and sprit levels, straight edges are also used for checking straight and flatness. Straight edge is a narrow, deep and flat sectioned measuring instrument. These are made up of steels (with up to 2 m) and cast iron (with upto 3 m). Straight edges are ribbed heavily and are built in box sections.

Straight edges are used for testing large areas of surfaces. The straightness of an edge or the flatness of a surface can be estimated by placing a standard straight edge on it and viewing against the lighting background.

Laser Measurement System for Straightness Measurement :

Straightness Measurement Using Laser highlights the bending or misalignment in the guide ways of a Machine. The laser systems Comprise of straightness beam splitter and straightness reflector.

Flatness Measurement :

Flatness is a minimum distance between two planes, which will cover all irregularities of the surface to be tested.

Determining Flatness means to determine the best fit Planes between two standard reference planes one above and one below the plane of surface to be tested. Which Flatness is a Quantitative term can be Quantified by measuring the distance d.

Flatness Testing is done by comparing the surface to be tested with an accurate surface. Flatness is analyzed by Quantifying deviations from a least - squares reference plane. A least squared reference plane is a plane where the areas above and below the plane are equal and are kept to a minimum Seperation.

METHODS OF FLATNESS MEASUREMENT

Beam Comparator Used For Flatness Testing :-

A Flatness reference plane is referred as surface plate Beam Comparator checks the general degree of flatness with a Method of Comparative Measurement By Using ; Beam Comparator, the flatness of a surface to be tested is compared with a Master plate.

Measurement of Flatness by Interferometry :-

Small Variations less than one or two Microns are Measured by Using this Method.

Flatness Measurement Using Laser Measurement system :-

This Measurement is used to Check the accuracy of CMM tables and all types of surface Plates.

It determines errors and then Quantifies them. If these errors are significant, then remedial work, like further lapping will be done.

Flatness Measurement Electro-Mechanical Gauges

Large Variations of several Microns are measured by using Conventional electromechanical Gauges, especially with the non-contact type for polished surface.

Surface Plates :-

The surface plate has top plane surface with a true and level plane. Normally the flat surface plate is used as a reference datum plane. It acts as a Master for checking the flatness of a work surface.

Cast Iron Surface Plates :-

These are used after rough Machining is done then followed by seasoning (ageing) for a suitable period then annealing up of 500°C for about three hours is done on the seasoned Plates to relieve the internal stress.

Granite Surface Plates :-

It has more rigidity than CI surface plates for the same depth without corrosion. They have high Modulus of rigidity and do not have moisture content.

Glass Surface Plates :-

These are also commercially available and comparatively light in weight and free from burr and corrosion.

PARALLELISM :-

Two entities line or plane or surface are parallel to each other when the perpendicular distance between the surfaces under test does not exceed an spread value over a specified time. Parallelism defines the angle between two surface of a sample specimen. It can be specified at a thickness difference per unit length, or as an angular deviation.

Methods of Parallelism measurement :-

1. Using Dial Indicator and Test Mandrel
   (i) Parallelism of Two planes (or) surface
   (ii) Parallelism of Two Axes (or) Two cylinder
   (iii) Parallelism of An Axis of cylinder to a reference surface.
   (iv) Parallelism of an axis of cylinder to the intersection of two planes.
2. Using Electro - Mechanical Gauges.
3. Using An Auto collimator.

Applications :-

Measuring the straightness of Machine Components :-

The straightness of Machine Components like guideways (or) the straight lines of motion of machine components, can be checked with the autocollimeter and a base mirror. The base mirror is moved step by step along the guide way which is to be measured

Measuring Flatness :-

Measuring the flatness of large surface is usually done by measuring the straightness in the relevant direction of a series of lines in the surface plane in a certain pattern. the procedure for each line is the same as for single straightness measurement.

Other applications :-

* Aircraft assembly Jigs.
* Rolling mills.
* Retro reflector measurement
* Test Plates measurement.

Thread Measurement

A screw thread is a helical structure used to convert rotational movement to linear movement and also used to convert rotational torque to linear force. A screw thread is a ridge wrapped around a cylinder or cone in the form of helix.

A screw thread is the helical ridge produced by forming a continuous helical groove of uniform section on the external (or) internal surface of a cylinder or a core.

A screw thread formed on a cylinder is known as straight (or) parallel screw thread, while the one formed on a cone is known as tapered threads.

It is used to transmit the power and motion. The screw thread also acts as a temporary fastner.

Nomenclature of screw threads :

Major diameter (or) Nominal diameter

It is defined as the diameter of an imaginary cylinder that bounds the crest of an external thread or root of an internal thread. It is the largest diameter of the screw thread.

Minor diameter or Core diameter or root diameter (d_c)

It is defined as the diameter of an imaginary cylinder that bounds the root of an external thread or crest of an internal thread. It is the smallest diameter of the screw thread.

Pitch diameter (or) Effective diameter

It is defined as an imaginary cylinder diameter, the surface of which would pass through the thread at such points as to make equal width of the thread and width of space between the thread.

Pitch :-

It is an axial distance between two similar points on adjacent threads. It is measured in millimeters.

Lead :-

It is defined as the axial distance which a screw thread advances in one rotation of the nut.

For single start threads, lead = Pitch

For double start threads, lead = 2 × Pitch

For multi start threads, lead = n × Pitch

Where n = number of starts of the thread.

Crest :-

It is the top surface generated by the two adjacent flanks of the thread.

Root :-

It is the bottom surface generated by the two adjacent flanks of the thread.

Depth of thread :-

It is defined as the perpendicular distance between crest and root.

Flank :-

The inclined surface, which joins crest and root.

Angle of thread :-

The included angle between two flank surface.

Slope of the thread :-

It is defined as the half the pitch of the thread.

