CSMSS's

Chh.Shahu College of Engineering, Aurangabad

Laboratory Manual

METROLOGY & QUALITY CONTROL

List of Practical's/Experiments

Part A

1. Determination of linear and angular dimensions of given composite part using precision/non precision measuring instruments.
2. Error determination with linear / angular measuring instruments.
3. Calibration of measuring instrument. Example – Dial gauge, Micrometer, Vernier (any one)
4. Machine tool alignment testing on any two machines.
5. Identification of surfaces using optical flat/interferometers and measure surface roughness using surface roughness tester.
6. Determination of geometry & dimensions of given composite object using profile projector and measurement of various angles of single point cutting tool using tool maker's microscope.
7. Measurement of thread parameters using floating carriage diameter measuring machine.
8. Measurement of spur gear parameters using Gear Tooth Vernier, Span, Gear Rolling Tester.

Part B

1. Determination of process capability from given components and plot variable control chart/ attribute chart.
2. Case study on various tools in Total Quality Management (TQM).

Part C

1. Industrial visit to Calibration lab /Quality control lab / Gear manufacturing unit / Automotive Industry / Engineering Industry.

PART A

EXPERIMENT NO 1

TITLE: Determination of linear and angular dimensions of given composite part using precision/non precision measuring instruments.

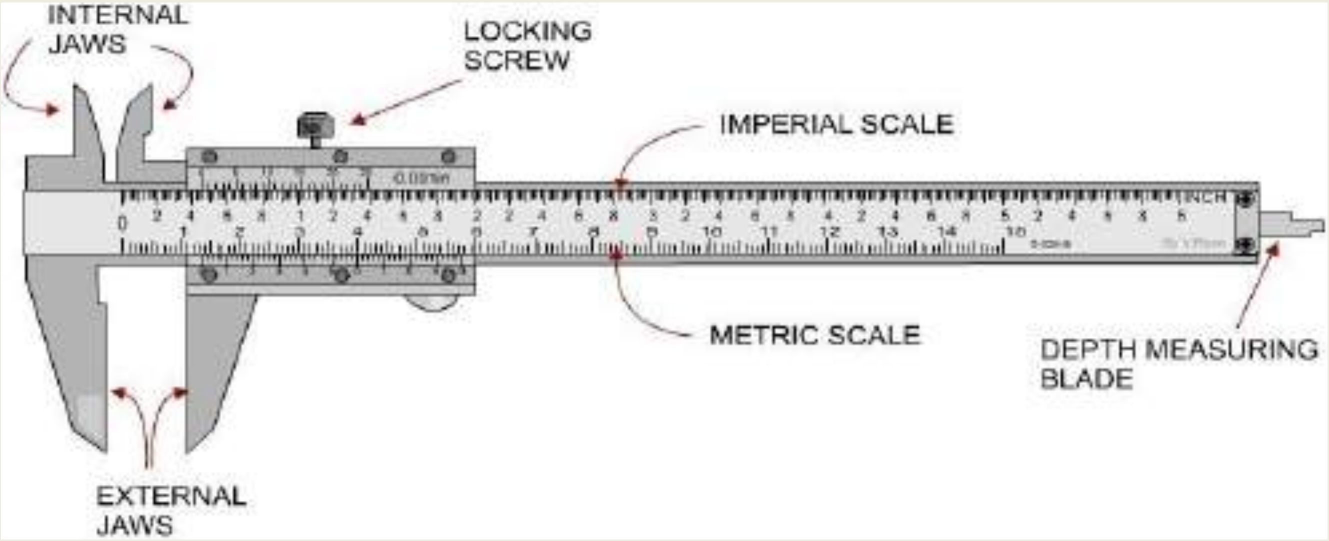
Aim: To study about linear and angular measuring instruments

APPARATUS: Steel Rule, Vernier Caliper, Vernier Height Gauge, Micrometer, Digital Vernier Caliper, Digital Micrometer, vernier bevel protractor (0° to 360°), least count=0°- 5°, Surface plate 450 x 450 mm, holding device to suit particular, sine bar/sine center.

THEORY:

STEEL RULE: It is also known as scale. It is the line measuring device. It is the simplest and common measuring instrument used for inspection. It works on the basic measuring technique of company on unknown length to the one previously calibrated. It consists of a strip of hundred steel having line graduation etched engraved on internal of fraction of standard unit of length, depending upon the internal at which graduations are made. The scale can be manufactured in different sizes and styles. It may be 150 mm, 300 mm, 600 mm or 1000 mm long.

VERNIER CALLIPER: The principle of vernier is that when two scales or divisions slightly different in size are used, the difference between them can be utilized to enhance the accuracy of



measurement. The Vernier Calliper essentially consists of two steel rules and these can slide along each other. The details are shown in fig. below

1. External jaws: used to measure external diameter or width of an object
2. Internal jaws: used to measure internal diameter of an object
3. Depth blade/probe: used to measure depths of an object or a hole
4. Main/metric scale: gives measurements of up to one decimal place (in cm).
5. Imperial scale: gives measurements in fraction(in inch)
6. Vernier gives measurements up to two decimal places (in cm).
7. Vernier gives measurements in fraction (in inch)

Least count main scale division-vernier scale division.

Least count = value of 1msd/total no. Of vsd

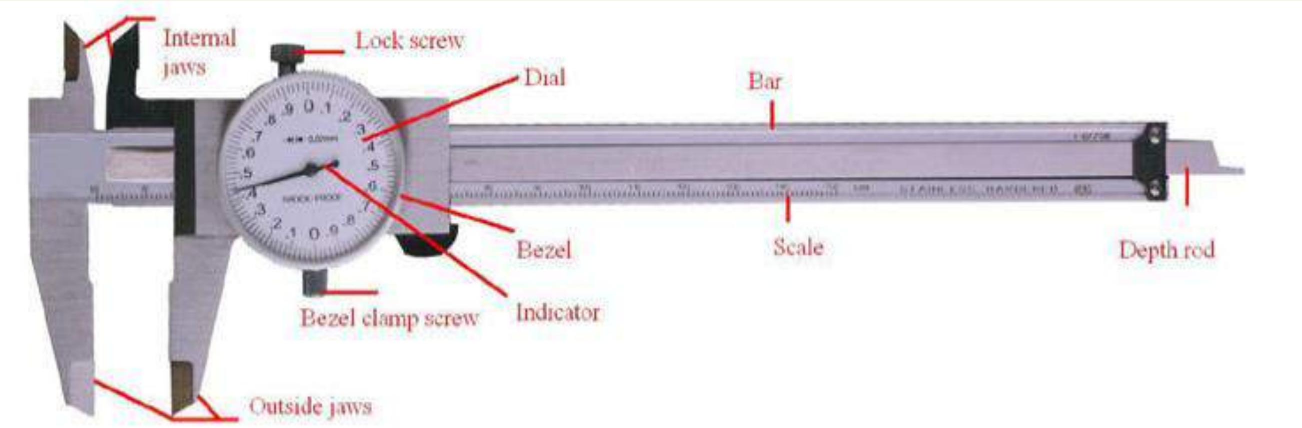
1 msd = 0.1mm, total no. Vsd = 5 therefore LC = 0.02mm

Suppose 50 vernier scale I division coincide with 49 divisions on main scale, and 1 msd=1mm. Then 1 VSD = 49/50 of MSD = 49/50MM.and LC = 1-49/50= 0.02mm.Alternatively, it is just as easy to read the 13 on the main scale and 42 on the hundredths scale. The correct measurement being 13.42mm.1 cmm = 10mm

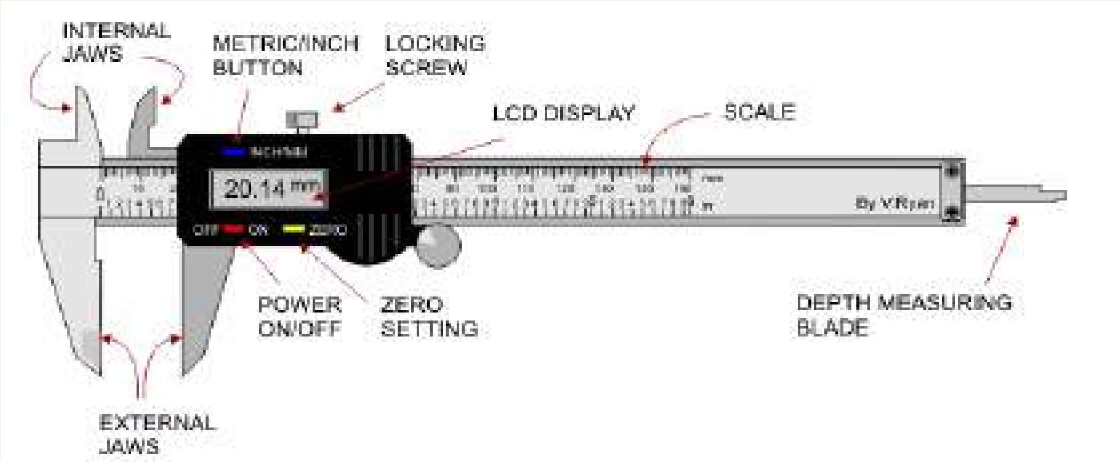
Types of Vernier Calliper:

Dial Vernier Calliper: Instead of using a vernier mechanism, which requires some practice to use, the dial caliper reads the final fraction of a millimeter or inch on a simple dial.

The pointer rotates once every inch, tenth of an inch, or 1 millimeter. This measurement must be added to the coarse whole inches or centimeters read from the slide. The slide of a dial caliper can usually be locked at a setting using a small lever or screw; this allows simple go/no-go checks of part sizes.



Digital caliper: Digital calipers can be switched between centimeters or millimeters, and inches. All provide for zeroing the display at any point along the slide, allowing the same sort of differential measurements as with the dial caliper. Digital calipers may contain some sort of "reading hold" feature, allowing the reading of dimensions even in awkward locations where the display cannot be seen.

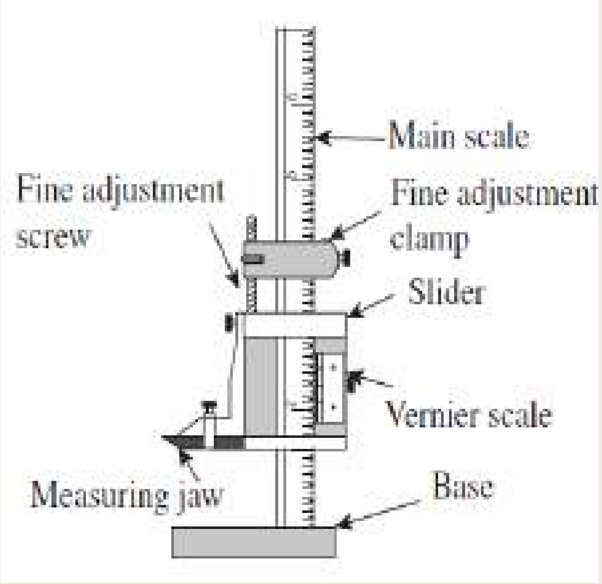


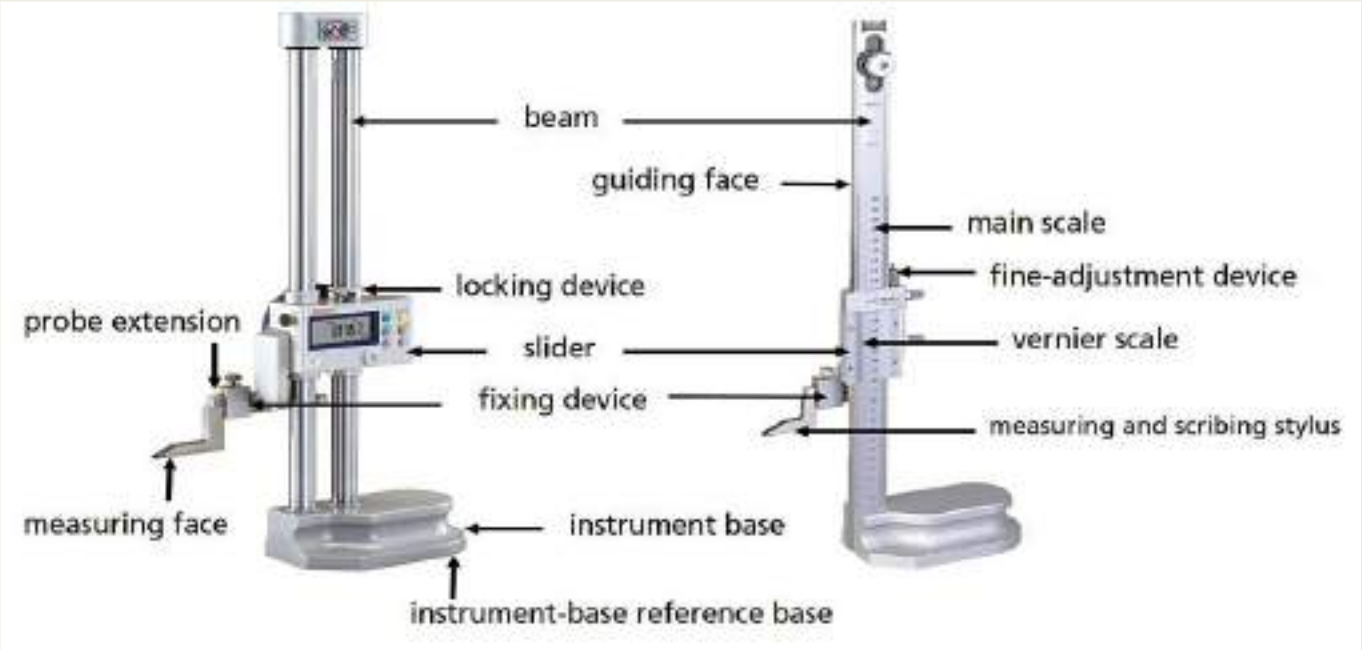
Observation Table:

Least Count =				
Component-I	Main Scale Reading(MSR) in mm	Vernier Scale Coincidence(VSC)	Vernier Scale Reading (VSR) = VSC x LC in mm	Measured Dimension = MSR + VSR in mm
Inner diameter				
Outer diameter				
Thickness				
Depth				
Total length				

VERNIER HEIGHT GUAGE: This is also a sort of a vernier caliper equipped with a special base back and other attachments which make the instrument suitable for height measurement. Along with the sliding jaw assembly arrangement is provided to carry a removable clamp.

The upper and the lower surface of the measuring jaw are parallel to the base so that it can be used for measurement over or under the surface. The vernier height guage is merely used to scribe lines of certain distance above surface. However, dial indicator can be attached in the clamp and many useful measurements can be exactly made as it exactly gives the indication when dial tip just touches the surfaces. For all these measurements, use of surface plates as datum surface is very essential.





Observation Table:

Least Count =				
Component-I	Main Scale Reading (MSR)in mm	Vernier Scale Coincidence (VSC)	Vernier Scale Reading (VSR) = VSC x LC in mm	Measured Dimension = MSR + VSR in mm
Height of Component				

MICROMETER: The micrometer essentially consists of U shaped frame. The component to be measured is held between fixed anvil and movable spindle. The spindle can be moved with the help of thimble. There are two scales on micrometer, a main scale and a circular scale. The barrel is graduated in unit of 0.5 mm whereas thimble has got 50 divisions around its periphery. One revo-lution of thimble moves 0.5 mm which is the lead of the screw and also the pitch. 2.5 mm+ (46*0.01) = 2.96 mm

DIGITAL MICROMETER:

1) It is used where high accuracy is required.
2) It is based on electronic technology.
3) It can be zeroed at any position, which greatly speeds the process of inspection.

