

TPCT's
College of Engineering, Osmanabad

Laboratory Manual

METROLOGY & QUALITY CONTROL

For

Final Year Students

Manual Prepared by

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Author COE, Osmanabad



**Solapur Road, Osmanabad
Department of Mechanical engineering**

Vision of the Department:

To impart strong foundation in Mechanical Engineering Fundamentals, so that students will be competent professionals to meet the global challenges

Mission of the Department:

To promote scientific & educational activities for facing problems of global competition and prepare engineering students for successful carriers.

College of Engineering

Technical Document

This technical document is a series of Laboratory manuals of Mechanical engineering Department and is a certified document of College of engineering, Osmanabad. The care has been taken to make the document error-free. But still if any error is found, kindly bring it to the notice of subject teacher and HOD.

Recommended by,

HOD

Approved by,

Principal

FOREWORD

It is my great pleasure to present this laboratory manual for final year engineering students for the subject of Metrology & Quality Control to understand the basic concepts of measurement and quality control.

This is a core subject to study and understands the measuring instruments. This lab manual provides a platform to the students for understanding the measurement and quality control. This practical background will help students to quality of job by checking its dimensions by gauges.

H.O.D
MECH Dept

LABORATORY MANUAL CONTENTS

This manual is intended for the final Year students of MECH branches in the subject of metrology & quality control. This manual typically contains practical/ Lab Sessions related to metrology & quality control covering various aspects related to the subject for enhanced understanding.

Students are advised to thoroughly go through this manual rather than only topics mentioned in the syllabus as practical aspects are the key to understanding and conceptual visualization of theoretical aspects covered in the books.

Dos and Don'ts in Laboratory :-

1. Do not handle any equipment before reading the instructions /Instruction manuals.
2. Don't use an electrical outlet or switch if the protective cover is cracked or missing.
3. Observe type of sockets of equipment power to avoid mechanical damage.
4. Ensure the fitting of stirrer while starting bomb calorimeter.
5. Do not touch the boiler during steam generation.
6. Ensure the flow of LPG gas is proper while starting the gas burner.
7. Strictly observe the instructions given by the Teacher/ Lab Instructor.

Instruction for Laboratory Teachers:-

1. Submission related to whatever lab work has been completed should be done during the next lab session.
2. Students should be instructed to switch on the power supply after getting the checked by the lab assistant / teacher. After the experiment is over, the students must hand over the model of equipment to the lab assistant/teacher.
3. The promptness of submission should be encouraged by way of marking and evaluation patterns that will benefit the sincere students.

T.P.C.T'S
COLLEGE OF ENGINEERING, OSMANABAD
DEPARTMENT OF MECHANICAL ENGINEERING

LABORATORY MANUAL

**SUBJECT: METROLOGY AND QUALITY
CONTROL**

CLASS: B.E. MECHANICAL

APPROVED BY:

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List of Experiments

1. Determination of linear / Angular dimensions of a part using precision/non-precision measuring instruments.
2. Precision Angular measurement using sine bar/sine center, Autocollimator/Angle Dekkor.
3. Machine Tool Alignment Test on any machine like-Lathe, Milling, Drilling.
4. Measurement of Screw Thread using Floating Carriage Micrometer.
5. Measurement of Gear Tooth Thickness by Gear Tooth vernier caliper/Constant Chord /Span Micrometer.
6. Measurement of Circularity / Roundness using Mechanical Comparator.
7. Calibration of Dial gauge using dial gauge Tester.
8. Study of Surfaces using optical flat.
9. Study and applications of profile projector and Tool Makers microscope.
10. Inspection of Production Job by statistical Process Control.

EXPERIMENT NO 1

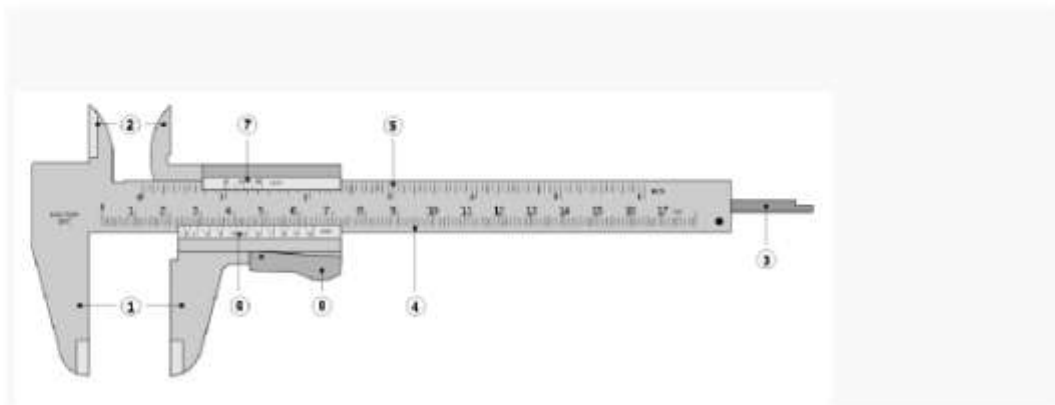
TITLE: Determination of Linear\Angular dimensions of a part using Precision\non-precision measuring instruments.

APPARATUS: Steel Rule, Vernier Caliper, Vernier Height Gauge, Micrometer, