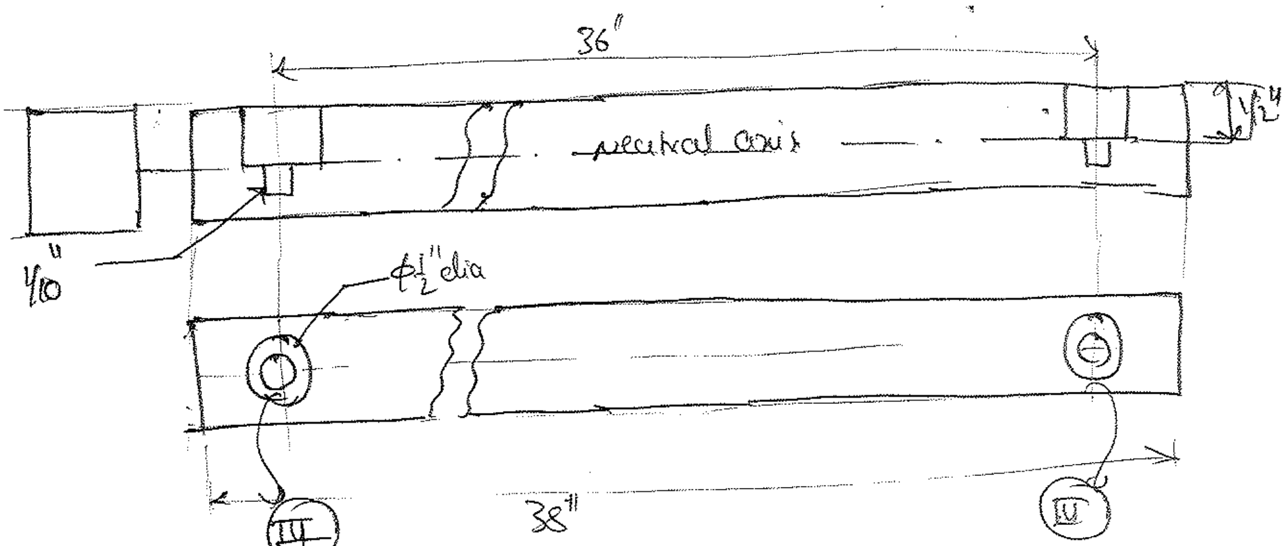
UNIT-V

Linear measurement:

(1) Length Standard:

Need for establishing Standard of length was araised. Length Standards are generally made with diff types at different times in History

(I) Imperical Standard yard:



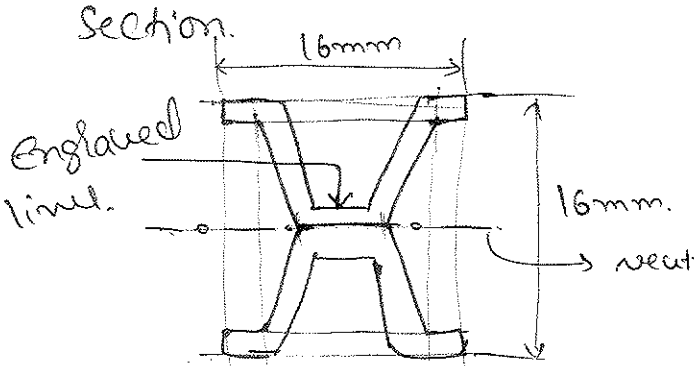
Imperical standard yard is made of 1 inch square cross-section Bronze bar [82% copper, 13 tin, 5 zinc] and 38 inches (38") long. The bar has two 1/2" inch dia deep holes. Ed each hole is fitted with 1/10th inch dia gold plug. The top surface of the gold plug are highly polished and contain 3 lines engraved transversely, two lines horizontally

The yard is defined as the distance between two central transver lines.

* The Temp of bar is content at 62°F
* The Bar is supported on roller in specified manner to prevent flexure.
* Bending moment of Beam the neutral axis remains content
* plug remains protected from accidental damage

(2) International Standard meter :-

This was established by International bureau of weights and measures. in 1875.
This prototype meter made up of platinum - iredium alloy (90% platinum, 10% irredium). having a cross section.



Length = 100cm.

The upper surface of the web is heighly polished. and has two fine lines engraved on it. It is inoxidable and have good finish required for ruling. The bar should be kept at 0°C, under normal atmospheric condition. It is supported by two rollers of dia atleast 1cm diameter and situated simmetrically in the horizantal plane. The distence between the these rollers are 589mm. so as to give the min deflection. The distence between two engraved lines on the web is said to be one meter.

" Acc to this standard. it is the distence b/n two engraved lines at 0°C b/n the centre position of the pure platinum irredium alloy, total length 102cm.

$$b = \frac{L}{\sqrt{n^2-1}}$$

L = Total length of Bar
b = distence b/n points
n = no of supports.

Dis Advantages of material Standard:

* matarial standard influenced by the variation of Environmamental condition like, Temparature pressure, humidity, and Acing
* The Standards are required to be preserved or stored under security to prevent thair damage or distruction
* The Replica of Standards are not available
* There are not easily reproducable
* Considerable difficulty is experienced while comparing and verifying the Size of Guages
* Convertion factor was to be used for Changing over the metric working

(3) wavelength standard

The major drawback with the Imperical yard and matarial standard is thair length slightly changes with time, considrable difficulty is Experienced while compairing and verifying the matarial Standard.

So we need to have a standard length which will be accurate and Invariable.

In 1907, Jaquas Babinet a Frech Scientist proposed a wavelength of monochromatic light can be used as a Natural and Invariable unit of length. A° (Angstrom) is a unit of wavelength, The light used is "Red cadmium" at 15°C.

Orange Radiation of Isotope krypton-86 was choosen for new definition of length

According to this definition The meter was defined as 1650763.73 wavelengths of Red Orange Radiation of Krypton Isotope 86 Gas

1 meter = 1650763.76 wavelength (Kr-86)

1 yard = 0.9144 x 1650763.76

1 yard = 1509458.3 wavelengths

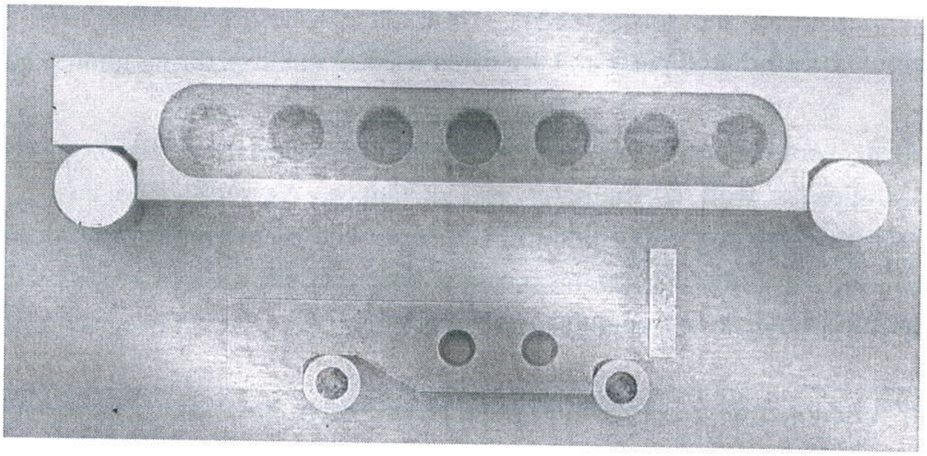
Acc to meter is now defined as the length of the path travelled by light in vaccume in $\frac{1}{299792458}$ seconds.

<u>Advantages of wavelength Standard:-</u>

* It is not influenced by the atm conditions like, Temp, pressure humidity and aging
* Need not to be preserved (or) stored under Controlled conditions.
* not subjected to distruction by wear & Tear
* This standard is easily available to all ~~Stats~~. Standardising laboratories and industries.
* No problem of transfering This Standard to other Standard meter and yard.
* Replica of Standard may available.
* It can be used for making Comparative measurements of very high accuracy.

Limit - 5, pg: 4/23

- The angle is calculated by using the sine rule. Some engineering and metalworking reference books contain tables showing the dimension required to obtain an angle from 0-90 degrees, incremented by 1minute intervals.



PRINCIPAL:

Angles are measured using a sine bar with the help of gauge blocks and a dial gauge or a spirit level. The aim of a measurement is to measure the surface on which the dial gauge or spirit level is placed horizontally. For example, to measure the angle of a wedge, the wedge is placed on a horizontal table. The sine bar is placed over the inclined surface of the wedge. At this position, the top surface of the sine bar is inclined the same amount as the wedge. Using gauge blocks, the top surface is made horizontal. The sine of the angle of inclination of the wedge is the ratio of the height of the gauge blocks used and the distance between the centers of the cylinders.

UNIT - V

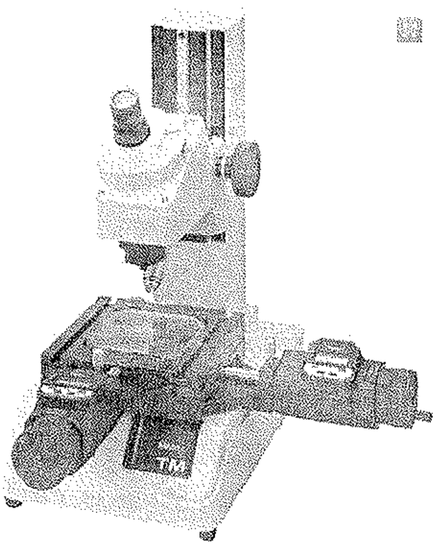
TOOLMAKERS MICROSCOPES

The toolmakers microscopes include either manual micrometer measuring heads or digimaticmicrometer measuring heads. Toolmakers microscopes are used for inspection and measurement of machined parts and are often used in manufacturing quality control processes.

The Radical Toolmakers Precise Measuring Microscope is usedfor the purposes of measuring lengths, angles as well as diameter and distances. As such, it is commonly used by auto component manufacturers, tool manufacturers as well as in quality control or various tools and parts. A toolmakers microscope has a robust base that allows it to hold a wide range of objects for observations and measurements.

As multi functional devices, toolmaker tools will often be found in most of the manufacturing companies/factories involved in the manufacturing of machines, electronics and tools. In such places, they help in the measurement of shapes, sizes, angles and positions of small components which fall under the measuring range of the microscope. This makes the microscope particular suitable for such tasks as measuring the shapes of such components as milling cutters, thread gauge and guide screw among others.

In addition, the device finds use for measuring center to center distance of holes in a plane, linear measurements as well as accurate angular measurements.



TOOLMAKERS MICROSCOPES

Application

Determining relative positions

Here, the microscope is used elative positions of different points by simply measuring the travel that is necessary for bringing a second point to the position that was formerly occupied by the first and so forth.

Measuring angles

Using this microscope, it is possible to measure the angles by using the protractor eyepiece. This allows for the angles of the object to be viewed and determined.

Comparison measurement

This is where the microscope is used to do comparison of the thread forms, measuring of the pitch and diameter. Here, the microscope achieves this using the master profiles engravings in the eyepiece.

Comparing with a scale

This is where the images of the object are compared with the scale in the projection screen.

COLLIMATOR

A collimator is a device that narrows a beam of particles or waves. To narrow can mean either to cause the directions of motion to become more aligned in a specific direction (i.e., make collimated light or parallel rays), or to cause the spatial cross section of the beam to become smaller (beam limiting device).

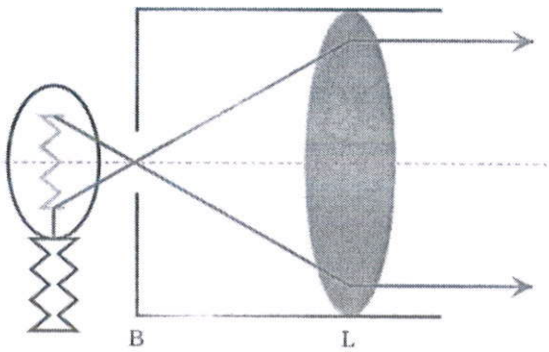
In optics, a collimator may consist of a curved mirror or lens with some type of light source and/or an image at its focus. This can be used to replicate a target focused at infinity with little or no parallax.

In lighting, collimators are typically designed using the principles of nonimaging optics.

Optical collimators can be used to calibrate other optical devices, to check if all elements are aligned on the optical axis, to set elements at proper focus, or to align two or more devices such as binoculars or gun barrels and gunsights. A surveying camera may be collimated by setting its fiduciary markers so that they define the principal point, as in photogrammetry.

Optical collimators are also used as gun sights in the collimator sight, which is a simple optical collimator with a cross hair or some other reticle at its focus. The viewer only sees an image of the reticle. They have to use it either with both eyes open and one eye looking into the collimator sight, with one eye open and moving the head to alternately see the sight and the target, or with one eye to partially see the sight and target at the same time. Adding a beam splitter allows the viewer to see the reticle and the field of view, making a reflector sight.

Collimators may be used with laser diodes and CO_2 cutting lasers. Proper collimation of a laser source with long enough coherence length can be verified with a shearing interferometer.



Optical collimator

OPTICAL PROJECTOR:

Optical Projector also known as an optical comparator, a profile projector is an optical instrument that can be used for measuring.

projector is an optical instrument that can be used for measuring. It is a useful item in a small parts machine shop or production line for the quality control inspection team.

A projector or image projector is an optical device that projects an image (or moving images) onto a surface, commonly a projection screen. Most projectors create an image by shining a light through a small transparent lens, but some newer types of projectors can project the image directly, by using lasers.

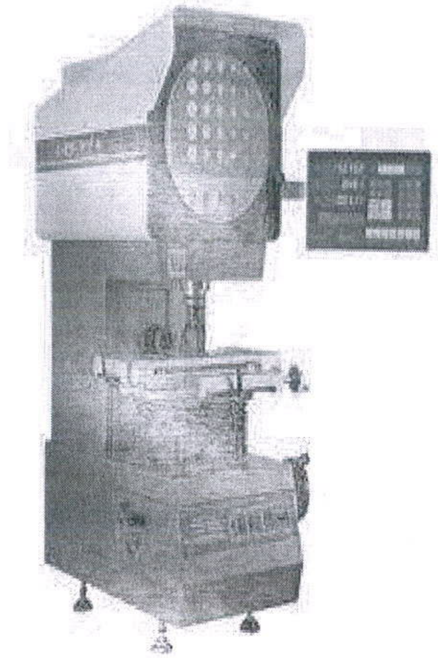
profile projector is used for measuring two-dimensionalcontours of precision specimens and other work pieces produced. The part to be measured is magnified by an optical system and projected on a screen.

The projector magnifies the profile of the specimen, and displays this on the built-in projection screen. On this screen there is typically a grid that can be rotated 360 degrees so the X-Y axis of the screen can be aligned with a straight edge of the machined part to examine or measure. This projection screen displays the profile of the specimen and is magnified for better ease of calculating linear measurements.

An edge of the specimen to examine may be lined up with the grid on the screen. From there, simple measurements may be taken for distances to other points. This is being done on a magnified profile of the specimen. It can be simpler as well as reduce errors by measuring on the magnified projection screen of a profile projector.

The typical method for lighting is by diascopic illumination, which is lighting from behind. This type of lighting is also called transmitted illumination when the specimen is translucent and light can pass through it. If the specimen is opaque, then the light will not go through it, but will form a profile of the specimen.

Measuring of the sample can be done on the projection screen. A profile projector may also have episcopic illumination (which is light shining from above). This useful in displaying bores or internal areas that may need to be measured.

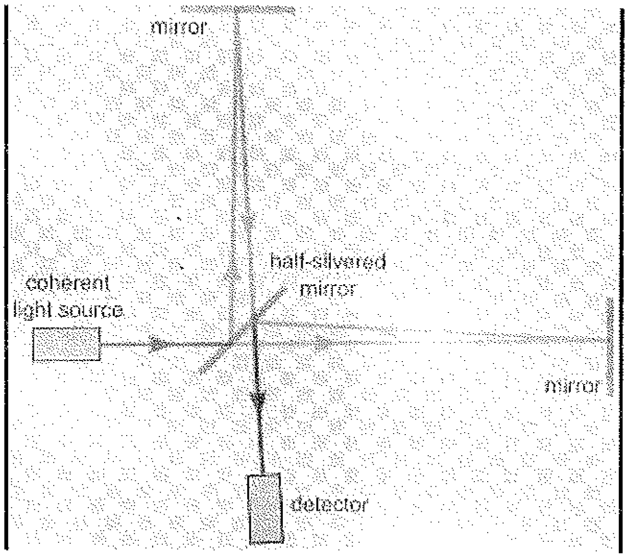


Projector

Interferometre:

Interferometre is a family of techniques in which waves, usually electromagnetic waves, are superimposed causing the phenomenon of interference in order to extract information. Interferometry is an important investigative technique in the fields of astronomy, fiberoptics, engineering metrology, optical metrology, oceanography, seismology, spectroscopy(and its applications to chemistry), quantum mechanics, nuclear and particle physics, plasma physics, remote sensing, biomolecular interactions, surface profiling, microfluidics, mechanical stress/strain measurement, velocimetry, and optometry.