Screw thread :-

A screw thread comprises a helical groove of specified cross-sectional shape. The helix angle of thread can be determined by,

$$\tan \alpha = \frac{P}{\pi d}$$

Let

α - Helix angle

P - Pitch.

d - diameter.

Flank angle :-

It is the angle between individual flank and the perpendicular to the axis of thread which passes through the vertex.

Helix angle :-

It is the angle made by the helix of the thread at the pitch line with plane perpendicular to the axis.

It is the angle between any helix & an axial line on its right circular cylinder or cone.

Thread Per Inch :-

$$\text{Thread Per Inch} = \frac{1}{\text{Pitch in inch}}$$

Addendum :-

It is radial distance between the Major dia & Pitch dia.

Deddendum :-

It is the radial distance between the Minor dia & Pitch dia.

Thread Angle :-

The angle of the Cross section which is standardized as 60 degree in V - thread, but any angle can be used.

Tolerance :-

The following are the requirement for Proper external and internal thread engagement.

External thread and Internal thread must have sufficient Contact at the flank.

External thread & Internal thread must have enough engagement.

Types of Thread :-

Triangle shaped Threads

Square shaped Threads.

Trapezoid shaped Threads.

Measurement of screw thread :-

It is necessary to measure following parameters of the screw thread to ensure the accuracy of the screw thread.

They are

Major diameter

Minor diameter

Effective diameter

Pitch.

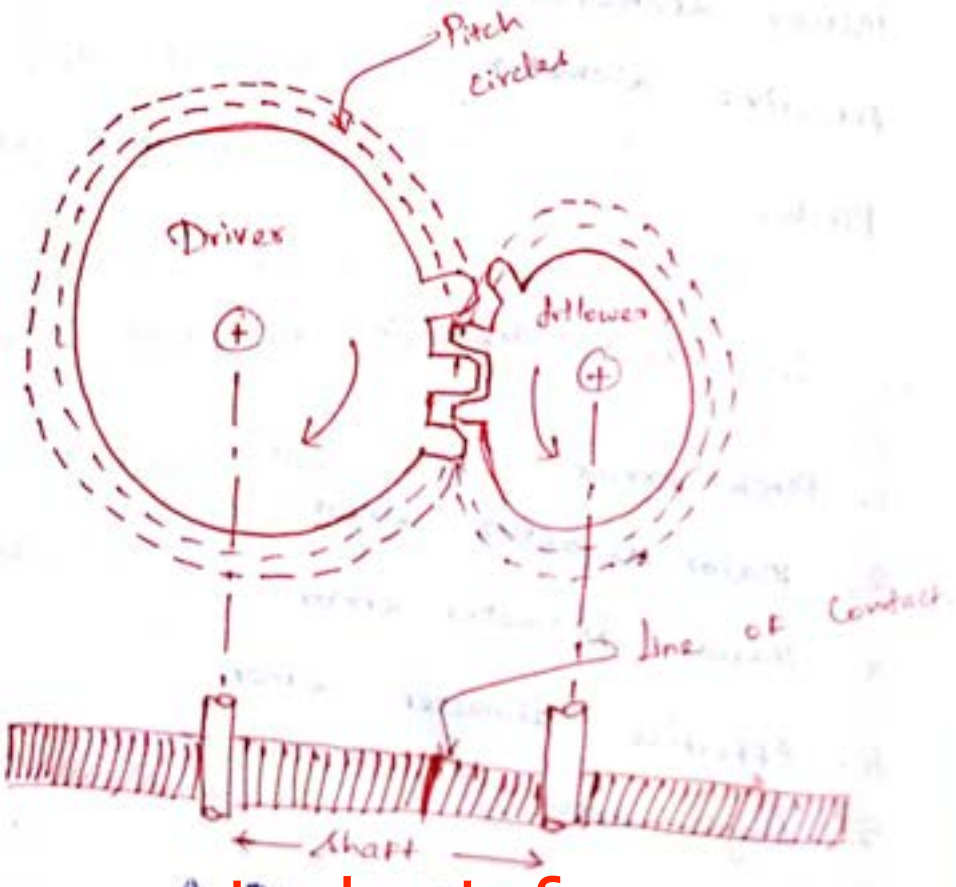
Errors in screw Thread :-

1. Pitch error.
2. Major diameter error.
3. Minor diameter error.
4. Effective diameter error.
5. Angle error.

Gears Measurement

When the positive drive (without slipping) is required for some precision machines and if the distance between the driver and followers is very small, the gears (or) toothed wheels are used.

Gears used for transmitting motion and power from one shaft to another with constant velocity ratio. When the driver gear is rotated by an input shaft it will rotate the follower in the opposite direction.



Advantages and limitations of Gear Drive

Advantages :

* There is no slipping. So exact velocity ratio is obtained.
* Large power can be transmitted.
* High efficiency.
* Reliable service.
* It requires less space, Hence Compact layout is possible.

Limitations :

Special machines, tools and Technology are required for the Manufacturing of gears.

The defective gears may cause Vibration and noise

Cost of Manufacturing is comparatively high.

Classification of Gears :-

Based on position of axes of the shaft

(i) Parallel shafts.
(ii) Intersecting shafts.
(iii) Non Parallel and Non-intersecting shafts.

Parallel shafts :-

In this case, two Parallel and Coplanar shafts are connected by any of the following gears.

Spur gears, Helical gear, Rack and Pinion, Herringbone gears and internal gears.

Bevel gears for Intersecting shafts :-

Bevel gears are used to connect two non-parallel (or) Intersecting but Coplanar shafts.

(iii) Non - Parallel and non - intersecting shafts :-

Spiral gears are used to connect two non - Parallel and non - intersecting i.e., non coplanar shafts. It is also called skew bevel gearing.

Based on type of gearing :-

External gearing.