Observation Table:

Least Count =				
Component-I	Main Scale Reading (MSR) in mm	Vernier Scale Coincidence (VSC)	Vernier Scale Reading (VSR) = VSC x LC in mm	Measured Dimension = MSR + VSR in mm
Diameter of Component				

V BLOCK:

The Vee-block is essentially tool steel blocks that are very precisely 100mm square. Standard Vee-blocks come as 45 degree block, i.e. the vee-sides slope 45 degree from horizontal or vertical, the included angle of the vee being of course, 90 degrees. But blocks with different angles and shapes are also available. For special purpose such as checking triangle effects or for taps and other three-fluted tools, 60 degree Vee-blocks are also available. The included angle of the vee then is 120 degrees.

The major purpose of the Vee-blocks is to hold cylindrical pieces, or move to the point, to establish precisely the centre line or axis of a cylindrical piece. In using a vee-block, it is very essential that the cylindrical piece should rest on firmly on the sides of the vee and not on the edges of the vee.

H & G Magnetic V Block

- All sides are hardened and ground,Used for grinding, light Milling, Drilling and inspection of round and square jobs
- Accuracy for Flatness, squareness and parallelism within 0.005 mm upto 150 L and 0.010 mm for 200 L
- Hardness above 60 Rc
- Supplied in matched pair Uniform and Strong magnetic pull to all three magnetic surface Top, Bottom and V Faces
- Easy ON - OFF facility

VERNIER DEPTH GAUGE

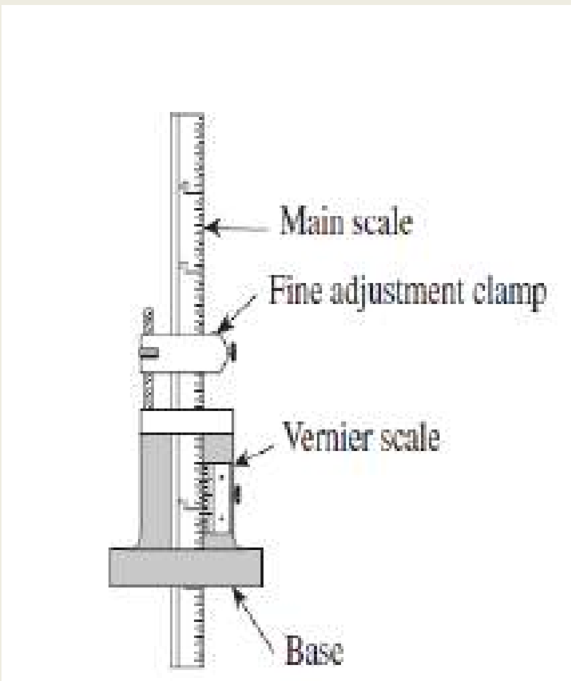
1) This is similar to vernier height gauge.
2) It consists of main scale, vernier scale, jaws, and lock nut fine adjustment screw like vernier caliper as shown in fig.
3) In vernier depth gauge, graduated scale can slide through the base and vernier scale

remains fixed.

4) The vernier scale is fixed to the main body of the depth gauge and is read in the same way as vernier caliper.

5) In vernier depth gauge, graduated scale can slide through the base and vernier scale remains fixed.

6) The main scale provides the datum surface from which the measurements are taken.Vernier depth gauge is used to measure depth of holes, distance from a plane surface to a projection and recess.



Observation Table:

Least Count =				
Component	Main Scale Reading (MSR) in mm	Vernier Scale Coincidence (VSC)	Vernier Scale Reading (VSR) = VSC x LC in mm	Measured Dimension = MSR + VSR in mm
Depthof Slot/Hole/Recesses				

SURFACE PLATE

For majority of dimension measurement and establishment of geometric accuracies, a reference datum plane and flat surface is required. The instrument and jobs are kept on this surface for measurement and also the surface is used for direct comparison and acts a master for checking of flatness and other characteristics of work surface.

This perfectly flat plane of reference is available on important methodical device known as surface plate.

Types of surface Plate:-

1) Cast Iron Surface Plate. 2) Granite Surface Plate.3) Glass Surface Plates.

PROCEDURE:

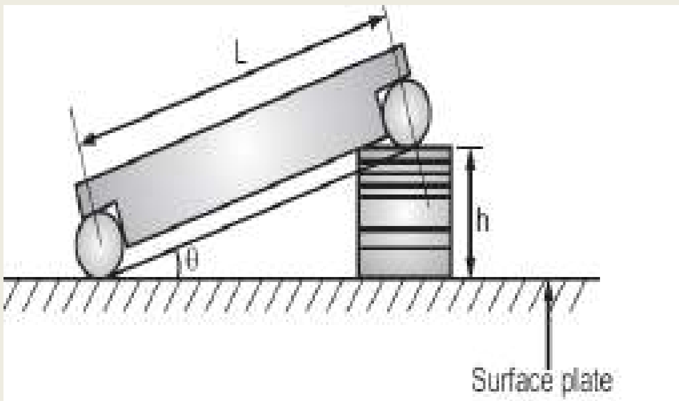
For Vernier Caliper/Micrometer/Height gauge:

1. Check the zero of main and Vernier scale to be coinciding.
2. Read the instrument for at least three random vernier positions.
3. Measure the samples at indicated places and record as per the format

Precision Angular Measurements.

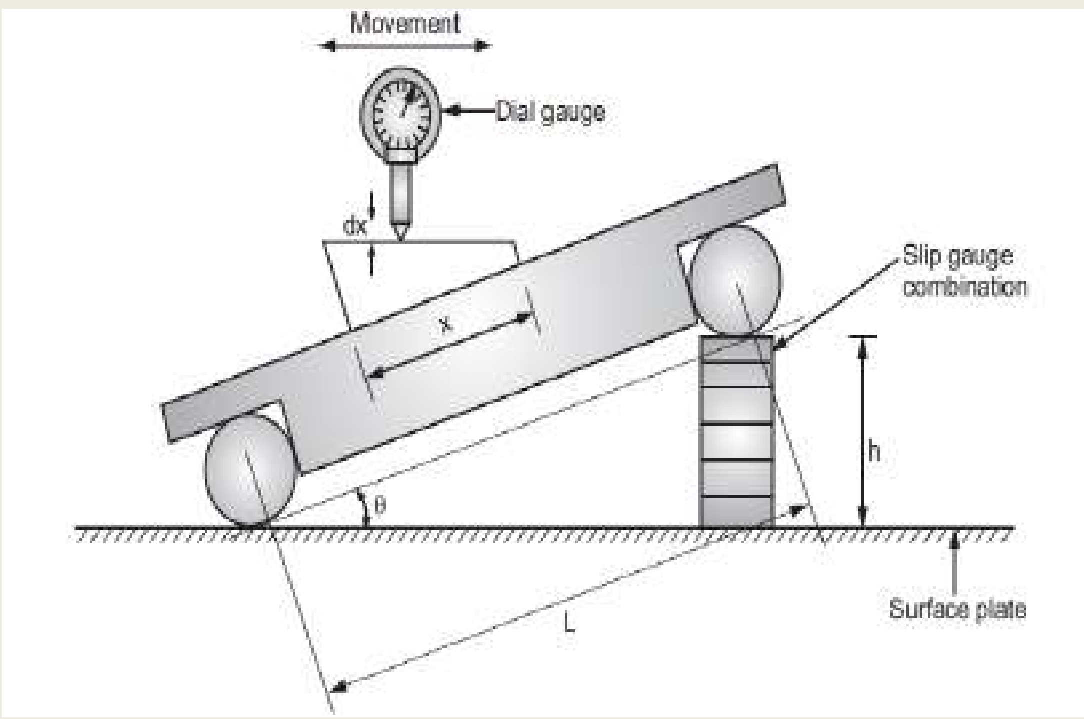
SINE BAR

A sine bar is a tool used to measure angles in metalworking. It consists of a hardened, precision ground body with two precision ground cylinders fixed at the ends. The distance between the centers of the cylinders is precisely controlled, and the top of the bar is parallel to a line through the centers of the two rollers as shown in Fig



$$\sin\theta = \frac{h}{L}$$

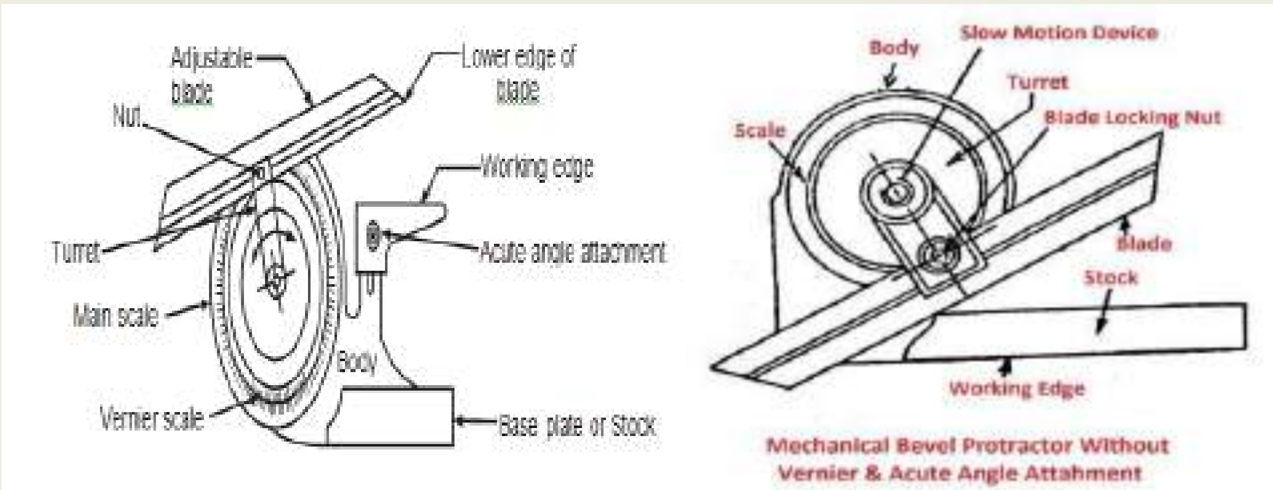
$$\theta = \sin^{-1}\frac{h}{L}$$



The dimension between the two rollers is chosen to be a whole number (for ease of later calculations) and forms the hypotenuse of a triangle when in use. Generally, the centre distance between two cylindrical rollers is 10 inch or 100 mm sine bar (however, in the U.S., 5 inch sine bars are the most commonly used).

BEVEL PROTRACTOR

A Bevel Protractor, a graduated circular protractor having a pivoted arm and used for measuring or marking off angles, is shown in Fig. Sometimes vernier scales are attached to give more accurate readings.



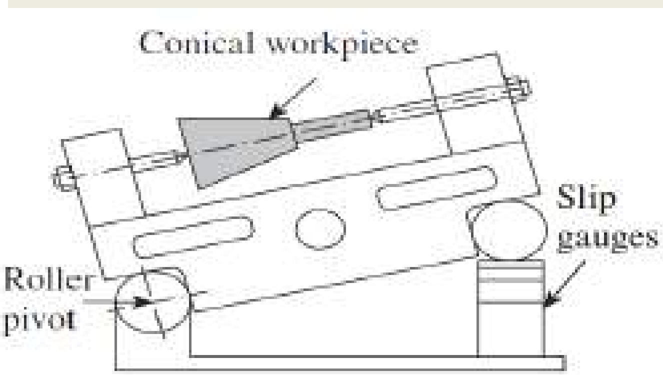
Observation Table:

Least Count = $\frac{\text{1 main scale division} \times 100}{\text{No.of division on vernier scale}}$				
Component	Main Scale Reading (MSR) in mm	Vernier Scale Coincidence (VSC)	Vernier Scale Reading (VSR) = VSC x LC in mm	Measured Reading = MSR + VSR in mm
Angle of Specimen				

Angles are measured using a sine bar with the help of gauge blocks and a dial gauge or a spirit level. sine of the angle of inclination of the wedge is the ratio of the height of the slip gauges used and the distance between the centers of the cylinders.

SINE CENTRE

Sine Centre is a special type of sine bar, which is used for conical objects having male and female parts, as shown in Fig. It cannot measure the angle more than 45 degrees. Sine table (or sine plate) is used to measure angles of large work pieces. Compound sine table is used to measure compound angles of large work pieces. In this case, two sine tables are mounted one over the other at right angles. The tables can be twisted to get the required alignment.



(2) Introduce the adjustable blade in the slot of body and clamp it with the help of knob In the convenient position.

(3) Place the working edge of the stock on one surface of the job and rotate the turret holding the blade so that the working edge of the blade coincides with another surface of the job. Fix the turret and read theangle. And now measure the angles of the sample pieces with the bevel protractor and record the reading.

OBSERVATION SINE BAR:

1.Length of sine bar=L=200 mm

2.Size, h=

3.Centre distance=200 mm 5. ø=sin-1(h/L)=

4.Angle of specimen=

5.Least count of dial indicator= mm

CONCLUSION: Hence we have studied various measuring instruments.

EXPERIMENT NO 2

TITLE: Error determination with linear / angular measuring instruments.

Aim: To find the Error using various Linear/Angular Measuring Instruments

APPARATUS:

1) **Linear Instruments:** Vernier Caliper, Digital Vernier Caliper, Vernier HeightGauge/Digital vernier height gauge, Vernier depth gauge, Micrometer, Digital Micrometer.

2) **Angular Instruments:** Bevel Protector, sine bar/sine Centre/profile projector/tool makers microscope.

OBSERVATION TABLE:

For Vernier Calliper:

S. NO.	ACTUAL READING (mm)	MEASURED READING (mm)	ERROR (mm)
1.			
2.			

For Micrometer:

S. NO.	ACTUAL READING(mm)	MEASURED READING(mm)	ERROR (mm)
1.			
2.			

CONCLUSION: Hence we have studied error determination with linear measuring instruments.

EXPERIMENT NO 03

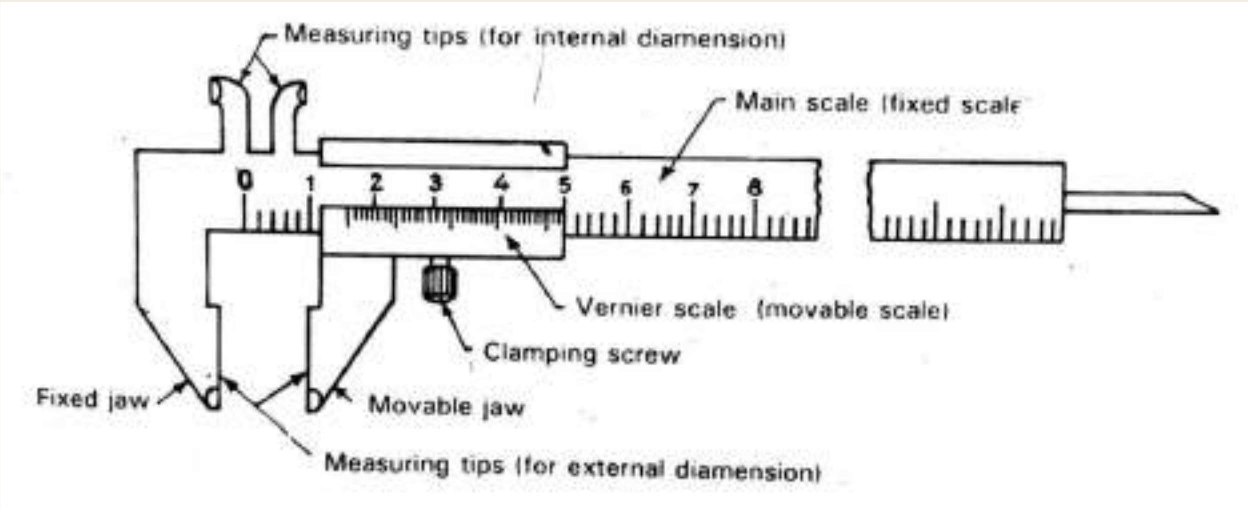
TITLE: CALIBRATION OF VERNIER CALIPERS

APPARATUS: Vernier calipers, Slip gauge set

THEORY:

Measuring instruments in usage will acquire certain errors due to wear and tear. So every instrument should be checked periodically to find out the errors and assess the accuracy. Comparing the reading of the instrument with a standard reference does this. This type of inspection is known as calibration. Depending on the type of instrument the standard reference is selected, against which the error of the instrument is evaluated. Since the error cannot be eliminated from the instrument, corresponding correction is applied to the measured reading of the instrument. Since the wear and tear of the instrument is not uniform, the error in the measured value will be different at different ranges of the instrument. To apply correction for the various readings in the range of the instrument, a calibration curve is to be drawn. Calibration curve is the curve drawn between the error and the instrument reading. The error at any stage of the instrument can be either positive or negative. The correction to be applied for a positive error is negative and vice–versa.