Interferometers are widely used in science and industry for the measurement of small displacements, refractive index changes and surface irregularities. In an interferometer, light from a single source is split into two beams that travel different optical paths, then combined again to produce interference. The resulting interference fringes give information about the difference in optical path length. In analytical science, interferometers are used to measure lengths and the shape of optical components with nanometer precision; they are the highest precision length measuring instruments existing. In Fourier transform spectroscopy they are used to analyze light containing features of absorption or emission associated with a substance or mixture. An astronomical interferometer consists of two or more separate telescopes that combine their signals, offering a resolution equivalent to that of a telescope of diameter equal to the largest separation between its individual elements.



Interferometer

PRINCIPAL:

Interferometry makes use of the principle of superposition to combine waves in a way that will cause the result of their combination to have some meaningful property that is diagnostic of the original state of the waves. This works because when two waves with the same frequency combine, the resulting intensity pattern is determined by the phase difference between the two waves—waves that are in phase will undergo constructive interference while waves that are out of phase will undergo destructive interference. Waves which are not completely in phase nor completely out of phase will have an intermediate intensity pattern, which can be used to determine their relative phase difference. Most interferometers use light or some other form of electromagnetic wave.

Typically (see Fig. 1, the well-known Michelson configuration) a single incoming beam of coherent light will be split into two identical beams by a beam splitter (a partially reflecting mirror). Each of these beams travels a different route, called a path, and they are recombined before arriving at a detector. The path difference, the difference in the distance traveled by each beam, creates a phase difference between them. It is this introduced phase difference that creates the interference pattern between the initially identical waves. If a single beam has been split along two paths, then the phase difference is diagnostic of anything that changes the phase along the paths. This could be a physical change in the path length itself or a change in the refractive index along the path.

SCREW THREAD MEASUREMENT

A screw thread, often shortened to thread, is a helical structure used to convert between rotational and linear movement or force. A screw thread is a ridge wrapped around a cylinder or cone in the form of a helix, with the former being called a straight thread and the latter called a tapered thread. A screw thread is the essential feature of the screw as a simple machine and also as a fastener.

The mechanical advantage of a screw thread depends on its lead, which is the linear distance the screw travels in one revolution. In most applications, the lead of a screw thread is chosen so that friction is sufficient to prevent linear motion being converted to rotary, that is so the screw does not slip even when linear force is applied, as long as no external rotational force is present. This characteristic is essential to the vast majority of its uses. The tightening of a fastener's screw thread is comparable to driving a wedge into a gap until it sticks fast through friction and slight elastic deformation.

APPLICATIONS:

- Fasteners such as wood screws, machine screws, nuts, and bolts.
- Connecting threaded pipes and hoses to each other and to caps and fixtures.
- Gear reduction via worm drives
- Moving objects linearly by converting rotary motion to linear motion, as in the leadscrew of a jack.
- Measuring by correlating linear motion to rotary motion (and simultaneously amplifying it), as in a micrometer.
- Both moving objects linearly and simultaneously measuring the movement, combining the two aforementioned functions, as in a leadscrew of a lathe.
- In all of these applications, the screw thread has two main functions:
- It converts rotary motion into linear motion.
- It prevents linear motion without the corresponding rotation.

Elements of measurements:

Most of the measurement systems contain three main functional elements are i) Primary sensing element ii) Variable conversion element & iii) Data presentationelement. Primary sensing element: The quantity under measurement makes its first contact with the primary sensing element of a measurement system.

Errors in Threads

Errors in screw threads are related to the five elements of the screw threads. They are major diameter, minor diameter, pitch diameter, pitch and thread angle. If any errors are taking place in these five elements the produced screw is rejected. So, these elements are also be checked with proper gauging system carefully. The threads are produced by a point cutting tools. The errors in major and minor diameter cause interference of the mating threads, less root section, less wall thickness and poor contact of the flanks, which ultimately cause the weak in strength of the component. The errors in effective diameter also cause the interference of the flanks.

The errors in pitch and thread angle also cause the progressive tightening of the mating parts due to the interference of the flank surfaces.

Let us discuss some important errors in thread forms. They are

1. Drunken error
2. Pitch errors

Drunken Error: It is error due to the irregular form of helical groove on a cylindrical surface. In this case pitch measured parallel to the axis is always same, but problem is with the thread is not cut to its true helix.

Due to this flank surface will not be as a straight edge, it will be as curved form.

Pitch errors:

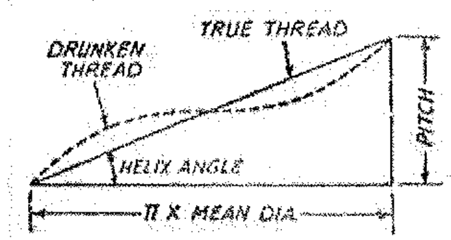
The pitch errors are due to improper ratios of cutting tool velocity to rotating velocity of the workpiece. these pitch errors are again classified as

Progressive pitch erros
Periodic pitch errors
Irregular errors

Progressive errors: In this the pitch error results increasing of major or minor diameter or decreasing of major or minor diameter. It means the error may either in increasing order or decreasing order.

Periodic errors: In this the pitch error causes the errors to repeat at certain time of interval.

Irregular errors: These are the errors randomly take place on threads without any specific reason. These are the combination of all the errors take place on threads.



MEASUREMENT OF EFFECTIVE DIAMETRE

The pitch diameter (often called the effective diameter) of a parallel thread is the diameter of the imaginary co-axial cylinder which intersects the surface of the thread in such a manner that theintercept on a generator of the cylinder, between the points where it meets the opposite flanks of a thread groove, is equal to half the nominal pitch of the thread.

The major diameter of a thread is the diameter of the imaginary co-axial cylinder that just touches the crest of an external thread or the root of an internal thread.

The minor diameter is the diameter of an imaginary cylinder that just touches the roots of an external thread and (or) the crests of an internal thread.