Internal gearing.

Rack and Pinion

Worm and Worm Wheel.

TERMINOLOGY AND DEFINATION :-

Spur gears are Normally straight tooth or involute gears. Some of the important terminologies of spur gear are defined as follows.

The Pitch Circle :-

It is a theoretical circle on which all calculations are usually based. The Pitch circle is an imaginary circle. The pitch circles of a pair of mating gears are tangent to each other.

Pitch circle diameter :-

The diameter of the pitch circle is known as pitch circle diameter. The size of the gear is usually specified by the pitch circle diameter.

Pinion :-

Pinion is a smaller of the two matting gears.

Gear (or) Wheel :-

The larger of the two mating gears is called the gear (or) wheel.

Pitch Point :-

It is a common normal to two gear teeth at the point of contact and the common tangent at the pitch point. The standard pressure angles are 14 ½° and 20°.

Addendum :-

It is the radial distance from the bottom top land and pitch

Dedendum :-

It is the radial distance from the bottom land and Pitch circle.

Whole depth (or) Total Depth :-

It is the sum of addendum and dedendum.

Addendum circle :-

It is the circle drawn through the top of the teeth and concentric with the Pitch circle.

Dedendum circle :-

It is the circle drawn through the bottom of the teeth (or) root circle.

$$\left.\begin{matrix}\text{Dedendum circle dia} \\ \text{(or)} \\ \text{root circle dia}\end{matrix}\right\} = \frac{\text{Pitch circle dia}}{\cos\phi}$$

Circular Pitch :-

It is the distance measured on the Pitch circle from a Point on one tooth to the corresponding Point on the adjacent teeth.

Circular pitch, $P_c = \frac{\pi D}{T}$

Where, D = Dia of Pitch circle in mm

T = No. of teeth on

Diametral Pitch

It is the ratio of number of teeth to the Pitch circle diameter.

Diametral Pitch $P_d = T/D = \pi/P_c$

Module :

It is the ratio of the Pitch circle diameter to the number of teeth (or) reciprocal of diametral Pitch.

$m = P/\pi = 1/P_d$

Clearance Circle :

It is a circle that is tangent to the addendum circle of the mating gear.

Tooth thickness :

It is a width of the tooth measured along the Pitch circle

Teeth Space :

It is a width of space between the two adjacent teeth measured along the Pitch circle

Pitch :-

It is the amount by which the width of a tooth space exceeds the thickness of the engaging tooth on the pitch circle

Face of tooth :-

It is the surface of the gear tooth above the pitch surface

Flank of tooth :-

It is the surface of the gear tooth above the pitch surface

Top land :-

It is the surface of the top of the tooth

Face width :-

It is the width of gear tooth measured parallel to its axis

Profile :-

It is the curve formed by the face and flank of the tooth

Fillet radius :-

It is the radius that connects the root circle to the profile of the tooth

Errors in Spur Gear :-

Gear Blank Run out Error

Gear tooth profile Error

Gear tooth Errors.

Gear tooth

Pitch Errors

Runout Error of Gear tooth

Lead Error

Composite Error

Assembly Errors

Recent Development :-

Due to the Improved Manufacturing Capability of gear Product equipment, higher accuracy Measurement equipment is required.

With the Introduction and develop of computer Numerical Control (CNC) Many Inspection Machines for lead/ involute Profile Checking and Pitch Measurement have

SURFACE FINISH MEASUREMENTS :-

Generally Components are subjected to several Machining operations for Producing required geometrical surface. But it is not Practically Possible to Produce a component in exact dimension & due to various factors like Machine Vibrations, Nature of Workpiece, Method of operations tool conditions and skills of the labours etc.,.

Surface Texture :-

The surface texture is defined as the regular (or) irregular surface spacings which tend to form a pattern on the surface.

Types of Irregularities :-

Primary Texture (or) Roughness.

Secondary Texture (or) Waviness.

Roughness Height (or) Height of Unevenness :-

It is the height of the irregularities with respect to a reference line. It is measured in "mm" or Microns.

Waviness Height :-

Waviness height is the peak-to-valley distance of the surface profile. It is measured in "mm".

Lay :-

Lay Indicates the direction of predominant surface pattern produced and it reflects the machining operation used to produce it. The various lay are given.

(a) Straight lay.
(b) Circular lay.

Reason for Measuring the Surface Texture :-

Surface Texture is Measured for following reasons.

* To Predict the Performance of the work Material.

To Control the Manufacturing Process.

Factor Affecting the Surface finish :-

The following factors affect the surface finish.

(a) Machine Variables.

(i) cutting speed.

(ii) Feed.

(iii) Depth of cut.

(iv).

Tool Geometry also influence the surface finish.

Nose radius.

Rake angle.

Side cutting edge angle.

Important terms :-

Avarge Roughness.

The root Mean Square roughness

The Skewness Sk and the Kurt...

The Maximum Peak height Rp,

The Maximum Valley height Rv

The Maximun Peak to Valley height

(Rmax)

Analysis of Surface finish :-

A Numerical assessment of Surface finish can be carried out a Number of Ways.

1. Peak to Valley height
2. The Avarge Roughness.
3. Form factor deducing ...

Measurement of Surface finish :-

The inspection and assesment of surface Roughness of machine components are carried out by means of various Measurement Techiques.

Surface finish can be Measured by following.

(a) Surface Inspection by Comparision Method.

(b) Direct Instrument method.

Surface Inspection by Comparision Method :-

The Surface Inspection by Comparion Method is classified as.

1. Touch Inspection
2. Visual Inspection
3. Scratch Inspection
4. Surface photographs
5. Reflected light Intensity.
6. Micro Interferometer.