CONSTRUCTIONAL DETAILS & APPLICATIONS:



PROCEDURE:

- The least count of the Vernier calipers was found.
- The two jaws of the Vernier calipers were cleaned and vernier was checked for zero error by bringing the two jaws close at each other.
- The given set of slip gauges, which is used as standard reference, was cleaned.
- A slip gauge was placed in between the two jaws of Vernier calipers and was adjusted.
- The slip gauge size and corresponding Vernier calipers reading were noted down. The difference between Vernier calipers reading and slip gauge size is the error.
- The experiment was repeated for slip gauges of different sizes within the range of the Vernier calipers and the readings were tabulated and corresponding errors were found.
- A graph is plotted against Vernier calipers reading and error / correction obtained.

PRECAUTIONS:

- Slip gauges should be degreased properly.
- Vernier reading should be taken without parallax error.
- Slip gauges should be increased in size with regular increments within the range of the

Vernier and wringing should be done properly to get the required size.

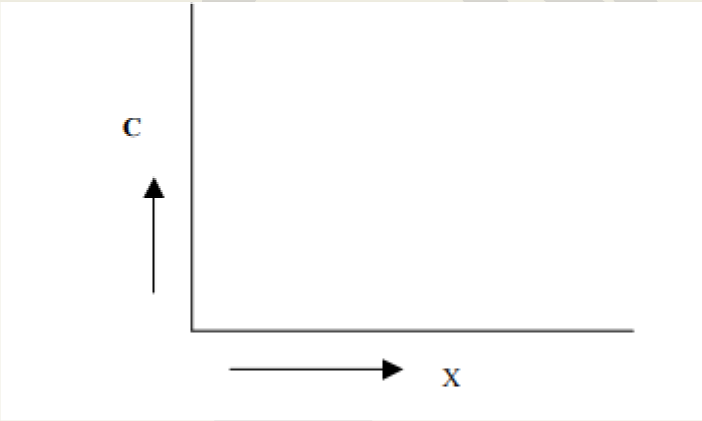
- Over tightening of the slip gauge in between the jaws of the instrument should be avoided.

OBSERVATIONS:

Least count of Vernier calipers =

S.No	Vernier calipers reading X mm	Slip gauge reading Y mm	Error E = X - Y	Correction C mm

GRAPH:



CONCLUSION: Hence we have studied Vernier calipers calibration.

EXPERIMENT NO 04

TITLE: Machine Tool Alignment Test On any two machines like-Lathe, Drilling, Milling.

APPARATUS:

A lathe in good working condition with all standard accessories,i.e. live and dead centers, sleeve etc, Dial indicator, Dial stand 'with magnetic base, Flexible dial stand, Parallel blocks, Straight edge, Straight bar, Standard teit mandrel, Straight spirit level, Box type spirit level, Alignment microscope, Taut wire, Set of spanners, Mandrel and centre draw bar.

THEORY: For metrology purposes the term alignment refers to two axes merged in each other or where one axis extends beyond the other.

Two lines or axes are said to be in alignment when their distance apart at several points over a given length is measured and this distance does not exceed a given standard tolerance.

The dimensions of a gauge, its surface finish, geometry and accurate production of components/ parts depend upon the inherent quality and accuracy of the machine tool used for its manufacture.

1. The alignment of various machine parts in relation to one other. This is very important because th e geometry of various shapes is based an the relative motions between various machine parts and hence on alignment of various parts,the quality and accuracy of the control devices and driving mechanism.
2. The various tests applied to any machine tool could be grouped as below :
    a) Tests for the level of installation of machine in horizontal and vertical planes,
    b) Tests for flatness of machine bed and for straightness and parallelism of bed ways or bearing surfaces,

c) Tests for perpendicularity of guide ways to other guide ways or bearing surfaces,

d) Tests for true running of the main spindle and its axial movements,

e) Tests for parallelism of spindle axis to guldeways or bearing surfaces.

f) Tests for the line of movement of various members, e.g., saddle and table cross slides etc. along their ways,

g) Practical tests in which some test pieces are machined and their accuracy and finish is checked.

PROCEDURE:

1. Clean all surfaces perfectly on which alignment tests are to be performed,
2. Level the bed of lathe for longitudinal as well as cross directions,
3. Follow the test chart for performing different alignment tests.

ALIGNMENT TABLE

S. NO	OBJECT	MEASURING INSTRUMENT	PERMISSIBLE ERROR	ACTUAL ERROR
1.	ABED verification of leveling of slide ways: a. Longitudinal verification and straightening of slide ways in vertical plane	Precision levels optical or other method. Precision level	500<=0<=1000 0.02 local tolerance. 0.075 for any length of 250>0>1000 For each 1000 increase in distance between centers beyond 1000 add to the corresponding	0.01-0010

2.	Checking parallelism of tailstock movement to carriage movement: a. In vertical plane b. In horizontal plane	Dial gauge	DC<=1500 a and b 0.03, local tolerance 0.02 for any length of 500 OC>1500 a and b 0.04 local tolerance 0.03 forany length	0.015
3.	Checking of parallelism of axis outside of tailstock sleeve to carriage movement: a. In vertical b. In horizontal	Dial gauge	a.0.02/100 upward b. 0.015/100 front ward	0.01 0.015
4.	Checking parallelism of taper base of sleeve to carry movement on length equal to Oa/2 to maximum of 300	Dial gauge and mandrel	0.03/300 upward 0.03/300 forward	0.01 0.01-00
5.	C-Carriage checking of straightening carriage movement in horizontal direction	Dial gauge and mandrel between centre or straight edge	500<=OC<1000 0.02DC>1000 To reach or increase in OC beyond 1000	
6.	D-centre checking of difference in height between headstock and tailstock	Dial gauge and test mandrel	0.01 tailstock centre higher than headstock centre	
7.	E-Headstock spindle a. measurement of periodic axial slip b. Measurement of carrying of face plate resting on the Surface	Dial gauge F=force=0	a.0.01 b 0.02 Including periodic axial slip	0.005
8.	Measurement of run out of spindle nose centering sleeve or centre	Dial gauge indicator F=force=0	0.01	0.01

9.	Measurement of run out of axis of centre a. at the spindle nose of housing b. at a distance from spindle nose equal to Da/2 or not more than 300	Dial gauge or test mandrel	a. 0.01 b. 0.02 c. For measuring length of 300	0.005 0.01
10	Checking of parallelism of sleeve to carriage movement	Dial gauge and mandrel	0.03/300 upward and forward	0.01 0.01-00
11	Turning of cylindrical test piece held in chuck D>=0.5 Da/8 t= 0.05Da maximum 300	a. roundness b. cylindrical roundness measurement, instrument micrometer	a. 0.01 b. 0.04 per 1-300	0.05 0.015
12	Facing of cylindrical pieces held in chuck. D>=0.5 Da/8 L=Da/8 maximum Facing of flat surface perpendicular to spindle.	Surface flatness	Flatness allowed flat	0.005 0015
13	Threading of cylindrical pieces-300 If triangular head is 4218-1967	Special instrument of tested precision	Dc<=2000 0.04 for any measure length 0.015 any length of 50	0.03 0.05

CONCLUSION: Hence we have studied the alignment test for lathe.

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EXPERIMENT NO 5

TITLE: Identification of surfaces using optical flat/interferometers and measure surface roughness using surface roughness tester.

Aim: - Study of Surfaces using optical flat and Monochromatic Light Source and measure surface roughness using surface roughness tester.

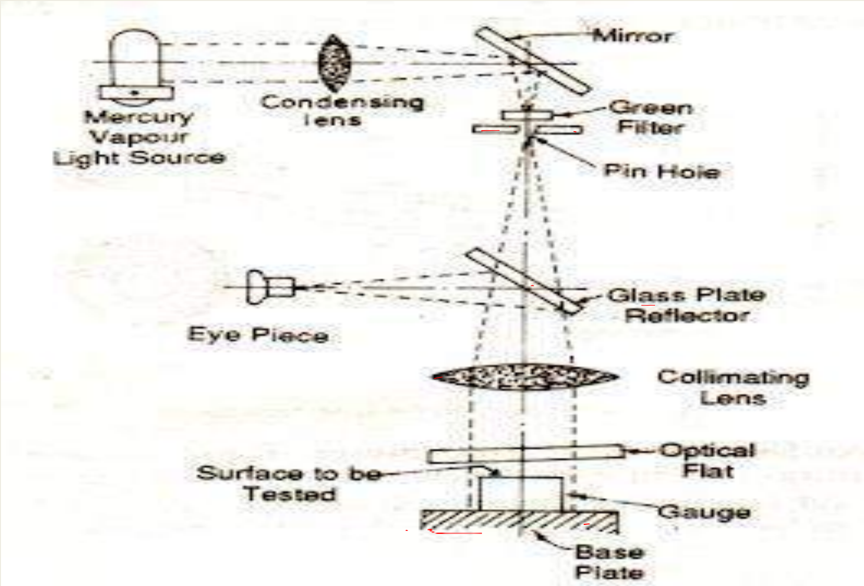
Apparatus: - Optical Flat and Monochromatic Light Source,surface roughness tester

Optical Flat and Monochromatic Light Source

Theory: Light band reading through an optical flat, using a monochromatic light source represent the most accurate method of checking surface flatness. The monochromatic light on which the diagrammatic interpretations of light wave readings are based comes from a source, which eliminates all colours except yellowish colour. The dark bands viewed under the optical flat are not light waves. They simply show where interference is produced by reflections from two surfaces. These dark bands are used in measuring flatness. The band unit indicates the level of the work that has risen or fallen in relation to the optical flat, between the centre of one dark band and the center of the next dark band.

The basis of comparison is the reflected line tangent to the interference band and parallel to the line of contact of work and the optical flat. The number of bands intersected by the tangent line indicates the degree of variation from the true flatness over the area of the piece. Optical flats are used to check flatness when surface to be tested shine and smooth i.e. Just like a mirror.

Optical flats are cylindrical piece made up of important materials such as quartz. Specification ranges from 25mm by 38mm (dia x Length) to 300mm by 70 mm. Working surface are finished by lapping and polishing process where as cylindrical surface are finished by grinding.



Procedure:

- Clean the surface to be tested to become shiny and wipe if with dry clean cloth

- Place the optical flat in between flatness of work piece to be tested and monochromatic Sources of light i.e. on the work piece.

- Both parts and flat must be absolutely clean and dry.

- After placing optical flat over work piece switch on the monochromatic source of light and Wait ungetting yellowish or orange colour.

- Apply slight pressure over optical and adjust until getting steady band approximately parallel tothe main edges.

- Count the number of fringes obtained on the flat with the help of naked eye and calculates theflatness error

1. By comparing behavior on the fringes with std-one & decided whether the surface is convexconcave or flat etc.

FLATNESS TEST:

Light from the mercury lamp is focused on to an operating piece. In eyepiece, particularly reflected light collimating lens which collimates through it. Further leveling arrangement is provided on a table.

PARALLEL TEST:

Light from the mercury vapor lamp is focused on the eyepiece and particularly reflected by a beam splitter. The reflected light strikes illuminated lens which collimates it and through it further on optical flat under test. The flat under test is placed on the table provided with leaving arrangement.

Observations:

- Monochromatic yellow light source is used for conducting this experiment.
- Wavelength of Monochromatic source of light.

$\lambda/2$ =___________mm. Where λ = 0.0002974 mm

Observation Table:

Sr.No	No. of Fringes Observed (N)	Flatness error = N x λ /2	Type of Surface (Concave/Convex etc.)

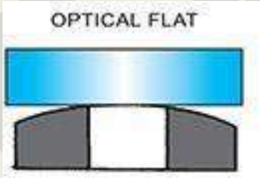
Applications:

Optical flats are used for testing the measuring surfaces of instruments like micrometers, measuringanvils & similar other devices for their flatness & parallelism.

These are used to calibrate the standard gauges, like slip gauges, angle gauges & secondary gaugesin the workshops.

In measuring the curvatures like convex and concave for surfaces of the standard gauges.

The rule for determining whether a surface is concave or convex is as follows: If the bands curve around the thin part of the wedge (contact or pressure point) the surface is convex. If they curve around the thick part of the wedge the surface is concave.



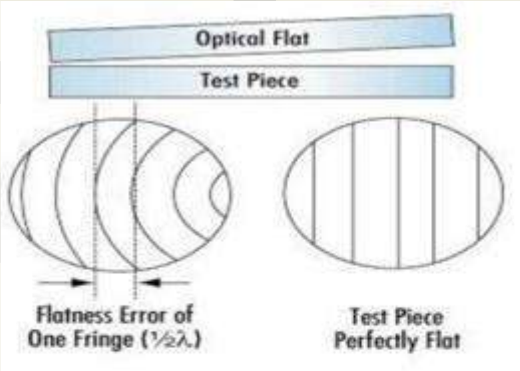
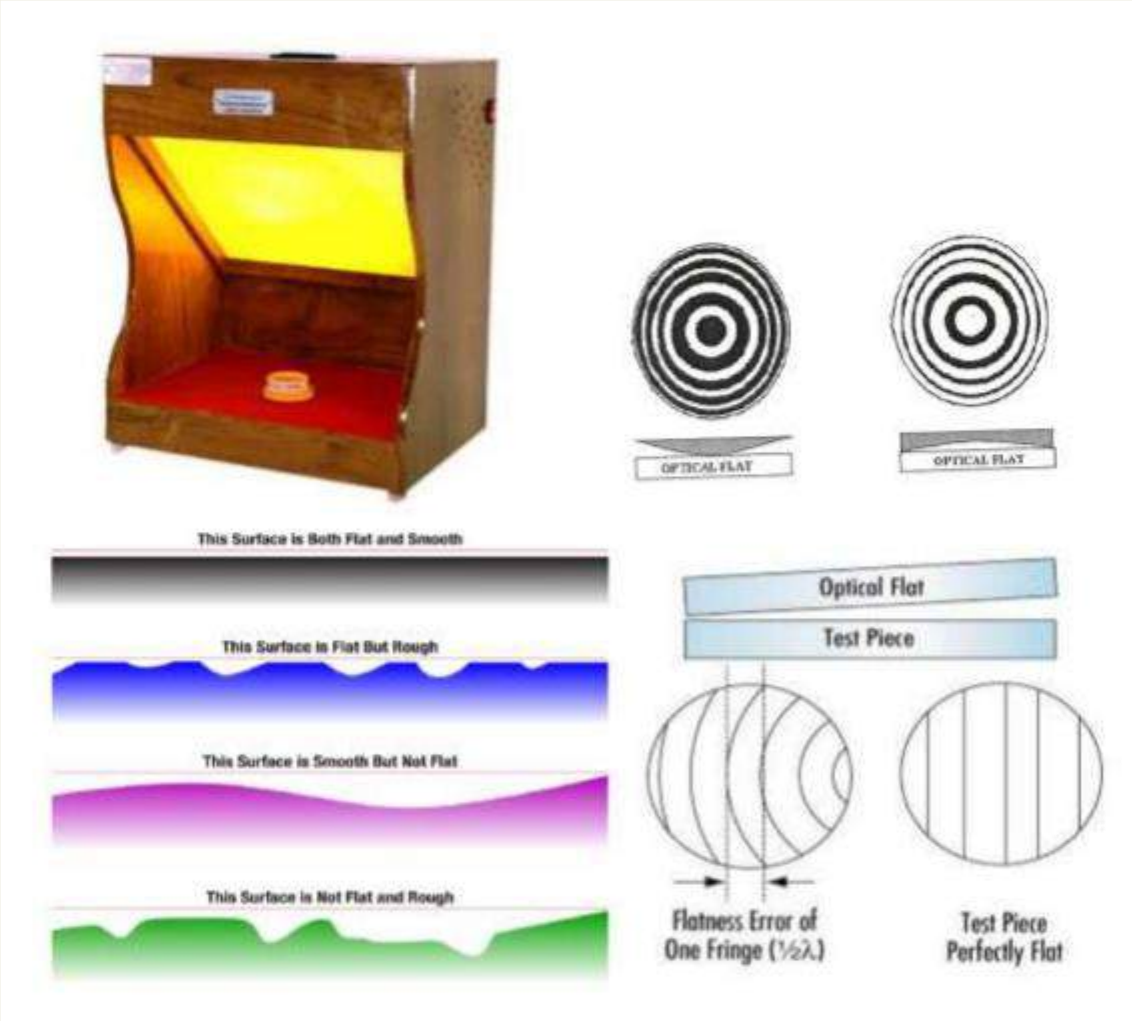