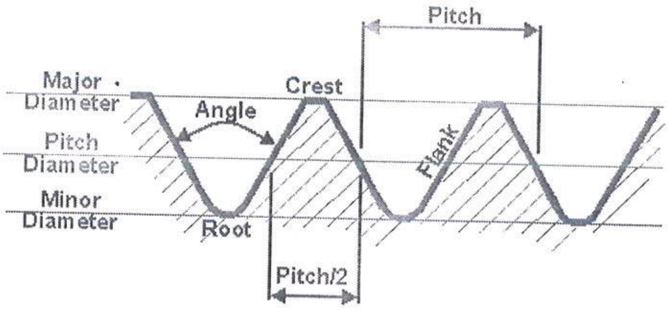
The crest of a thread is the prominent part of a thread, whether internal or external.

The root is the bottom of the groove between the two flanking surfaces of the thread whether internal or external.

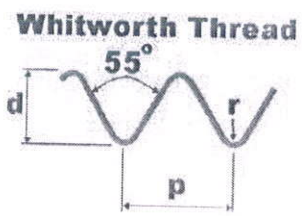
The flanks of a thread are the straight sides that connect the crest and the root.

The angle of a thread is the angle between the flanks, measured in an axial plane section.

The pitch of a thread is the distance, measured parallel to its axis, between corresponding points on adjacent surfaces, in the same axial plane.



Sir Joseph Whitworth proposed this thread in 1841. This was the first standardised thread form. The form of the thread is shown in the diagram. The principal features of the British Standard Whitworth (BSW) thread form are that the angle between the thread flanks is 55 degrees and the thread has radii at both the roots and the crests of the thread. The relevant standard for this thread form is the British Standard BS 84 - 2007. The thread form is now redundant and has been replaced by Unified and Metric threads but there are many applications in which it is still used. The British Standard Fine (BSF) thread has the same profile as the BSW thread form but was used when a finer pitch was required for a given diameter.



If

p = pitch of the thread

d = depth of the thread

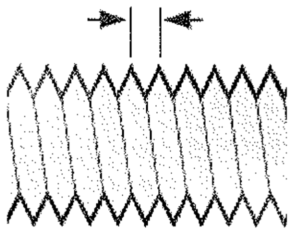
r = radius at the top and bottom of the threadsthen:

$d = 0.640327\ p$

$r = 0.137329\ p$

Thread pitch:

Metric fasteners are specified with a thread pitch instead of a thread count. The thread pitch is the distance between threads expressed in millimeters (measured along the length of the fastener). For example a thread pitch of 1.5 means that the distance between one thread and the next is 1.5mm. In general smaller fasteners have finer thread so they have lower thread pitch. For a table of standard metric thread pitchs please see our Metric Thead Pitch Table.



Metric - Thread pitch

Thread angle:

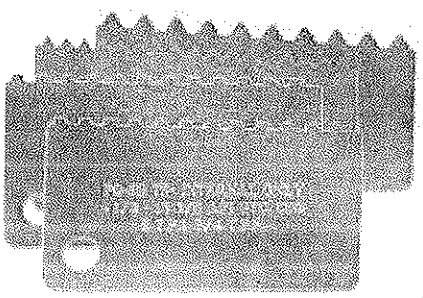
The thread angle of a screw is the included angle between the thread flanks, measured in a plane containing the thread axis.[1] This is a defining factor for the shape of a screw thread.

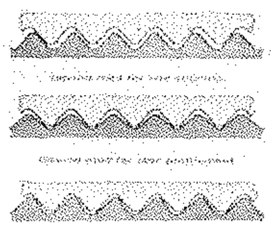
Thread angle

Name	Code	Angle
Acme thread		29°
Metric trapezoidal threads	Tr	30°
Buttress threads	S	45°
German buttress threads	S	30°

Profile thread gauges:

Thread Profile Gages are manufactured to industry standard tolerances using our state-of-the-art Wire EDM technology. Our Thread Profile Gages quickly identify tapered thread forms per the API Standards 5B and Spec 7 as well as Stub Acme, National Acme and others. All our Thread Profile Gages are in stock for immediate delivery and we offer specials made to your specifications.





unit 5, pg. 14/23

Surface measurement

synonymous with surface metrology – determines surface topography, which is essential for confirming a surface's suitability for its function. Surface measurement conceptually includes surface shape, surface finish, surface profile roughness (R_a), or in surface area roughness (S_a), surface texture, asperity and structural characterization.

For example, engine parts may be exposed to lubricants to prevent potential wear, and these surfaces require precise engineering – at a microscopic level – to ensure that the surface roughness holds enough of the lubricants between the parts under compression, while it is smooth enough not to make metal to metal contact. For manufacturing and design purposes, measurement is critical to ensure that the finished material meets the design specification.

In the image above, a microscopic surface is measured in three dimensions using an interference microscope. For scale, the 3-D surface measurement above maps features within a 22 nanometer range of height, and the indicated pit defect is less than 12 nanometers deep. A nanometer (nm) is one one-thousandth of a micron (µm). There are about 80 microns (80,000 nm) in the thickness of a human hair. The area of the measured surface is 449 × 335 microns.

Surface Roughness Measurement **for Defect Analysis**

Defects may occur either in material surfaces during processing or after use, and defect analysis is often essential for providing the information to improve effectiveness, efficiency and durability of surfaces. For example, a product that requires long life in adverse conditions is prosthetic joints, such as hip joints. Being able to measure the surface material for wear, scratches, and the shape of a prosthetic joint after it has been removed for replacement can be beneficial for future hip replacement procedures. Optical surface measurement techniques have been used to measure these and other medical-quality surfaces such as stents, dental implants and artificial bone.