UNIT V

MEASUREMENT OF POWER, FLOW AND TEMPERATURE

Force, Torque, Power - Mechanical, Pneumatic, Hydralic and Electrical Type, Flow Measurement, Venturimeter, Orifice meter, Rotameter, Pitot tube - Temperature. bimetallic strip, thermocouples, electrical resistance Theometer - Reliability and Calibration - Readeability and Reliability.

Force Measurement :-

Force is Nothing but Product of Mass and acceleration.

$$F = ma$$

The force is a Vector Quantity.

Unit of force is Newton (N)

Generally Force can be Measured by two Methods.

1. Direct force Measurement.
2. Indirect force Measurement.

Direct force Measurement :-

(i) Analytical Balance Method.

(ii) platform Balance

(iii) Chemical Arm Balance Method

(iv) Pendulam Scale.

InDirect force Measurement :-

(i) Accelerometers -

(ii) Electromagnetic Balance Method

(iii) Load cells.

(a) Capacitive Load cells.

(b) Magnetoelastic Load cells

(c) Strain Gauge Load cells.

(D) Hydraulic Load cells.

(E) Pneumatic Load Cells.

(F) Shear Type Load Cells.

Elastic loaded Members :-

Elastic loaded Members are also used to measure the force. The deflection can be measured either directly or Indirectly by using secondary Transducers.

Direct measurement of elastic load members are

(i) Coil springs
(ii) Proving rings
(iii) Load cells.
(iv) Electronic weighing system.

Measurement of Pressure :-

Fluid Pressure sensors :-

The Fluid Pressure sensors are Used to measure the pressure within the fluid to various forces acting on the fluid during flow.

The Various types of Pressure devices are discussed.

The Pressure in a fluid is measured by the following device.

1). Mano Meters.

2). Mechanical Gauges.

Mano Meters :

Mano Meters are defined as the devices used for measuring the Pressure at a Point in a fluid by balancing the column of fluid by the same or another column of fluid.

Mano Meters are classified as.

Simple Manometers :

Used to measure Pressure at a Point in a fluid following through Pipe (or) Contained in Vessel.

differential Manometers :-

Used to measure the pressure difference between any two points in a fluid flowing through pipe (or) contained in a vessel.

Mechanical Gauges :-

Mechanical Gauges are devices used for measuring the pressure by balancing the fluid column by the spring or dead weight.

(a) Diaphragm Pressure gauge
(b) Bourdon tube Pressure gauge.
(c) Dead - weight Pressure gauge
(d) Bellows Pressure gauge

Pressure Measurement Methods

1). Elastic Pressure Transducers ;
Bourdon tube . Pressure Gauge
(C - type , Helical type , spiral type)
Diaphragm pressure Transducers , Bellows.

2. Manometer Method.

3. Electric Pressure Transducers.

Strain Gauge type, Potentiometer type (resistance type), Capacitance type etc.

SIMPLE MANOMETERS :-

A simple Manometer consists of a glass tube having one of its ends connected to a point where Pressure is to be measured and other end remains open to atmosphere.

Common type of Simple Manometers are.

(i) Piezometer.

(ii) U- Tube Manometer

(iii) Single Column Manometer.

Piezometer :

It is the simplest form of Manometer used for measuring gauge Pressure.

Piezometer

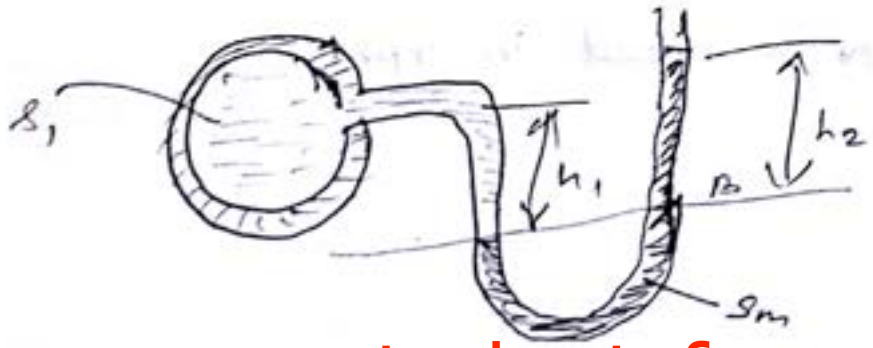
$P_A = \rho \times g \times h$

ρ = Density of liquid in kg/m^3.

g = Acceleration due to gravity.

Simple U tube Manometer :-

U tube Manometer consist of a glass tube bent in U-shape. One end is connected to the pipe and other end is open to atmosphere.



Single Column Manometer :-

Single Column Manometer is modified form of U tube Manometer having a very large reservior. There are two types of single column Manometer

(a) Vertical single Column Manometer

(b) Inclined single Column Manometer

Torque Measurement :-

Torque is nothing but twisting Moment. Torque may be defined as the force applied on the body on which it acts about an axis. Causing the tendency of body to rotate.

$$\text{Power}, P = \frac{2\pi NT}{60}$$

Let T = Torque in (N-M)

N = Speed in rpm

Dynamometers :-

Hydralic Dynamometer :-

The Water brake is of hydralic nature and it is the simplest example for hydralic dynamometer. Generally the water brake is used for large amount of heat is dissipated to the water in water brake system.

Other types of Dynamometer are.

Eddy current Dynamometer.

Strain Gauge type.

Slip ring type.

These are the types of Dynamometers

Torque Measurement Using Torsion Bar :-

It is classified into following types:

(i) Torsion bar

(ii) Magneto strictive

(iii) Laser Optic Method.

(iv) Proximity sensor method.

(v) Stroboscope Method.

(vi) SAW Method.

Flow Measurement :-

The fluid flow can be measured by flow meters. The flow meters (or) Obstruction meters are generally Mechanical type,

(a) Orifice meter.

(b) Venturimeter.