Fig: Fringes



Conclusion: Hence we have studied about surface flatness using optical flat for different surfaces wegot different patterns as follows:

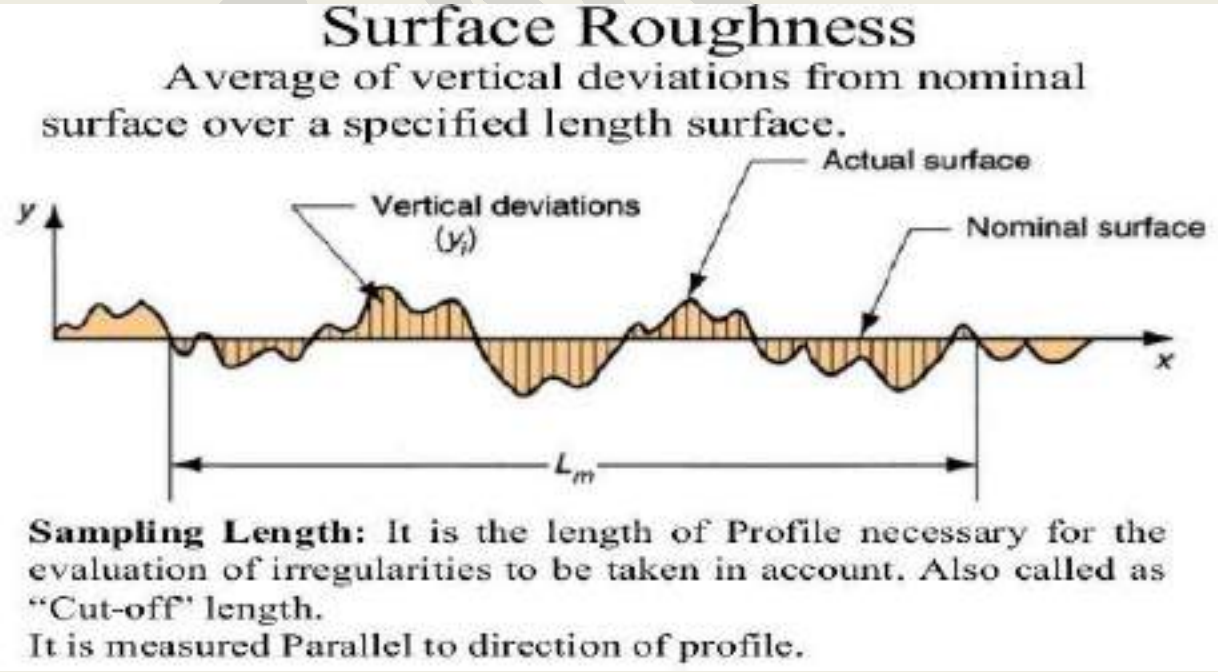
Flat surface: Straight lines

Concave surface: Concentric circles moving away from center.

B) Measure surface roughness using surface roughness tester.

Apparatus: Mitituyo make surface roughness tester, Calibrated specimen, Surface plate, Specimen

Surface roughness often shortened to roughness, is a component of surface texture. It is quantified bythe deviations in the direction of the normal vector of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small, the surface is smooth. In surface metrology, roughness is typically considered to be the high-frequency, short-wavelength component of a measured surface. However, in practice it is often necessary to know both the amplitude and frequency to ensure that a surface is fit for a purpose. Surface roughness is measured by using surface roughness tester and is denoted by Ra (Roughness Average).



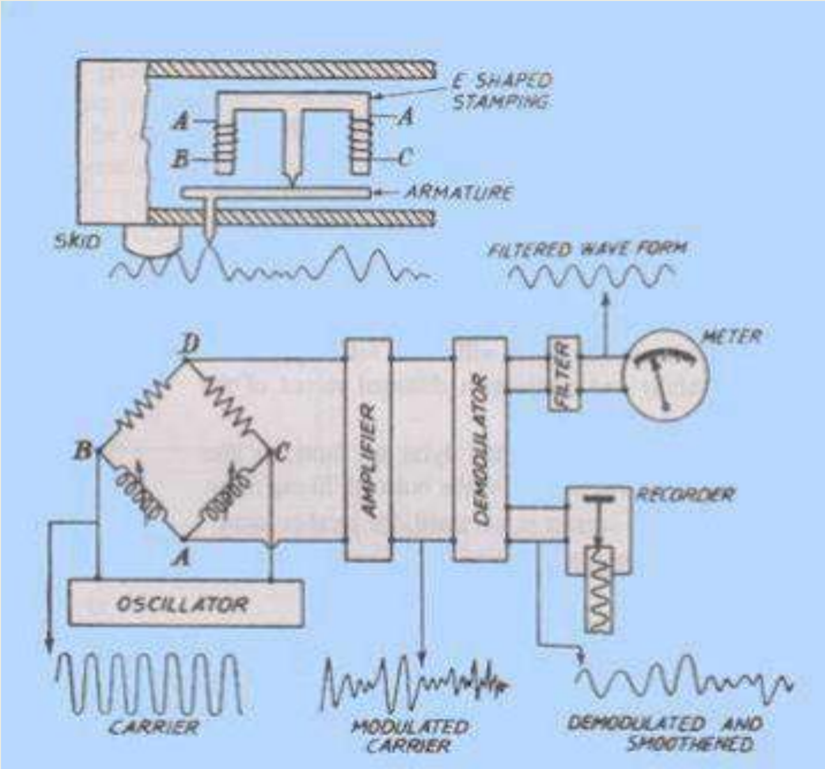
Procedure:

1. Connect Ac adopter to the measuring instrument & Switch on the power supply
2. Attach the drive detector unit & connect to all the cable connection as shown when mounting the detector to the drive unit, take care not to apply excessive force to the drive unit.
3. Adjust or modify the measurement condition such as sample length, number samples, Standard required for the measurement
4. Calibrate the instrument using standard calibration piece
5. Carefully place the detector on the work piece. Care should be taken to see that work piece &detector are aligned properly
6. Press the start button to measure the work piece & result are displaced on the console
7. Press print button to take the print out.

Applications:

1. Taly surf is the dynamic electronic instrument used on the factory floor as well as in the laboratory.
2. To find out the surface roughness of the machines & components.
3. To check the accuracy of the cast iron, granites used in workshops for checking the surface finish & flatness.


Mitutoyo
Rq
*****
µm



Experimental setup for Taly surf

Ra Determination Table: Ra value of a machined component is determine using Surface roughnesstester and V-Block for holding the cylindrical job.

Observation:

Sl. no	Specimen	Ra value	R z value	R q value
1				
2				
3				
4				

CONCLUSION: Hence we have studied about_Measure surface roughness using surface roughness tester

EXPERIMENT NO 6

TITLE: Determination of geometry & dimensions of given composite object using profile projector and measurement of various angles of single point cutting tool using tool maker's microscope

Part A) using profile projector

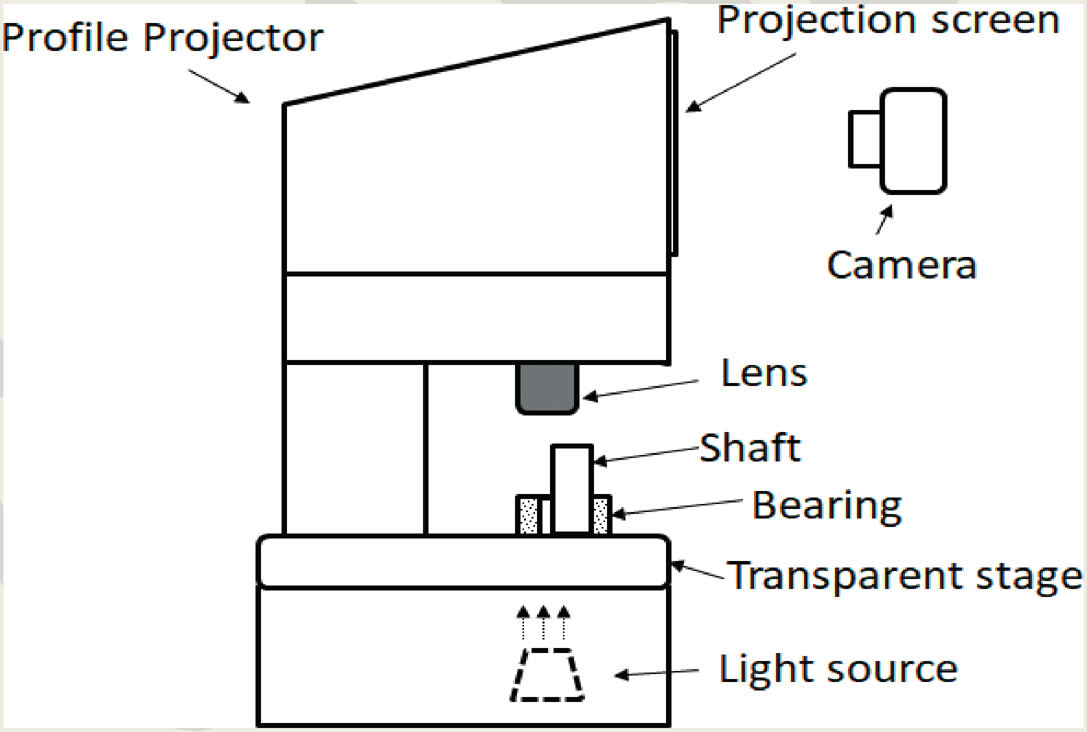
APPARATUS: Profile Projector, Thread Specimen

THEORY: By using lenses and beams of light, profiles of small shapes can be magnified. The enlarged image can be compared with accurate drawing made to the scale of magnification. Such a comparison can reveal any deviations in the sizes and contours of the objects and to get a numerical assessment of such deviations, measurements can be made on the enlarged shadow. The measured

Dimensions on the shadow will then have to be divided by the multiplication factor. The projection apparatus used for this purpose is termed as an optical profile projector.

The essential features of a profile projector are that, it should be accurately as stated and that there should be maximum latitude in holding and adjusting the work piece and examining the projected shadow.


Mitutoyo


Profile Projector
Projection screen
Camera
Lens
Shaft
Bearing
Transparent stage
Light source

Observation:

S NO	PARAMETER	INITIAL READING (MM)	FINAL READING (MM)	ACTUAL READING (MM)
1.	MAJOR DIAMETER			
2.	MINOR DIAMETER			
3.	PITCH			
4.	ANGLE			

CONCLUSION: Thus diameter of given component thread pitch etc. of the component is measured by using profile projector

Part B) using tool maker's microscope

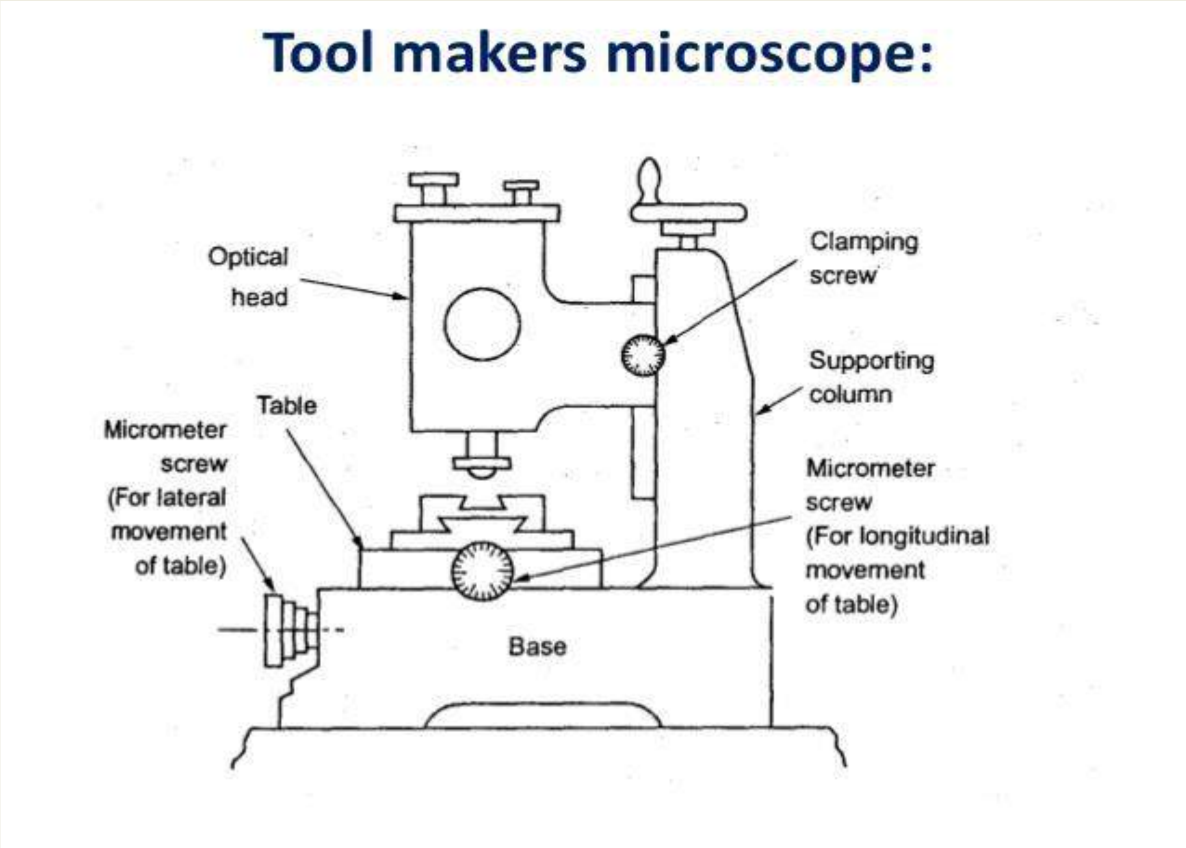
APPARATUS: Tool maker's microscope, Single point cutting tool

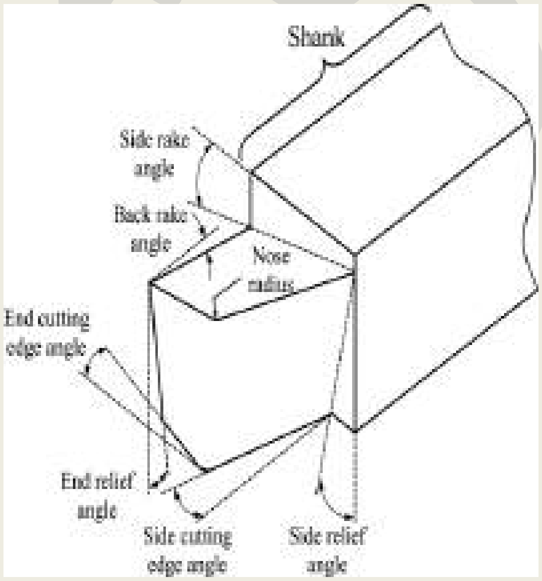
THEORY: A general view of the small model of tool maker's microscope giving its design and its optical system is shown in figure. This is designed for measurement of parts of complex figure profiles of external threads, tool templates and gauges. It can be used to measure center to center difference of holes in dry plane as well as in co-ordinate measuring systems. Basically it consists of the optical hand which can be adjusted vertically along the guide ways of the supporting column. The optical head can be in any portion by screw. The working table on which parts to be inspected are placed on a heavy hollow box. The table has a compound slide by means of which the measurement part has longitudinal and lateral movement. The beam of the light passes through transparent glass plate on which parts to be checked are placed.