In the image of a 3-D surface map above, several pits appear in a step height calibration standard, which is made of quartz and then chrome plated. This type of standard is often used for calibration of profilometers of all types. The pits may be the result of impacts, wear, or chemical effects. If enough of these pits were present, the surface's suitability as a step height standard would be compromised. Depending on the application, the determination of pits versus asperities (bumps) is critical to the performance of the surface.

While computer hard disk surfaces can accommodate a certain number of pits, asperities can cause failures due to low flying height of the disk read/write heads. Optical profilers must be able to resolve the defect sufficiently to determine its polarity (pit or bump) and to characterize its height or depth.

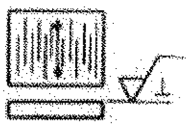
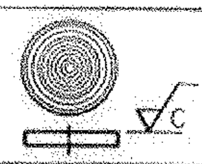
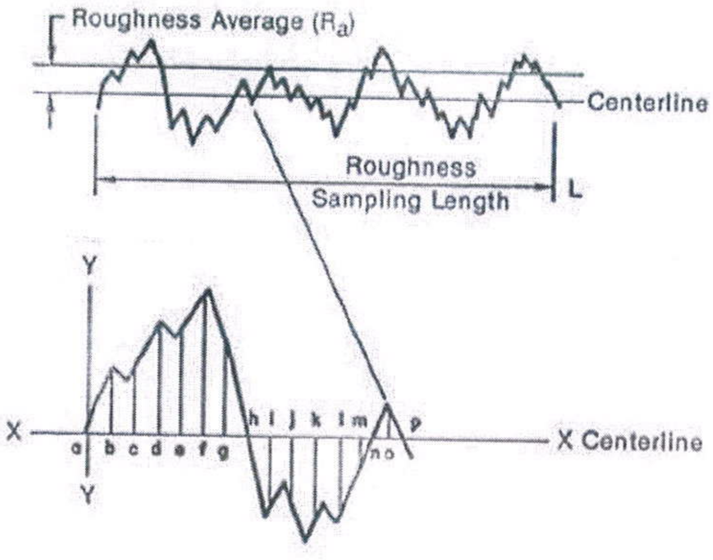
Lay Symbol	Meaning	Example Showing Direction of Tool Marks
=	Lay approximately parallel to the line representing the surface to which the symbol is applied.	
⊥	Lay approximately perpendicular to the line representing the surface to which the symbol is applied.	
X	Lay angular in both directions to line representing the surface to which the symbol is applied.	
M	Lay multidirectional.	
C	Lay approximately circular relative to the center of the surface to which the symbol is applied.	
R	Lay approximately radial relative to the center of the surface to which the symbol is applied.	
P^3	Lay particulate, non-directional, or protuberant.	

chart categorizes the various lay configurations and shows the standardizes symbols used on drawing

NUMERICAL VALUES FOR ASSESSMENT

- Arithmetic roughness average
  - This method is also known as roughness average and by two earlier term; arithmetic average (AA) and center-line average (CLA)
  - The roughness average is the arithmetic average of the absolute values of the deviation from the profile height measured from the centerline along a specified sampling length
  - Two method for determining the value
    - i. Graphical method
    - ii. Electrical averaging



$$R_a = \frac{y_a + y_b + y_c \cdots\cdots + y_n}{n}$$

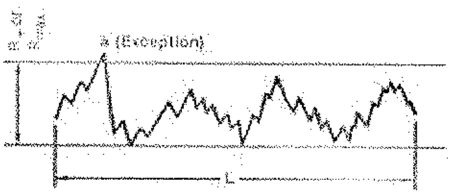
Other standardized assessment methods

1. Root-Means-Square roughness (R_a or RMS)
   - Closely related to the roughness average (Ra)
   - Square the distances, average them, and determine the square root of the result
   - The resulting value is the index for surface texture comparison
   - Usually 11% higher than the Ra value
2. Maximum Peak-Valley Roughness (R_{max} or R_t)
   - Determine the distance between the lines that contact the extreme outer and inner point of the profile
   - Second most popular method in industry
   - See figure A
3. Ten-Point Height (R_z)
   - Averages the distance between the five peaks and five deepest valleys within the sampling length
   - See figure B
4. Average Peak-to-Valley Roughness (R or H or H_{pl})
   - Average the individual peak-to-valley heights
   - See figure C
   - Use the height between adjacent peaks and valleys, not measure from a center line to peak valleys
5. Average Spacing of Roughness Peaks ($A_r$or A_R)
   - Average the distance between the peaks without regard to their height
   - See figure D
6. Swedish Height of Irregularities (R or H)
   - Also known as Profiljupmethos
   - Only standard in Sweden (H) and Denmark (R)
   - It assume that, in wear situation, the peaks are affected by wear, but the valleys are not.
7. Bearing Length Ration ($T_p$and others)
   - Create a reference line through some of the peaks

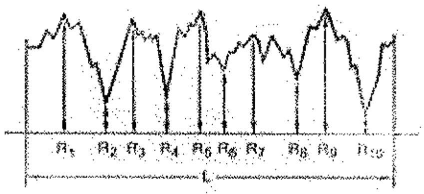
unit - 5, pg-17/23

- This line is at a predetermined height from the mean line, and you have then divide the subtended length through the peaks by sampling length to arrive at the assessment value
- See figure F

8. Leveling Depth (R_p and others)
    - Measure the height between the highest peak and the mean line
    - See figure G
9. Waviness Height (W)
    - Assess the waviness without regard to roughness by determining the peak-to-valley distance of the total profile within the sampling length