(c) Variable area meter

(d) Flow Nozzle.

Types of Fluid Flow :-

The fluid flow can be divided into three categories.

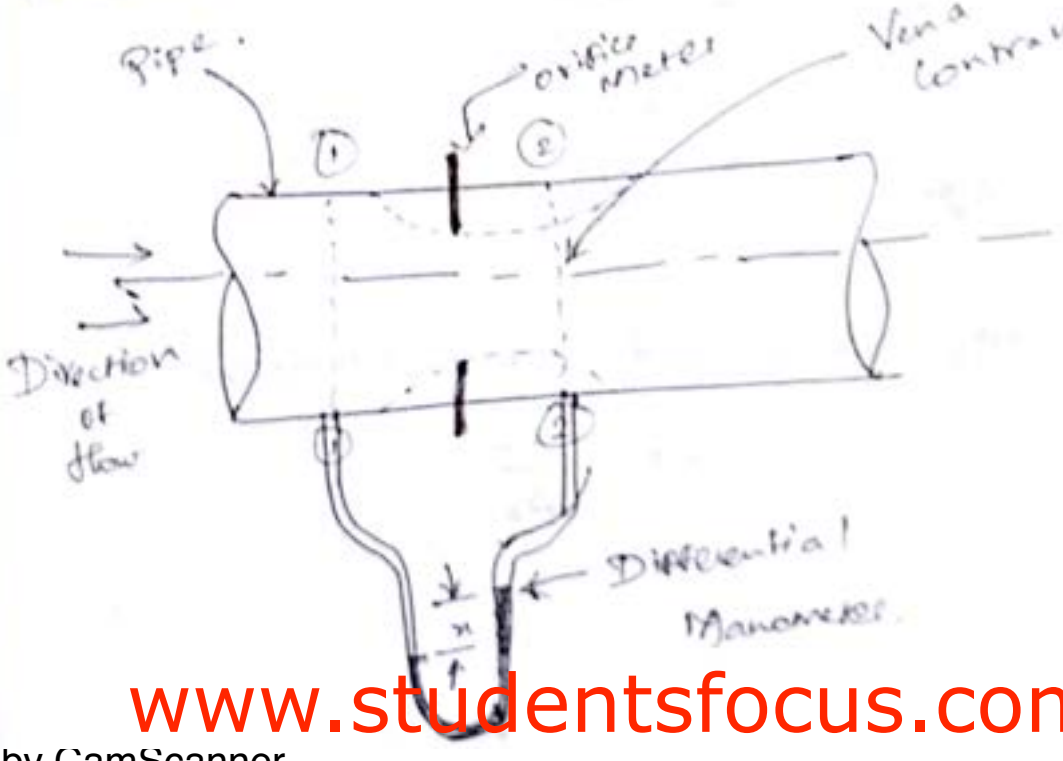
There are

1. Laminar flow.
2. Transient flow.
3. Turbulent flow.

ORIFICE METER :-

An orifice meter is a simple device used for measuring discharge of fluid through a pipe.

It works on the basis of Bernoulli's equation like Venturi meter



P_1, V_1 and A_1 are Pressure, Velocity and Area at the section 1

My P_2, V_2, A_2 are section 2

Applying Bernoulli's equation

$$\frac{P_1}{\omega} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\omega} + \frac{V_2^2}{2g} + Z_2$$

$$\left(\frac{P_1}{\omega} + Z_1\right) - \left(\frac{P_2}{\omega} + Z_2\right) = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

But $\left(\frac{P_1}{\omega} + Z_1\right) - \left(\frac{P_2}{\omega} + Z_2\right) = h =$