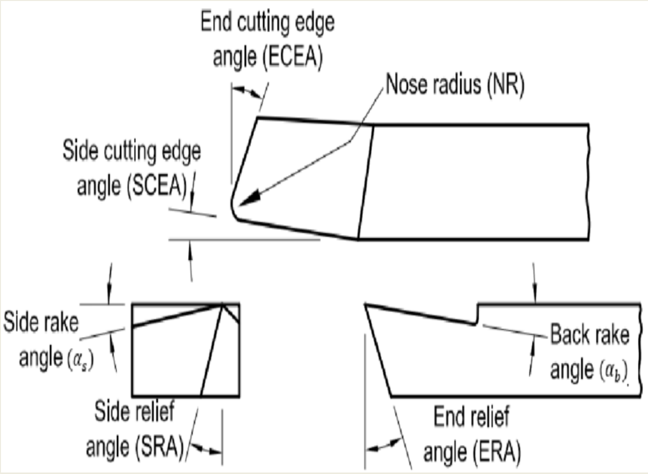
APPLICATIONS;

1. Determination of relative position by using protractor.
2. Measurement of angle by using protector eyepiece.
3. Comparison in eyepiece measurement of pitch and effective diameter.
4. Comparison of an enlarged protector image with a tracing fixed to projecting image.

TOOLMAKER‟S MICROSCOPE:







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PROCEDURE:

1. Determination of the relative position of two or more points on a piece of work. This is measured by measuring the travel of the work table necessary to transfer a second point to the position previously occupied by the first and so on.
2. Measurement of angles: Angles pre measured by successively setting fiducially line simply in the focal plane of the eyepiece along with arm of the image of the angle, or through indicating the angle and noting from a protractor scale the angle through which the line has been turned.
3. Comparison of thread forms with respect to outlines on a glass template situated at the focal plane of the microscope eyepiece and measurement of discrepancies there from.
4. Comparison of the enlarged projected image with a tracing drawn on exact number if times full size and affixed to the projection screen.

Observation:

Observations	Initial Reading	Final Reading	Actual Reading
Side rake angle			
Side cutting edge angle			
Side relief angle			
End cutting edge angle			
End relief angle			
Back rake angle			

CONCLUSION: Hence various angles of single point cutting tool is measured by tool maker’s microscope.

EXPERIMENT NO 7

TITLE: Measurements of threads parameters using floating carriage diameter measuring machine.

APPARATUS: Floating carriage micrometer with all accessories and specimens.

THEORY:

The measurement of minor diameter is carried out on a floating carriage diameter measuring machine in which threaded work piece is mounted between centers. Such micrometer is constrained to move at right angles to axis of centers by v ball side. If reading on setting cylinder with u-pipe in position R1 and reading R2 and diameter D=Dm+ (R2-R1) reading may be taken at various positions in order to determine the tapers variety. The machine consists of parts:-

1. Base: base casting carries a pair of center's on which threaded work piece is mounted
2. Another carriage is mounted on it and exactly 90° to it on this provided carriage is capable of moving towards center.
3. On this carriage one head having a large thimble enabling reading up to 0.002 mm is provided.

PROCEDURE: TWO WIRE METHOD:

The effective diameter of the screw may be as certain by planning two wires or rods at identical diameter between the flanks of thread and measuring the effective diameter „E" is then calculated as:

E=T+d Where D=diameter under wire

T=m-2d m=dimension over the wire d=diameter of wire"

The wires used are made up of hardened steel to sustain wear and tear in use. Diameter „T" can also be determined by placing wires over standard cylinder greater than the diameter under wire and note the reading R1 and take with other gauge say R2,

T=S-(R1-R2)

D= It is the value which depends upon the diameter of wire and pitch on thread. P=0.8P-d(for metric thread)

In figure line BD on the effective diameter,

BC=0.5pithch=0.5P

OP=d x cosec(x/2) X 0.5   PA=a(cosec(x/2- 1))/2

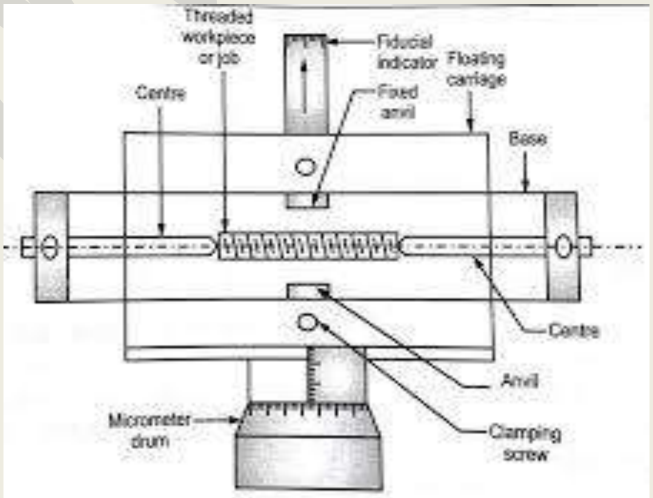
PQ=2cosec(x/2)=0.25Pcot(x/2)

AQ=PQ-AP=0.25Pcot(x/2)=0.5dcosec(x/2-1)

AQ is half value of P.

P=2AQ=0.5cos(x/2)-dcosec(x/2-1)

Two wire methods cannot be carried out on diameter measuring because alignment is not possible by two wires.



Floating carriage diameter measuring machine

OBSERVATIONS:

Best wire diameter= mm

Master cylinder diameter= mm

Reading over specimen= mm

Reading over master cylinder= mm

CALCULATIONS:

R1=Standard specimen reading,

R2=reading over the wire with specimen

R1=

Master cylinder diameter, D= mm,

M=D+(R2-R1)

Effective diameter E=T+P,

RESULT:

Diameter over wire M= mm

Major diameter D= mm

Effective diameter E= mm

CONCLUSION: Hence we have studied the floating carriage micrometer and found out effective diameter of given threaded specimen.

EXPERIMENT NO 8

TITLE: Measurement of spur gear parameters using Gear Tooth Vernier, Span, Gear Rolling Tester.

APPARATUS: Gear tooth vernier caliper, vernier caliper, Tooth span micrometer, Gear Roll Tester bench vice.

THEORY:

Brief description of different characteristics of measuring of tooth thickness by gear truth vernier is given. It consists of a horizontal and a vertical vernier scale. It is based on the principle of vernier scale. The thickness of a tooth at pitch line and the addendum is measured by an independent tongue each of which is adjusted independently by adjusting the slide screws on graduated beams.

TERMINOLOGY OF GEAR TOOTH

(i) Pitch circle diameter (PCD): It is the diameter of a circle which by pure rolling action would produce the same motion on the toothed gear wheel.

It is equal to D = (T X OD)/(T+2)OD = outside diameter T = number of teeth

(ii) MODULE: It is defined as the length of the pitch circle diameter per truth. Module m=D/T and is expressed in mm.

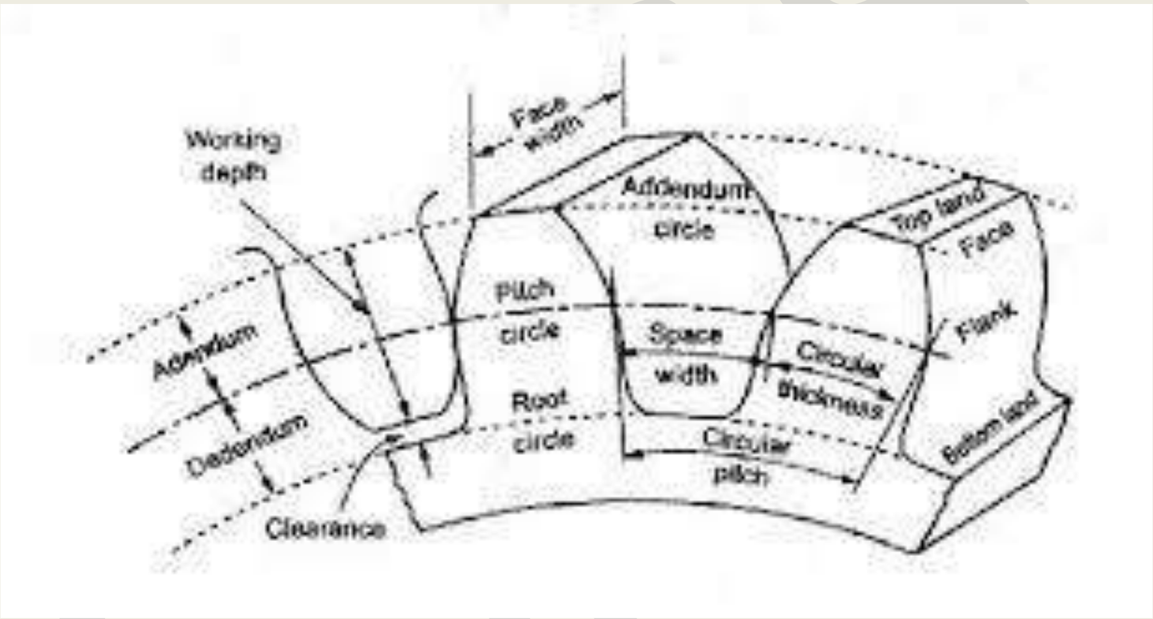
(iii) CIRCULAR PITCH (CP): It is the arc distance measured around the pitch circle from the flank of one truth to a similar flank in the next 1.00th CP==ΠD/T=Πm.

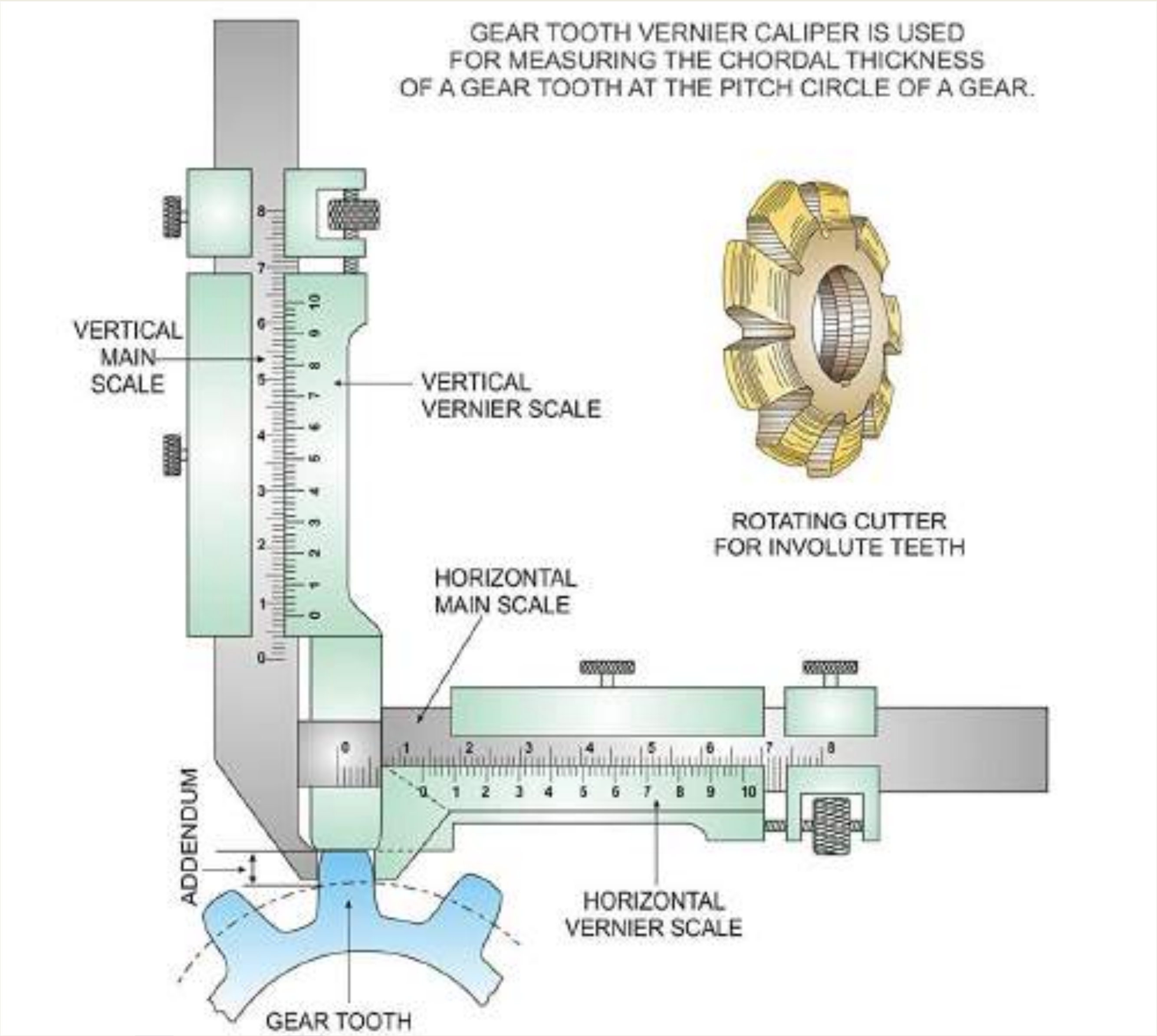
(iv) ADDENDUM: This is the radial distance from the pitch circle to the tip of the truth. It is equal to one module.

(v) Clearance: This is the radial distance from the tip of a tooth to the bottom of the mating tooth space when the teeth are symmetrically engaged. Its standard value is 0.157m or 0.25m.

(vi) DEDENDUM: This is the radial distance from the pitch circle to the bottom of tooth space.Dedendum = Addendum +Clearance = m +0.157m =1.157m.=1.25m (metric gearing system)

(vii) TOOTH THICKNESS: This is the arc distance measured along the pitch from the intercepts with one flank to the intercepts with the other flank of the same tooth.





PROCEDURE:

For finding PCD, module, addendum, dedendum and clearance:

1. First find the blank diameter, OD by a vernier caliper and also count the number of teeth T of the spur gear.

2. Next calculate pitch circle diameter D=(TxOD)/(T+2)

3. Find addendum, clearance, pitch, module and dedendum as per the formulae given in the theory.

FOR CHORDAL TOOTH THICKNESS (using gear tooth calliper):

1. Set the chordal depth (addendum) on the vertical slide of the gear tooth vernier and then insert the jaws of the instrument on the tooth to be measured.