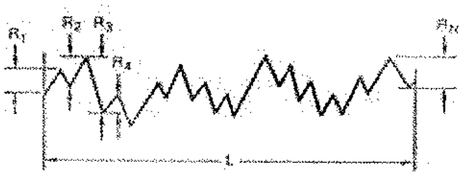


A. MAXIMUM PEAK-TO-VALLEY ROUGHNESS HEIGHT (R_t OR R_{max})



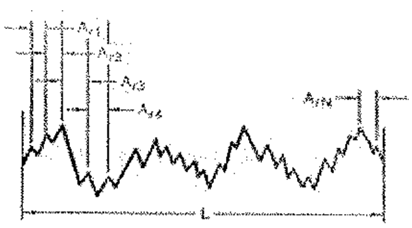
$$R_z = \frac{(R_1 + R_3 + R_5 + R_7 + R_9) - (R_2 + R_4 + R_6 + R_8 + R_{10})}{5}$$

B. TEN-POINT HEIGHT (R_z)



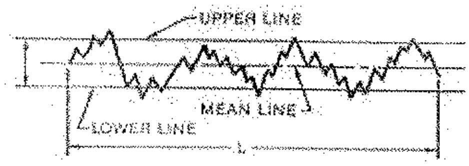
$$R = \frac{R_1 + R_2 + R_3 + \cdots R_N}{N}$$

C. AVERAGE PEAK-TO-VALLEY ROUGHNESS (R AND OTHER SYMBOLS)

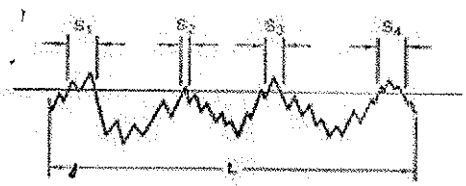


$$A_r = \frac{A_{r1} + A_{r2} + A_{r3} + \cdots A_{rN}}{N}$$

D. AVERAGE SPACING OF ROUGHNESS PEAKS (A_r OR A_R)

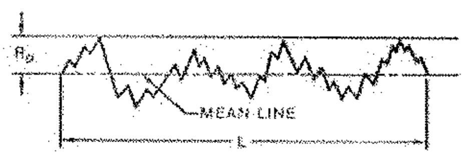


E. SWEDISH HEIGHT OF IRREGULARITIES. PROFILJUP (R OR H)

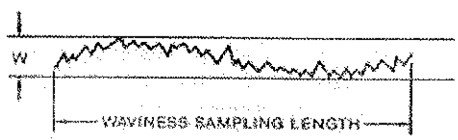


$$t_p = \frac{S_1 + S_2 + S_3 + S_4}{L}$$

F. BEARING LENGTH RATIO (t_p AND OTHER SYMBOLS)



G. LEVELING DEPTH (R_p AND OTHER SYMBOLS)



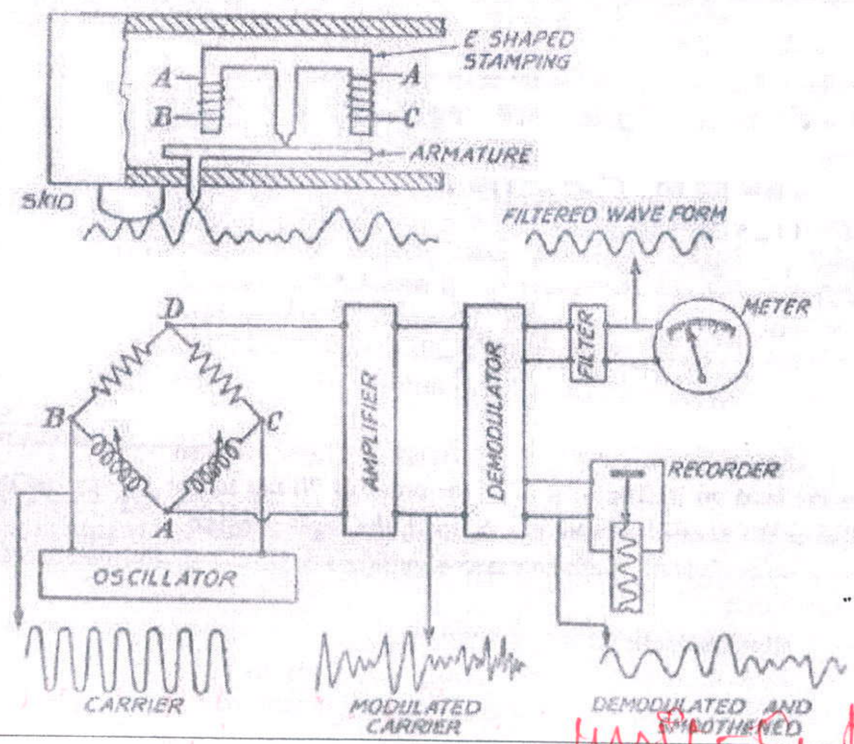
H. WAVINESS HEIGHT (W)

X	X^2
3	9
15	225
20	400
33	1089
25	625
18	324
5	25
10	100
15	225
15	225
5	25
11	121
14	196
13	169
27	729
8	64
Total 234	4551

AA = 234/16 = 14.6 micro in.

RMS = $(4551/16)^{1/2}$ = 16.9 micro in.

TAYLOR HOBSON TALYSURF

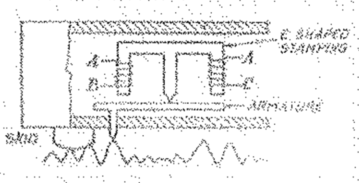


Unit-V, Pg: 19/23

This instrument also gives the same information as the previous instrument, but much more rapidly and accurately.

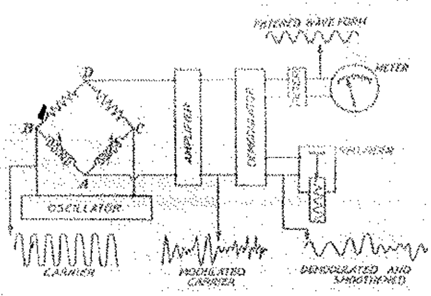
This instrument also as the previous one records the static displacement of the stylus and is dynamic instrument like profilometer.