Difference head

$$h = \frac{V_2^2 - V_1^2}{2g}$$

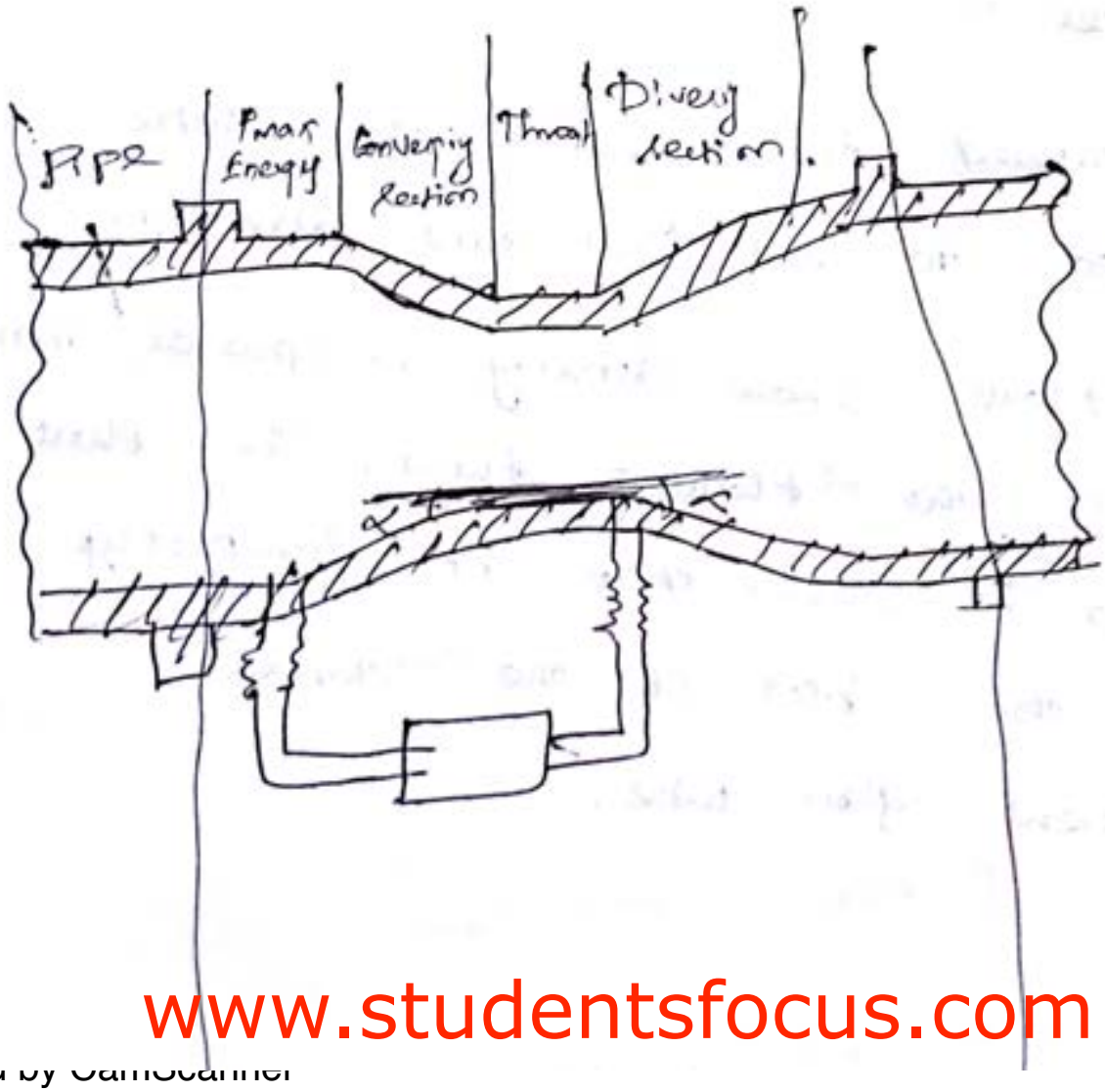
$$2gh = V_2^2 - V_1^2$$

The Coefficient of Contraction.

$$C_c = \frac{A_2}{A_0}$$

Venturimeter :-

When a Venturimeter is Placed in a Pipe carrying the fluid whose flow rate is to be Measured, a Pressure drop occurs between the entrance and throat of the Venturimeter. This Pressure drop is measured using a differential Pressure sensor and when Calibrated this Pressure drop becomes a Measure of flow rate.



It is used where high Pressure recovery is required.

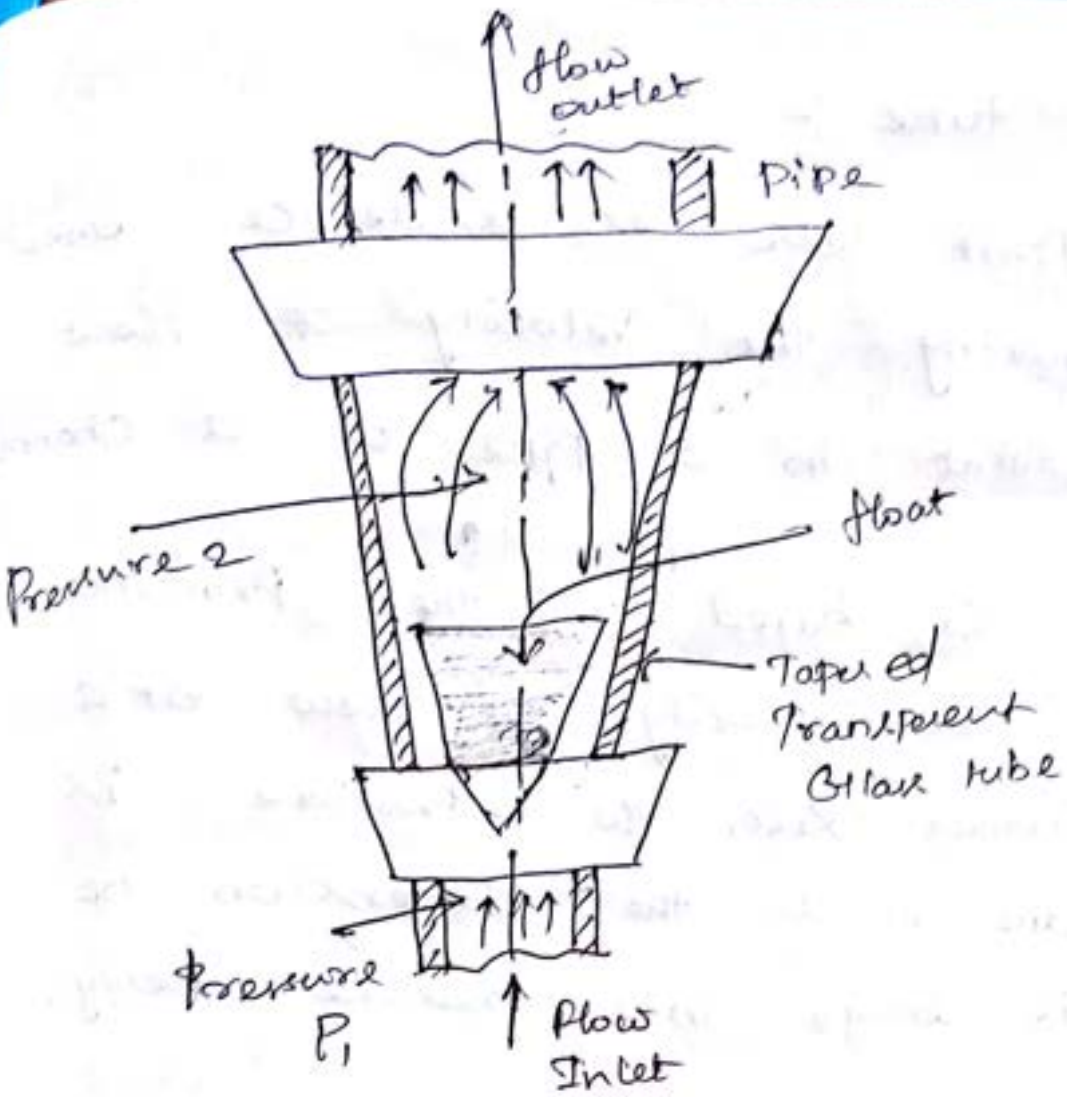
Can be used for Measuring flow rates of Waters, Wastes, gases, suspended solids, slurries and dirty liquids.