2. Adjust the horizontal vernier slide by the fine adjusting screw so that the jaws just touch the tooth.

3. Read the horizontal vernier slide and note the reading. It gives the chordal thickness of tooth.

4. Repeat the observations for the different teeth.

5. Compare the values of different characteristics with the standard value and set the percentage error.

OBSERVATION:

1. Least count of caliper= 0.02mm

2. Number of teeth=

TABLE FOR SETTING GEAR TOOTH CALLIPER FOR SPUR GEAR

NO. OF TEETH	30	32	34	36	38	40	42
CHORDAL THICKNESS	1.5700	1.5701	1.5702	1.5703	1.5703	1.5704	1.5704
HEIGHT OF TOOTH	1.0206	1.0192	1.0182	1.0171	1.0162	1.0154	1.0146

CHORDAL THICKNESS:

S NO	M.S.R	V.S.R	CHORDAL THICKNESS (M.S.R+V.S.R*L.C)	VERIFICATION(DIGITALVERNIER CALIPER)
1.				
2.				

HEIGHT OF THE TOOTH:

S NO	M.S.R	V.S.R	CHORDAL THICKNESS (M.S.R+V.S.R*L.C)	VERIFICATION(DIGITALVERNIER CALIPER)
1.				
2.				

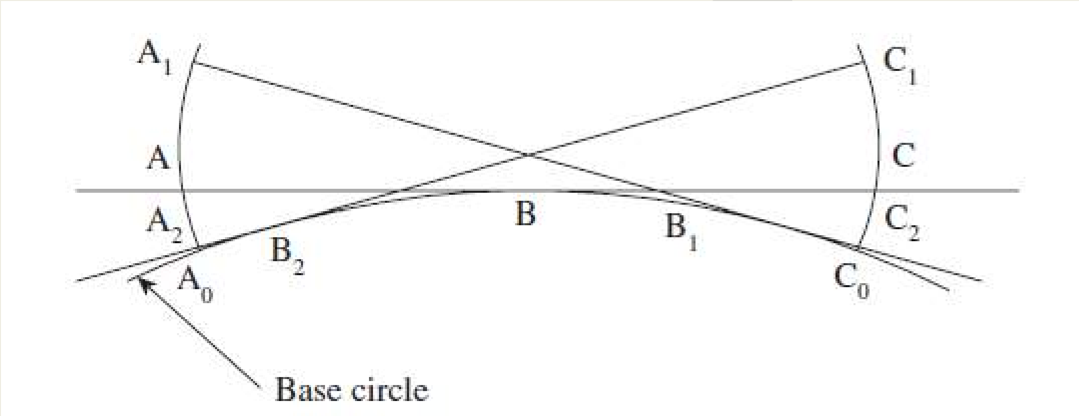
CALCULATIONS:

1. Pitch circle diameter, D=(TxOD)/(T+2)=
2. module, m=D/T mm=
3. Addendum=m=
4. Dedendum=m+0.157m=

CONCLUSION: Hence we have various gear parameters of gear using Vernier gear caliper.

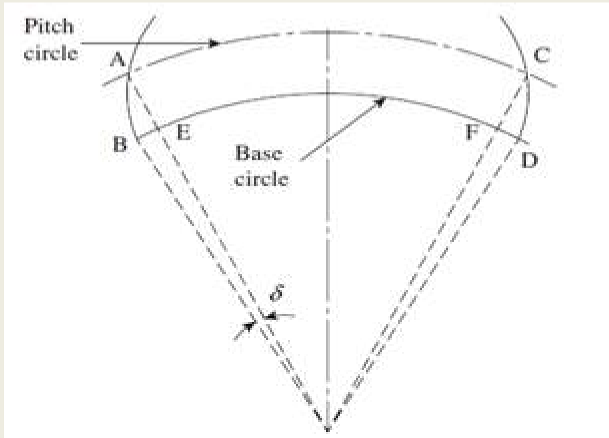
Measurement with Tooth Span Micrometers

Tooth thickness is measured by measuring the chordal distance over a number of teeth by using a tooth span micrometer, also called a flange micrometer. The inspection of gear is simple, easy, and fast. The measurement is based on the base tangent method and is illustrated in Fig.



The reader may recall that an involute is the path traced by a point on a circle that is rolling on a straight line without slipping. We can easily see that if a straight generator ABC is being rolled along a base circle, then its ends trace involute profiles A2AA1 and C2CC1, as shown in Fig. Therefore, any measurement made by gauging the span of a number of teeth will be constant, that is, AC = A1C2 = A2C1 = A0C0, where A0C0 is the arc length of the base circle between the origins of involutes. Thus, the accuracy of this method is better than that of a gear calliper since it is independent of the position of flanges of the micrometer on teeth flanks. Suppose, the gear has N number of teeth and the length AC on the pitch circle corresponds to S number of teeth (called the tooth span), then AC = (S −1/2.) pitches.

Therefore, angle subtended by AC = (S – 1/2.) × 2π/N radians.



Measurement across two opposed involutes

Above Figure illustrates the measurement across two opposed involutes over a span of several teeth.

Involute function of pressure angle= δ = tan f − f, where f is the pressure angle.

Therefore, angle of arc BD = (S − ½)× 2π/N + 2(tan f − f).

From Fig., it is clear that BD = angle of arc BD × Rb, where Rb is the radius of the base circle.

Thus,

$$\mathrm{BD} = [(S - ½) \times 2\pi/N + 2(\tan\phi - \phi)] \times R_p \cos\phi \quad (R_b = R_p \cos\phi)$$
$$= \frac{mN}{2}\cos\phi\,[(S - ½) \times 2\pi/N + 2(\tan\phi - \phi)] \quad (R_b = R_p \cos\phi)$$

Therefore,

$$\text{length of arc BD} = Nm\cos\phi\left[\frac{\pi S}{N} - \frac{\pi}{2N} + \tan\phi - \phi\right]$$

This is the measurement Ws made across opposed involutes using the tooth span micrometer The following paragraphs illustrate the methodology.

Span gauging length is called the base tangent length and is denoted by Ws, where s is the number of spans. If the measurement is carried over five teeth, then s will be denoted as 5. While carrying out measurements, the micrometer reading is set to the value of Ws as determined from above Eq. If the span selected is 3, then s is taken as 3 in the equation. The micrometer reading is locked using a locking screw. Now, the micrometer is as good as an inspection gauge and can be used to check gears for accuracy of span width. The inspection is carried out with the contact of measuring flanges being made approximately at the mid-working depth of the gear teeth.

Tables that serve as ready reckoners for the span width for given values of module, number of teeth on the gear, and span width are available. Table gives a sample of the tabulated values. The advantage of using the table is that the span width can be readily measured without having to calculate the value using relevant equations.

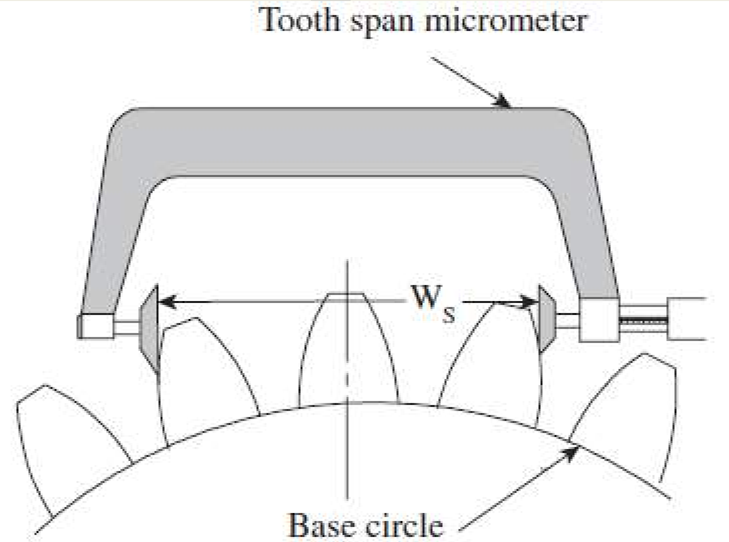


Fig. Tooth span micrometer

Table Values of span width

Value of base tangent length W_s for uncorrected spur gears in mm					
Pressure angle = 20°			Module m = 1		
Number of teeth on the gear (z)	Number of teeth spanned (s)	Base tangent length (W_s, mm)	Number of teeth on the gear (z)	Number of teeth spanned (s)	Base tangent length (W_s, mm)
7	1	1.5741	25	3	7.7305
8	1	1.5881	26	3	7.7445
9	2	4.5542	27	4	10.7106
10	2	4.5683	28	4	10.7246
11	2	4.5823	29	4	10.7386
–	–		–	–	–
–	–		–	–	–

Measurement with Gear Roll Tester:

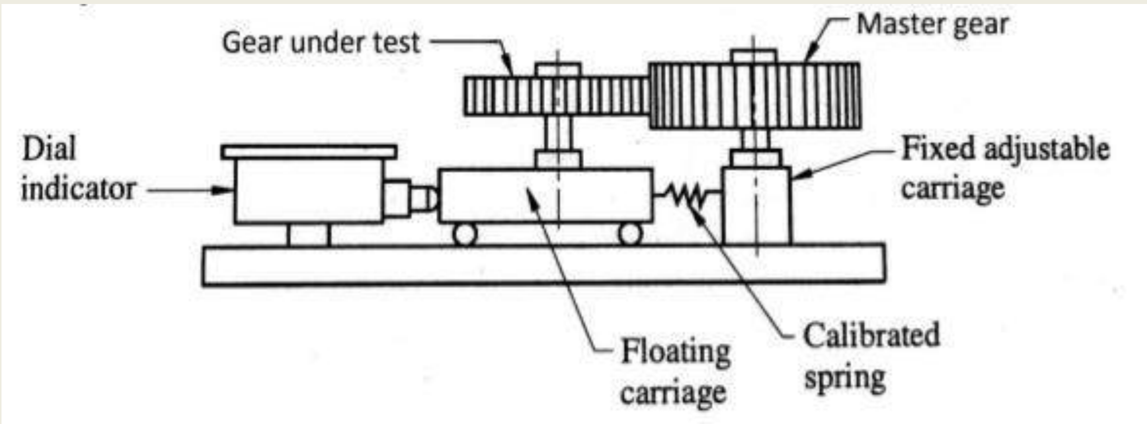
Gear Roll Tester is a simple workshop gear checking facility, designed to measure double flank error of Component Gear meshing with its Master. The results indicate size, hence backlash, run out, tooth damage, and some measure of individual tooth quality.

The Tester is robust intended for workshop use where it may be placed next to gear generating machine or on the production line.

Construction: The improved GRT consists of the following components:

1. Base
2. Drive top
3. Float Bottom
4. Float top
5. Shaft
6. Induction motor with Gearbox

7. Digital Dial Gauge



CONSTRUCTIONAL FEATURES

<u>FLOATING CARRIAGE MECHANISM:</u>

It is essentially a mechanism having a base float plate mounted on the main body. This plate supports two CRW bearings. These CRW bearings further to support a top float plate. This top plate has a bush suitable for adapting the mandrels for the test Gear. This plate also has an actuator for actuating a dial gauge to read the variations in the gears. The actuator has a stopper mounted on it. The dial holder should be rested on this stopper and the dial loaded to approximately 1 mm. While changing the center distance for different gear pair, the float bottom plate can be shifted by sliding for range of 20mm and moved by removing bolts for higher distance. When the gears are finally engaged for testing the fixed saddle should be moved such that the load on the dial is approximately 0.3 mm to 0.5 mm.

<u>FIXED SADDLE</u> - Fixed Saddle is provided on the other side of Floating Carriage the main body. Master Gear Mandrel is mounted on shaft on this, which is made flat and parallel to Master Gear Mandrel mounting face on Floating Carriage Mechanism. Fixed saddle also works as bearing housing for deep groove ball bearings, which guide the driving shaft below base plate.

DRIVING MECHANISM –

Driving mechanism consists 90 watt 1440 rpm induction motor with gearbox having reduction ratio of 100 which is connected to the driving shaft with the help of lovejoy coupling. The motor is mounted on a separate plate which is connected to base plate at bottom side, which allows the placement of base plate on table such that motor assembly is guided through cutout on the table.

METHOD OF OPERATION OF GEAR ROLL TESTER:

The Tester must be set up. This merely involves adjusting vertical level of both gears, and setting center distance to the required datum using gauge blocks or special setting discs. The operations are very simple. Floating Carriage is withdrawn to Disengage position. Component Gear is mounted and engaged with it's Master gear. Master gear is loaded on fixed saddle and is clamped with the help of washer and bolt to the driving mandrel. Component gear mounted on floating carriage is free to rotate transferring only radial displacement to the carriage assembly. When power is turned on master gear rotates the component gear through mesh, floating carriage is displaced when there is defect at the point of meshing. This deflection is displayed on the digital dial gauge as well as it is recorded on the computer using Data Acquisition System. Readings obtained from DAQ is fed into program to generate graph.

The following elements can be deduced from the results:

[1] SIZE & BACKLASH - If Component Gear is oversize, its close mesh center distance will be greater than desired, and will be reflected in dial indicator readings. An oversized gear will have a reduced backlash, resulting in tight running, overheating, excessive noise and possible physical damage. An undersized Component Gear will record lower than desired dial readings; will have more than desired backlash, which in turn may cause loss of tooth strength excessive noise on reversal and change pressure angle reducing transmission efficiency.

[2] ECCENTRICITY - Continuous measure of effective center distance during roll is indicated, as gears rotate. Run out is TIR (excluding localized defects registered as sudden flickers or kicks) on dial indicator. Run out will cause transmission errors & noise, and may cause harmful backlash either too great or too small.

[3] COMPOSITE ERRORS - Center distance between gears under roll change, as each pair of teeth move into & out of contact. The change is registered on dial indicator. This is known as `Tooth-to-Tooth Composite Error (TTCE). Total Composite Error (TCE) is the difference between minimum & maximum reading on the dial indicator.

[4] DAMAGE - Sharp flicker on dial indicator is generally caused by some localized defects, viz. bruising, raised burrs or dent on tooth profile. 'ZERO BACKLASH - DOUBLE FLANK' Roll Test between Component Gear & its Master is the quickest and satisfactory method to determine all the above four parameters, in a single pass.

CONCLUSION: Hence we have studied various gear parameters of gear using gear tester and tooth span micrometer.

PART B

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Experiments No. 01

TITLE: Determination of process capability from given components and plot variable control chart

Components are being turned on a CNC lathe to a specification of 12.58 ± 0.05 mm. Five batches of five components each have been drawn for inspection at 1-hour intervals. The readings are tabulated in Table

(a) Determine the process capability.
(b) Determine the three-sigma limits for the $\overline{X}$ chart.
(c) Draw the control chart and give your assessment.
(Assume that normal distribution and d_2 for group size 5 is 2.326

Solution

The values of $\overline{X}$ and R for the five batches are calculated first as shown in Table

Table Reading of components

Batch 1	Batch 2	Batch 3	Batch 4	Batch 5
12.62	12.63	12.62	12.61	12.59
12.60	12.56	12.56	12.66	12.58
12.62	12.60	12.57	12.62	12.57
12.61	12.59	12.58	12.61	12.59
12.65	12.60	12.63	12.60	12.56

Table Values of $\overline{X}$ and R

	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5
$\overline{X}$	12.62	12.60	12.59	12.62	12.50
R	0.05	0.07	0.07	0.06	0.03

$\overline{X} = 62.93/5 = 12.586$ mm

$\overline{R} = 0.28/5 = 0.056$ mm

σ' = population standard deviation = $\overline{R}/d_2 = 0.056/2.326 = 0.0241$

Process capability is the minimum spread of the measurement variation that includes 99.73% of the measurements from the given process, that is, $6\sigma'$.

$\therefore$ Process capability = $6 \times 0.0241 = 0.1446$ mm

3σ limits for $\overline{X}$ chart,

$3\sigma_{\overline{X}} = 3\sigma'/\sqrt{n} = 3(0.0241)/\sqrt{5} = 0.0323$

Therefore, UCL = $\overline{X} + 3\sigma_{\overline{X}} = 12.618$ mm

LCL = $\overline{X} - 3\sigma_{\overline{X}} = 12.554$ mm

The control chart is drawn as shown in Fig.