The measuring head of this instrument consists of a diamond stylus of about 0.002 mm tip radius and skid or shoe which is drawn across the surface by means of a motorised driving unit. A neutral position in which the pick-up can be traversed manually is also provided.



The arm carrying the stylus forms an armature which pivots about the centre piece of E-shaped stamping. On two legs of (outer pole pieces) the E-shaped stamping there are coils carrying an a.c. current.

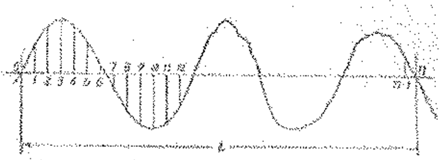
These two coils with other two resistances form an oscillator. The amplitude of the original a.c. current flowing in the coils is modulated because of air gap between the armature and E-shaped stamping. This is further demodulated so that the current now is directly proportional to the vertical displacement of the stylus only.



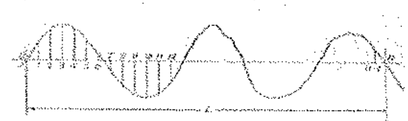
The demodulated output is caused to operate a pen recorder to produce a permanent record and a meter to give a numerical assessment directly. In recorder of this instrument the marking medium is an electric discharge through a specially treated paper which blackens at the point of the stylus.

Analysis of Surface Traces

- **Root Mean Square (R.M.S) Value**
- R.M.S. value is defined as the square root of the mean of the squares of



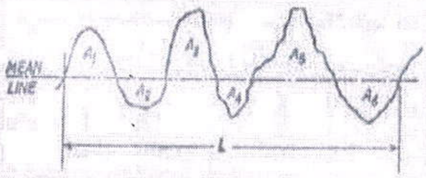
- **Centre Line Average (C.L.A) value.**
- This is defined as the average height from a mean line of all ordinates of the surface, regardless of the sign



$$C.L.A = \frac{h_1 + h_2 + \ldots\ldots + h_n}{n}$$

Unit-5, Pg: 20/23

- Things can be much simplified by using a planimeter which can find out the area of any curve. Then C.L.A. value



$$C.L.A = \frac{A_1 + A_2 + \ldots\ldots + A_n}{L} \times \frac{1}{\text{Vertical magnification}}$$

- *Calculate the CLA (Ra) value of a surface for which the sampling length was 0.8 mm. The graph was drawn to a vertical magnification of 10000 and a horizontal magnification of 100. and the areas above and below the datum line were :*

Above(mm2)	180	90	155	55
Below(mm2)	70	90	170	150

- Solution:

$$\frac{\text{Sum of areas } (mm^2)}{\text{Sampling length (mm)}} \times \frac{1000}{\text{Vertical magnification}} \times \frac{1}{\text{Horizontal magnification}}$$

- *In the measurement of surface roughness, heights of 20 successive peaks and troughs were measured from a datum and were 35, 25, 40, 22, 35, 18, 42, 25, 35, 22, 36, 18, 42, 22, 32, 21, 37, 18, 35, 20 microns.*
- *If these measurements were obtained over a length of 20 mm, determine the C.L.A. (Ra) and R.M.S value of the rough surface.*

Profilo graph This equipment is used for checking and recording the smoothness of profiles of pavements with accuracy and cost-effectiveness. The equipment, developed by Central Road Research Institute, comprises of a mobile trussed frame, four datum wheels which provide the plan of reference with respect to which the instrument, moves along the pavement surface during the test. The probing wheel undulates with the surface irregularities and the pen marker linked to probing wheel records the magnitude of the undulation on a graph sheet. The road roughness level is estimated using this equipment.

PROFILOGRAPH TESTING

accurately measures surface roughness through a computerized recorder capable of graphing a pavement profile both vertically and horizontally. The information it collects is used to calculate the International Roughness Index (IRI), which is expressed in units of inches/mile or millimeters/meters. An IRI value of 0 (zero) is equivalent to driving on a plate of glass. High ranges, upward to several hundred inches in a mile, indicate a very rough road. The Profilograph also measures a pavement's cross slope, allows bi-directional testing and multiple wheel path reporting, and can append data to existing files, which improves tracking and correlations throughout a project.

Another type of profilograph system is for measuring the surface texture of a road and how it relates to the coefficient of friction and thus to skid resistance. Pavement texture is divided into three categories; megatexture, macrotexture, and microtexture. Microtexture cannot currently be measured directly, except in a laboratory. Megatexture is measured using a similar profiling method as when obtaining IRI values, while macrotexture is the measurement of the individual variations of the road within a small interval of a few centimeters. For example, a road which has gravel spread on top followed by an asphalt seal coat will have a high macrotexture, and a road built with concrete slabs will have low macrotexture. For this reason, concrete is often grooved or roughed up immediately after it is laid on the road bed to increase the friction between the tire and road.

Equipment to measure macrotexture currently consists of a distance measuring laser with an extremely small spot size (< 1 mm) and data acquisition systems capable of recording elevations spaced at 1 mm or less. The sample rate is generally over 32 kHz. Macrotexture data can be used to calculate the speed-dependent part of friction between typical car tires and the road surface in both dry and wet conditions. Microtexture affects friction as well.

Lateral friction and cross slope are the key reaction forces acting to keep a cornering vehicle in steady lateral position, while it is subject to exiting forces arising from speed and curvature. Cross slope and curvature can be measured with a road profilograph, and in combination with friction-related measurements can be used to identify improperly banked curves, which can increase the risk of motor vehicle accidents.

ISI SYMBOL FOR INDICATION OF SURFACE FININSH

Roughness Values Ra µm	Roughness Grade Number	Roughness Triangle Symbols
50	N 12	~
25 12.5	N11 N10	▽
6.3 3.2 1.6	N9 N8 N7	▽▽
0.8 0.4 0.2	N6 N5 N4	▽▽▽
0.1 0.05 0.025	N3 N2 N1	▽▽▽▽