Can be Used Used to Measure high flow rates in Pipes having diameters in a few Meters.

Rotameter :-

A tapered transparent glass tube graduated to read flow rate directly.

A float whose density is greater than that of the flowing fluid. The float diameter is such that it completly blocks the inlet of the tapered transparent glass tube.



Ca be Used to Measure flow rates of Corrosive fluids.

Particularly Useful to Measure low flow rate.

flow conditions are Visible.

flow rate is a linear function.

Pitot tube :

Pitot tube is a device used for measuring the velocity of flow at any point in a pipe or a channel.

It is based on the principle that if the velocity of flow at a point becomes zero, the pressure is increased due to the conversion of the kinetic energy into pressure energy.

P_1 : Intensity of Pressure at Point 1

V_1 : Velocity at 1

P_2 : Intensity of Pressure at 2

V_2 : Velocity at Point 2.

H : depth of tube in the liquid.

h : rise of liquid in the tube

Applying Bernoulli's equation at (1) and (2)

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 \quad \rightarrow (i)$$

But $z_1 = z_2$

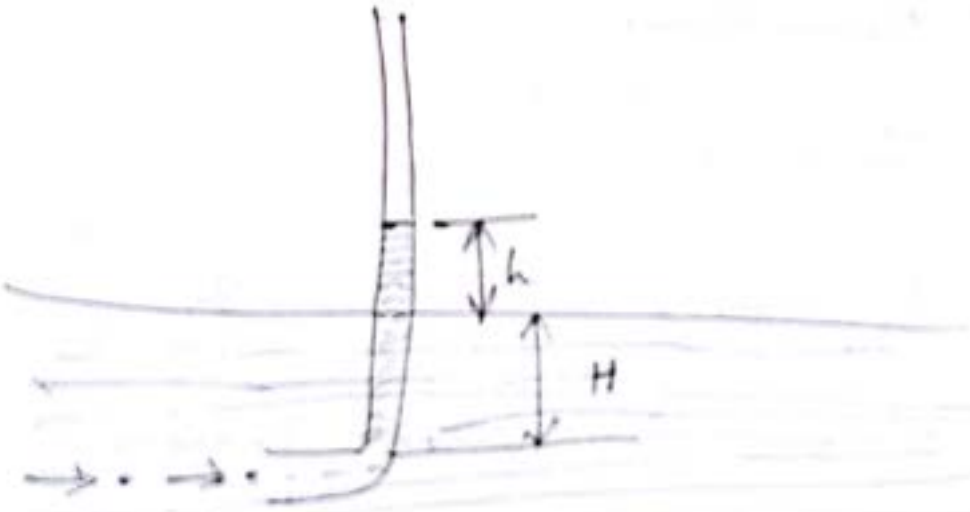
Pressure at (1) $= \frac{P_1}{\rho g} = H$

Pressure at (2) $= \frac{P_2}{\rho g} = (h + H)$

Substitute these values.

$$\therefore H + \frac{V_1^2}{2g} = (h + H)$$

$$h = \frac{V_1^2}{2g} \quad (\text{or}) \quad V_1 = \sqrt{2gh}$$



Pitot tube

Temperature :-

It is a Numerical Measure of hot and cold bodies.

It's measurement is done by detection of heat transfer. Temperature is one of the most frequently used parameters for measurement and controlling of industrial Processes.

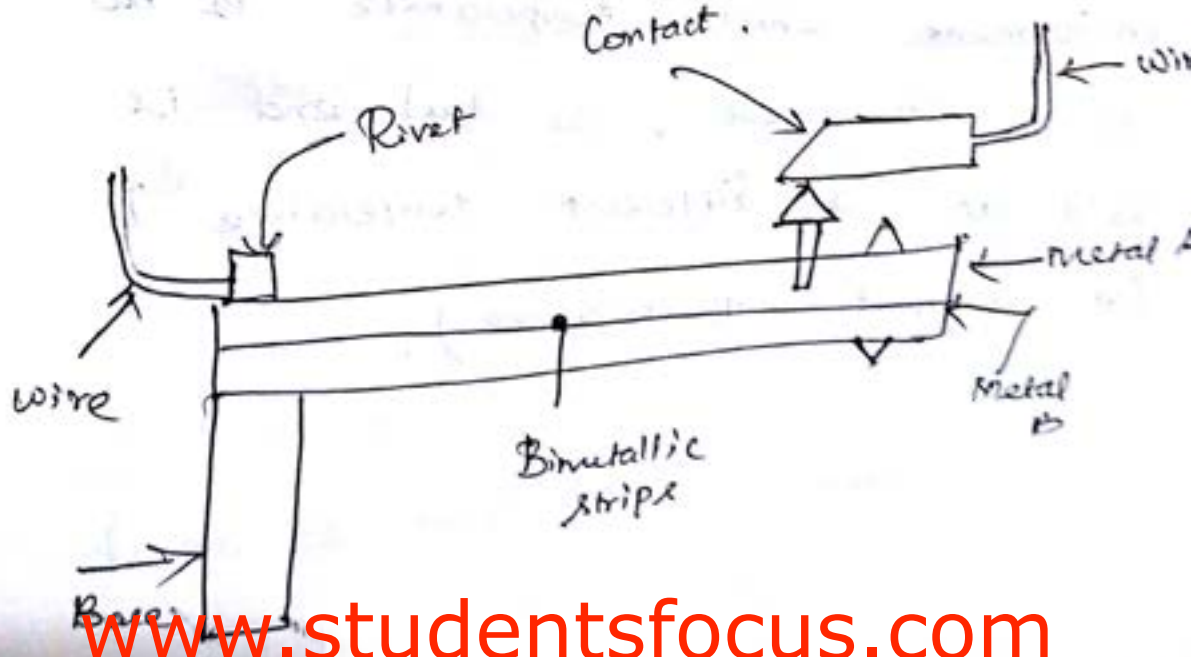
Examples : Metallurgical Processes.