It is clear that several points lie outside the control limits and the process is out of control.

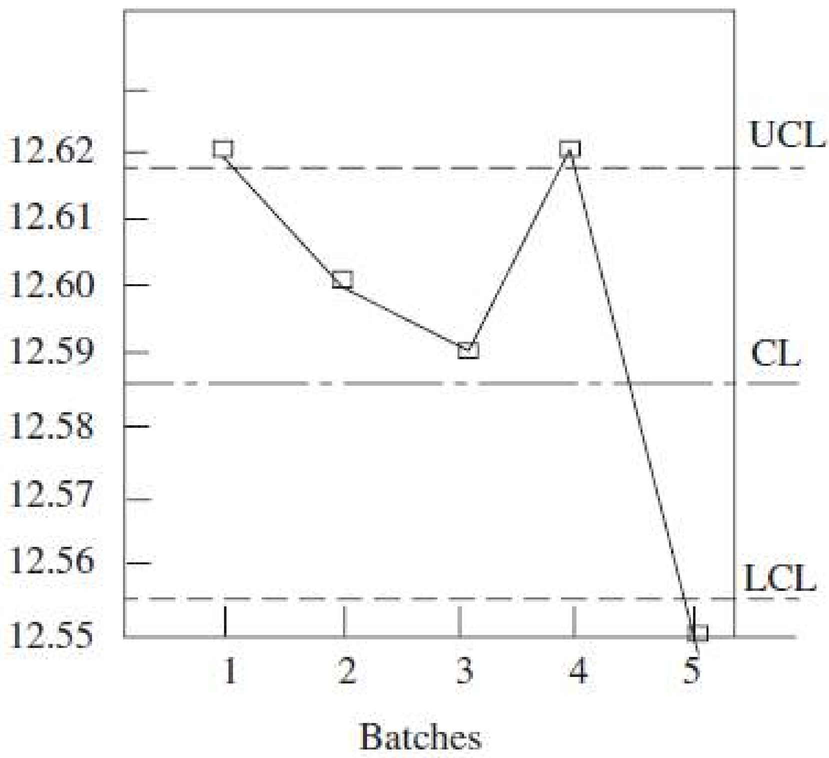

Fig. $\overline{X}$ chart for

Experiments No. 02

TITLE: Case study on various tools in Total Quality Management (TQM)

Quality Improvement of Fan Manufacturing Industry By Using Basic Seven Tools Of Quality: A Case Study

INTRODUCTION

No one can deny the importance of quality in modern world competitive market where only those survive, who can provide better quality products. Edward Deming explains "The Deming Chain Reaction" in his book "out of the crisis" in 1986 [1]. According to him "when the quality is improved, the cost decrease (because of less rework, fewer mistakes, fewer delays and better use of machine, time and material), when cost decrease productivity improves, when productivity improves they capture the market with better quality & low price and in this way they stay in the business, enhance their business and provide more jobs". No one can deny the importance of quality especially in such a competitive market where only those survive, who can provide better quality products. The seven quality tools were developed independently of each other's however it was first popularized by Dr. Kaoru Ishikawa of Tokyo University during the Quality revolution in Japan. Dr. Kaoru Ishikawa did not invent all of these tools, some of these were already in use since 1900s, but he took all these seven tools and made a set of these seven tools and named it "the basic seven tools of quality". That's why these tools are also called Ishikawa tools of quality. These tools are also known as basic quality tools because these tools are suitable for people and required less formal training statistics and because they can be used to solve the vast majority of quality-related issues [2]. Tools of quality can be implemented through many ways in the process industry but PDCA cycle and DMAIC methodology are the most famous and widely used technique through quality tools can be implemented in industrial process.

PDCA is a continual improvement Deming's cycle. PDCA is abbreviation of plan, do, study, act, this as a four step iterative cycle used for process improvement. Planning step is about establishing quality targets and observing the process, in second step data is collected and problem is identified, in third step problem is analyzed and at the end steps are taken to remove the problems and to achieve quality targets. DMAIC methodology is also same as PDCA cycle but the steps of DMAIC are a bit more explanatory than the PDCA cycle. DMAIC is the abbreviation of Define, Measure, Analyze, Improve and Control. DMAIC methodology is used for process improvement. DMAIC is a systematic way of improving process by defining the problem then measuring its impact, examining why the problem is occurring, then improving the process by removing the problem and at the end control the process so that no more problems occurs. Professor "Nankana" named these tools as the "Magnificent Seven" due to their efficiency in solving and improving process in industry. One of the simplest and most effective tools used by engineers in manufacturing and service processes for problem solving and quality improvement, are the basic tools known as magnificent seven [3]. A single quality tool on its own is enough to produce positive results in a limited area [4]. Quality tools can be used at all stages of the product development and production, with the primary goals of cost reduction and customer satisfaction [5]. Quality tools are considered to be the simplest and easiest tools that one can use to improve the quality of their industrial process and no special skills or huge capital is required to use these tools [3].

LITERATURE REVIEW

This research was carried out in "Fecto Fan Company". Who are specialized in manufacturing all type of ceiling fans. There were two sections in plant, manufacturing and assembling. The study found that there were total five types of defect occurring in fan manufacturing process. Defects are as below: • Difference between size of Upper and Lower Ribbon (ULR) • Shorter length of Down Rod (DR) • Variation in size of Canopy (VC) • Blade Flange under size (BF) • Steel Ribbon over size (SR) Now the goal was to eliminate all these problems and to ensure flawless manufacturing process. For this purpose basic seven tools of quality were implemented. Following are the basic 7QC tools: 1. Flow Chart 2. Check Sheet 3. Pareto Chart 4. Histogram 5. Cause & Effect Diagram 6. Scatter Diagram 7. Control Chart There tools were implemented through DMAIC methodology. Every tool was used in different steps of DMAIC methodology for better results. Use quality tools in different steps of DMAIC methodology are shown in table 1

S.N	Tool	Application
1	Flow chart	Define, Control
2	Check Sheet	Measure, Analyze
3	Histogram	Measure, Analyze
4	Cause & effect diagram	Analyze
5	Pareto diagram	Analyze
6	Scatter diagram	Analyze, Improve
7	Control charts	Control

Table 1: Use of 7QC in different Steps of DMAIC Methodology.

2.1 FLOW CHART

Flow chart is one the basic tool. It is used to study the whole process. Flow charts are used to identify the problem and control the process after defect removal. Flow chart shows the whole process step wise. Flow chart of the whole process (from raw material to end product) was designed and after studying the process it was found that manufacturing section is the most problematic section as all of the five defects occur in manufacturing section and assembling section was declared as non-defective section. So, at this stage it was decided all other tools will be implemented only on manufacturing section

2.2 CHECK SHEET

Check sheet is an important tool used to collect data and record that which process occurs how many times. It helps to categorize data. The data collected through check sheet can be used in other tools like Pareto chart and Histogram. Data was collected through check sheet for 30 days and the results are as below shown in table 2. Table 2: Check Sheet for various modes of defects with frequency and percentage.

Type of Defects	Total Qty Produced	Rej. Qty	% Rej Qty	Cum. Qty	% Cum Qty
Difference between upper and lower Ribbon (ULR)	7578	363	54.50 %	363	54.50
Shorter length of Down Rod (DR)		112	16.81 %	475	71.33
Variation in size of Canopy (VC)		92	13.81 %	567	85.15
Blade Flange under size (BF)		78	11.71 %	645	96.85
Steel Ribbon over size (SR)		21	3.15 %	666	100
Total	4578	666	100%	666	100

2.3 PARETO CHART

Pareto is one of the most important and useful tool. It was initially developed by Italian economist named Vilfredo Pareto. It consists of simple series of bar whose height indicated the impact of defect/problem. It is based on 20-80 rule. This shows that which of the 20% errors cause 80% defects. Data in Pareto chart is arranged in descending order and shows variables in graphical form. Pareto chart in Figure 1 shows the data in graphical form. The frequency of every defect is visible and its height shows the impact of every problem. After implementing 20-

80 rule on the Pareto chart it shows that two problems URL (difference between upper and lower ribbon) and DR (shorter length of down rod) are the most problematic areas and these two problems whose contribution in all the problems are just 20%, cause 80% of disturbance. So from this Pareto chart it figured out the first we have to focus on these two problems (URL and DR), to eliminate them from the process. If the two problems are eliminated then 80% of defects will be reduced.

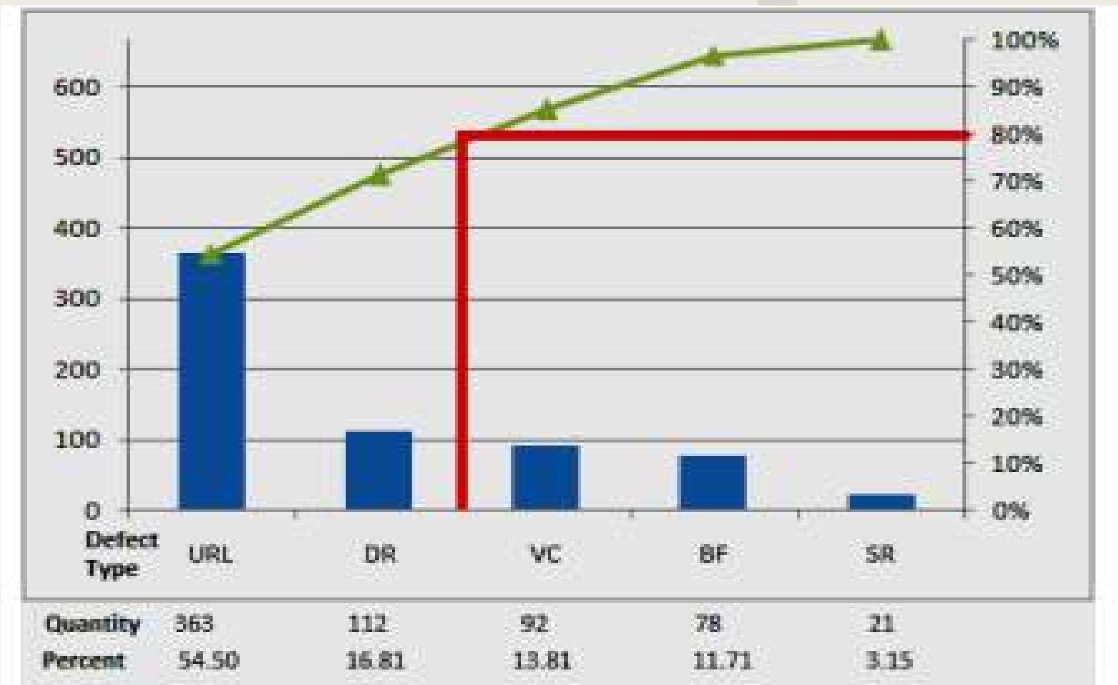

Figure 1: Pareto Chart shows types of defects in graphical form.

2.4 HISTOGRAM

Histogram is most commonly used graph among all quality tools. Histogram is graphical representation of numeric data used to shows how often each different value in a set of data occurs. Histogram is used to determine shape of data set. Histogram works best when the amount of data is less but when there is huge data we go for Pareto chart as Pareto chart also arrange data in descending order. Histogram is shown in figure 2 below shows the data of upper and lower ribbon. It shows cell boundaries and its frequencies.

S.N	Cell Boundaries (cm)		Frequency
1	15.50	16.00	2
2	16.00	16.50	2
3	16.50	17.00	4
4	17.00	17.50	0
5	17.50	18.00	8
6	18.00	18.50	13
7	18.50	19.00	16
8	19.00	19.50	11
9	19.50	20.00	0
10	20.00	20.50	9
11	20.50	21.00	6
12	21.00	21.50	5
13	21.50	22.00	3
14	22.00	22.50	3
15	22.50	23.00	3

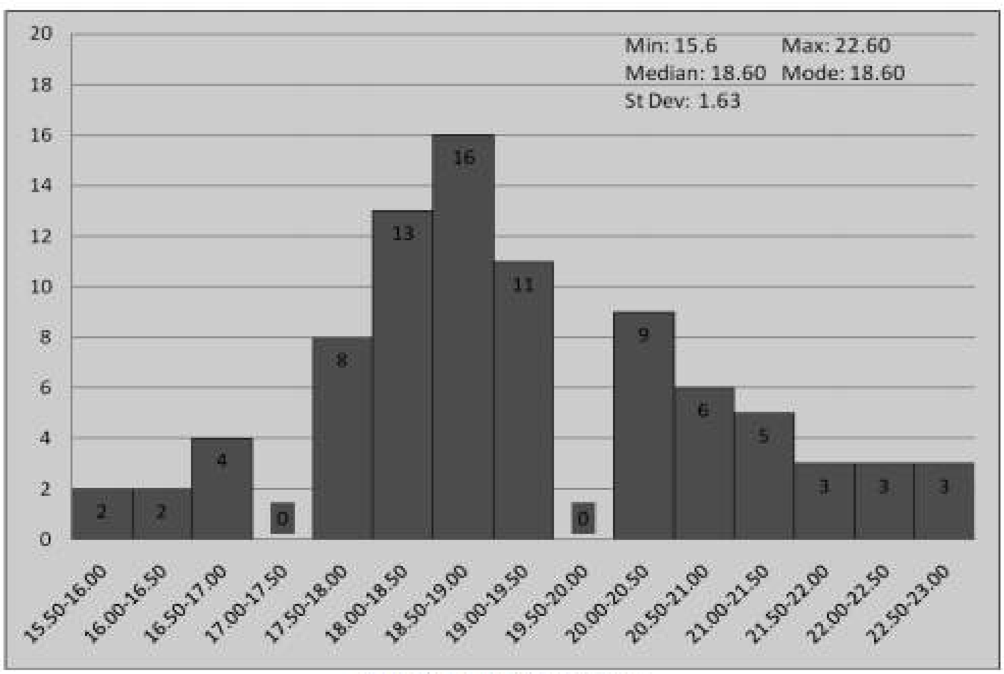

Figure 2: Histogram Chart

2.5 **CAUSE & EFFECT DIAGRAM**

Cause and effect diagram was invented by a Japanese professor name Dr. Ishikawa. This tool is also known as Ishikawa or Fish bone diagram because of its graphical structure. It is an important tool used to figure out the root causes of a problem. In this technique all the possible causes of a problem are taken into account and try to find out the reason of every cause which makes the problem happen. This technique can be applied by two methods i.e. 4M's Method or 6M's Method. If problem is small than 4M's Method is enough to find its root cause.

The 4M's includes Men, Material, Machine and Method. But we will go for 6M's method if problem is very complex and its scale is very high. In 6M's technique there will be addition of Measurement and Mother Nature. M's of fish bone diagram be increase as per requirement which includes Money, Management etc. Cause and effect diagrams were constructed for two major defects (URL & DR) which cause 80% of the problem. Cause and effect diagram shown in figure 3 and 4, were built to find out the root causes of the problem URL and DR Respectively.