Temperature Measurement devices :-

* Bimetallic Strips
* Thermocouples
* Thermometers
* Thermistors
* Pyrometers
* Resistance Temperature Detectors.

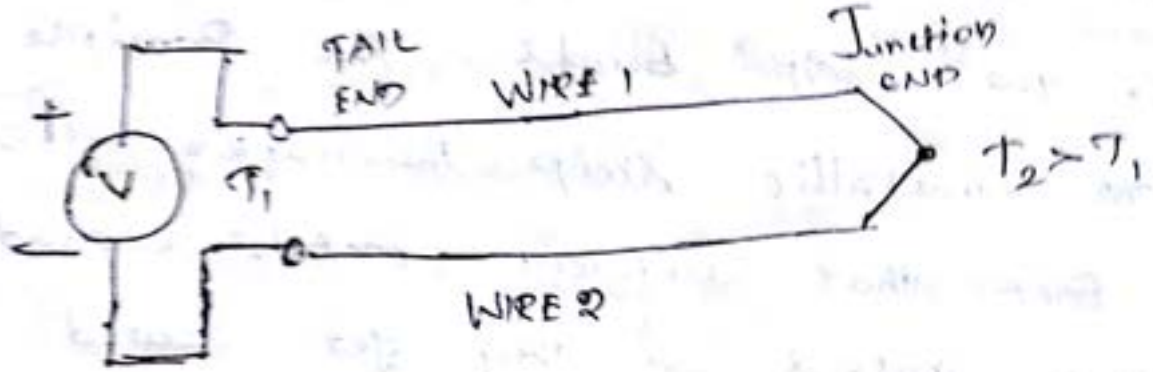
Bimetallic strip Thermometer :-

It is a strip made of two different Metals, one on each side. In a bimetallic strip, the two metals have two different coefficient of expansion and when the temperature changes, the strip bends. The principle behind the bimetallic strip thermometer relies on the fact that different metals expand at different rates as they get heated up. By Bonding two different metals together, we can make a simple electric Controller that can withstand fairly high temperatures. This type of Controller is often found in ovens.



Thermocouple :-

A thermocouple is a device made of two different wires joined at one end, called Junction end. The two wires are called thermo elements.



The two thermocouples are distinguished as positive and negative ones. The one end of the thermocouple is called tail end or reference end.

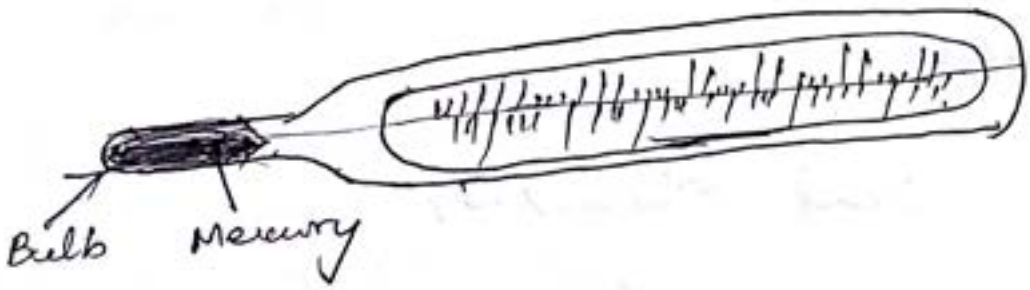
The Junction end is placed in the enviorment whose temperature T_2 has to be measured. The tail end is held at a different temperature T_1 (at ambient temperature).

Thermometer :-

Thermometer was invented by Daniel Gabriel Fahrenheit. One of the most common device for measuring Temperature is the glass thermometer.

It consist of glass tube filled with mercury or some other liquid, which act as the working fluid.

When the Liquid Mercury is heated, it expands inside a Narrow tube that has been Calibrated to show the temperature. Temperature can be recorded in celsius,



Thermometer.

This is similar to the design of medical thermometer.

Thermistor :

Thermistors are made up of solid semiconductor materials having high coefficient of resistivity.

Semiconductors used to measure the temperature are called thermistors.

When a thermistor is employed for temperature measurement, it resistance decreases with increase in temperature.

The valence electrons, which are mutually shared by the metal atoms, move continously and freely through the metal during their movement from atom to atom.

Bead Thermistor

Washer Thermistor

Disc Thermistor

Rod Thermistor

Probe Thermistor

PYROMETERS :-

If the temperature of a very hot body has to be measured, then contact type temperature - measuring devices will not be suitable, since they will be damaged.

When they come in contact with the very hot body.

So, Non contact type temperature measuring device are needed and they are called Pyrometers.

Types of Pyrometers :-

* Optical Pyrometers.
* Total Radiation Pyrometer
* Infrared Pyrometer.

Pyrometer derived from the Greek word Pyro mean fire and Metro mean measuring.

Readability :-

It is a measure of an instruments ability to display incremental changes in its output value. This is known as Readability.

Realiability :-

Realiability of an item is the probability that it will perform a required functions under a specified conditions for a stated period of time is known as Realiablity.

Activity Completed

× ——— ×.