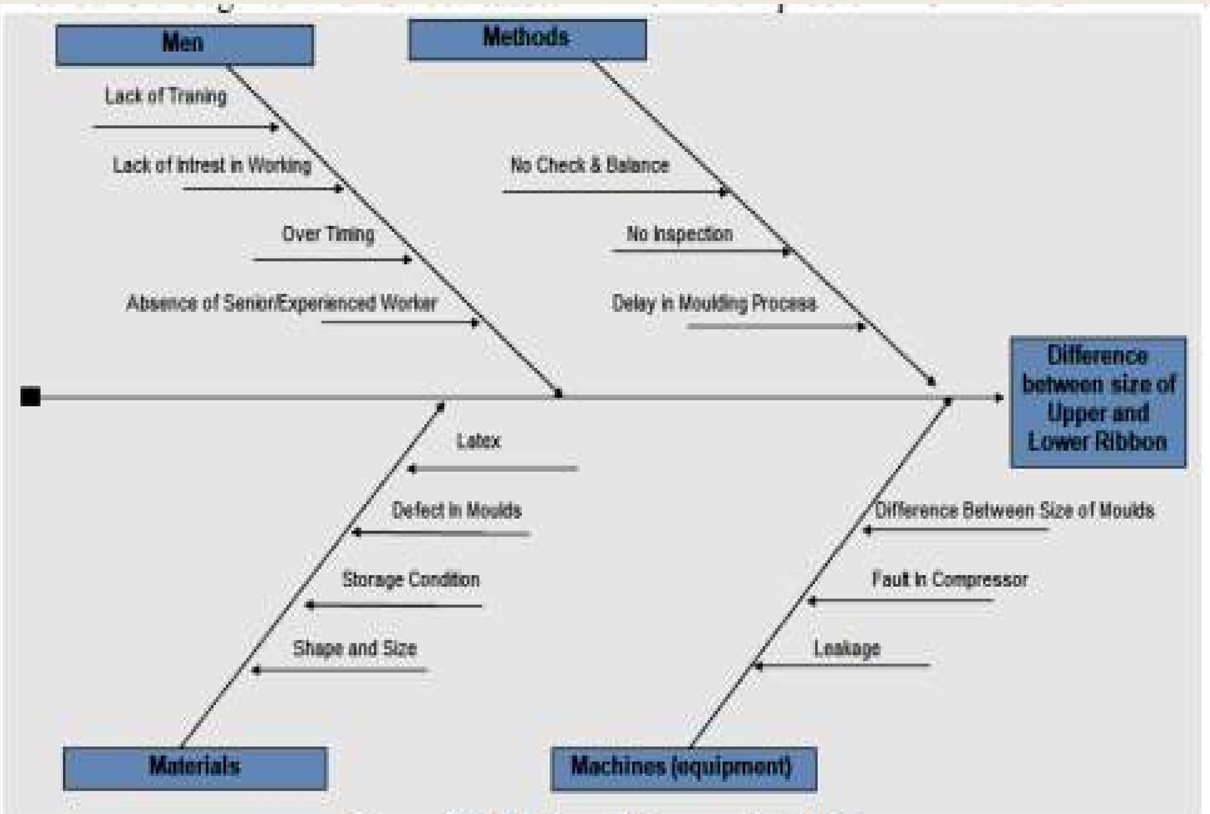

Figure 3: Fish Bone Diagram for URL

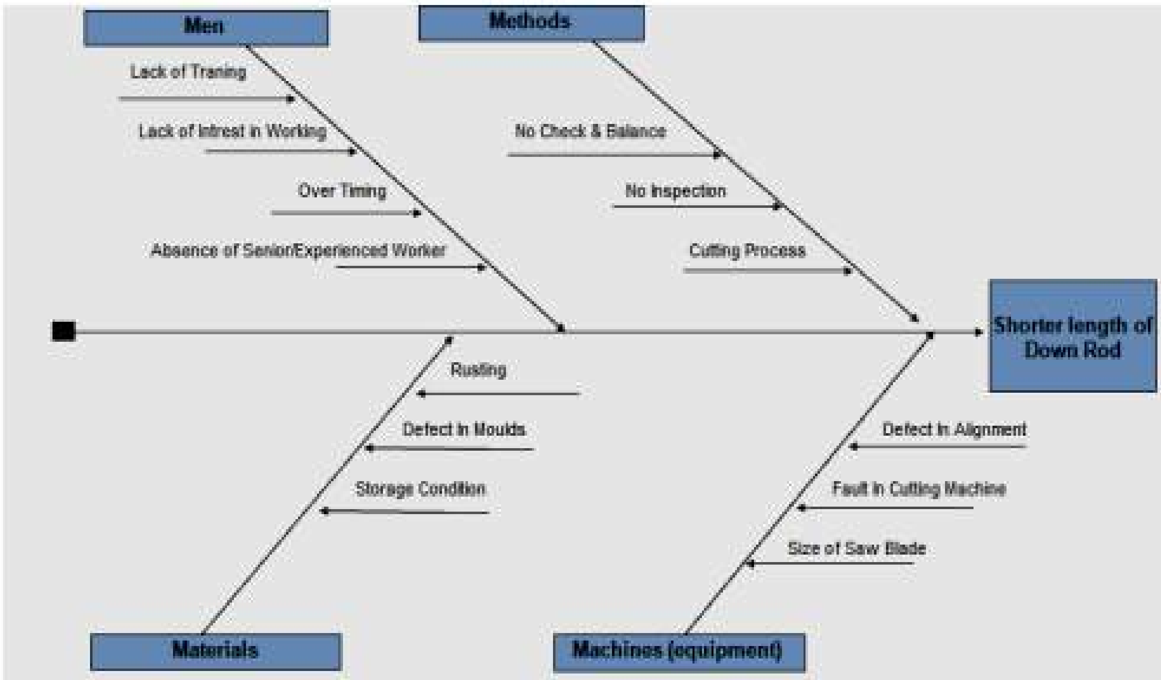

Figure 3: Fishbone Diagram for DR

2.6 SCATTER DIAGRAM

Scatter diagram is used for paired numeric data, it is also known as X-Y plot. Relation between two variables can find out through scatter diagram. In scatter diagram independent variable is plotted on Xaxis and dependent variable is plotted on Y-axis. Scatter plot strengthen the results of cause & effect diagram. In cause and effect diagram it was noticed that difference between upper and lower ribbon is mainly due to huge delay between molding process and storage condition (high temperature in store room). Now to prove this statement true scatter diagram was implemented to find out whether delay in molding process and high temperature of store room effect the size of ribbon or not?

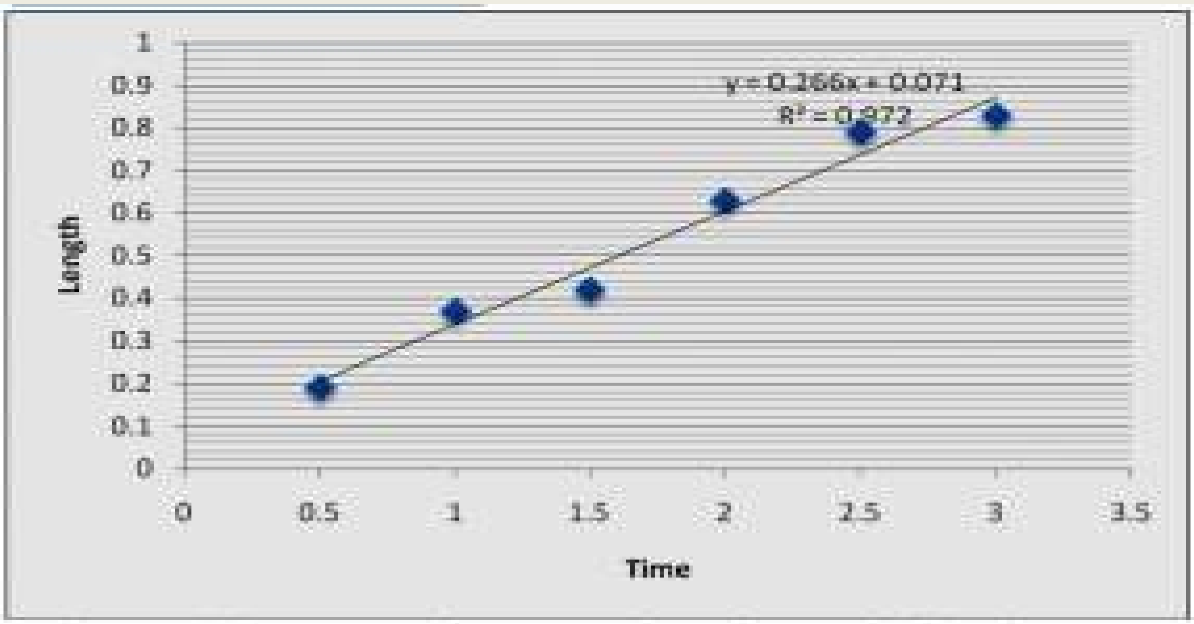

Figure 4: Scatter Diagram showing relation between time delay and deviation in length of ribbon.

Figure above shows strong relation between time delay and deviation in length of ribbon. It is clear from the scatter plot that when time delay increase the length of ribbon deviate. Scatter diagram shows high positive corelation between time and length of ribbon. Another scatter diagram was constructed to findout the relation between storage condition size of ribbon.

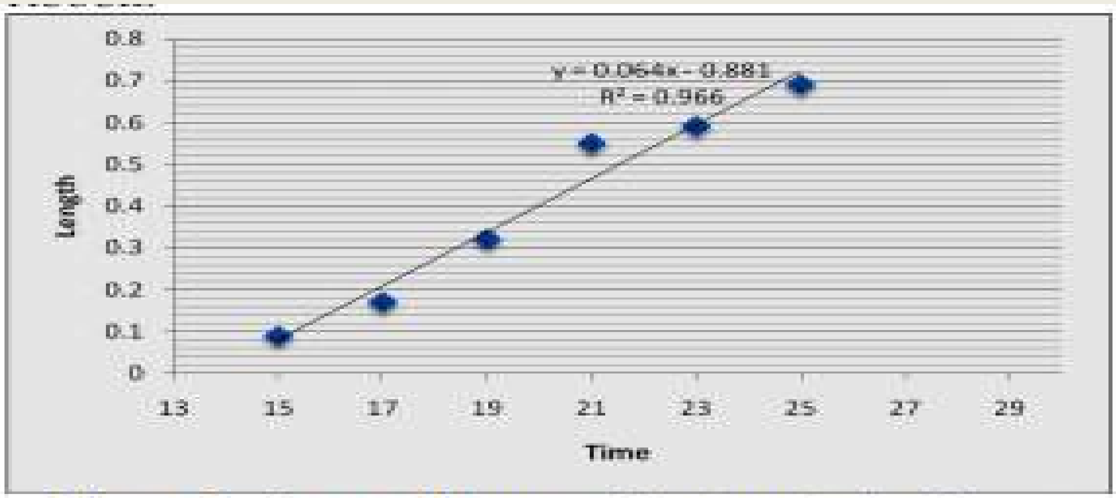

Figure 5: Scatter Diagram showin relation bween temperature and deviation in length.

The figure above shows high positive corelation between temperature and length of ribbon. These two scatter diagram confirms that's the difference between upper and lower ribbon is due to delay between moulding process and high temperature of store room. Another scatter diagram was also constructed for second defect DR (shorter length of Down Rod), which confirm that this defect is due to defect in the allignment of saw machine. III. RESULTS AND REMOVAL OF DEFECTS After implementing basic tools of quality the entire root causes of major defects were find out.Result of every single tool of quality is shown in table 3 below.

Table 5: Results of basic tools of quality

Tools of Quality	Result
Flow Chart	Defects are only in manufacturing section
Check Sheet	Categorize defects according to their magnitude
Pareto Chart	80% of the problems are due to URL and DR
Histogram	Maximum variation between 18.50-19.00
Cause & Effect	Find out the root causes of major problems
Scatter Diagram	Strong correlation between variables

After the identification of major defects and its root causes the technical and managerial staff of the company remove these defects from the manufacturing process. IV. QUALITY ASSURANCE After removal of defects from manufacturing process control chart was implemented to make it sure that process is now under control.

2.7 **CONTROL CHART**

Control charts are also known as statistical process control charts (SPC). These are most important and powerful quality tool to study variation of process with time. Control charts are used to check stability of process. Control charts have two control limits. These limits define boundaries for minimum and maximum values. Data for control is shown below in table 6.

Xbar-R Chart of data 1-6								
Tolerance: ± 8%								
S.N	1	2	3	4	5	6	X-Bar	R-Bar
1	0.13	0.36	0.32	0.45	0.67	0.54	0.41	0.54
2	0.25	0.83	0.46	0.34	0.45	0.65	0.49	0.58
3	0.91	0.81	0.10	0.76	0.33	0.74	0.60	0.81
4	0.45	0.18	0.54	0.39	0.98	0.24	0.46	0.80
5	0.19	0.44	0.77	0.29	0.54	0.46	0.44	0.58
6	0.67	0.58	0.21	0.58	0.46	0.57	0.51	0.46

The figure 5 shows control process chart which was constructed after removal of defects from the manufacturing process. The chart shows that the process is completely under control and there is no variation beyond the given tolerance.

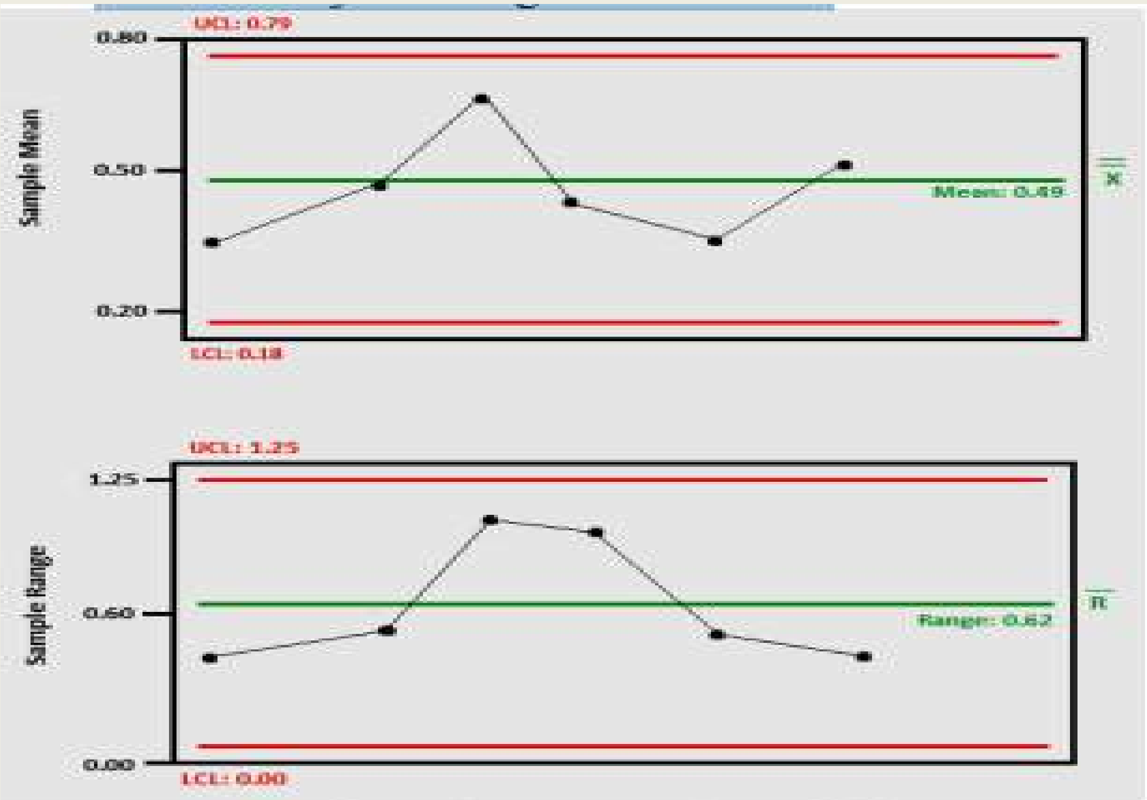

Figure 6: X-R Bar Control Chart

CONCLUSION

From the case study it has been concluded that basic seven tools of quality are very useful and effective in identifying and removal of defects from the manufacturing process. These tools are helpful in every stage of defect removal process. This case study strengthen the famous statement of quality guru Dr. Ishikawa that "95% of quality related industrial problems can be solved simply by applying seven basic tools of quality"

PART C

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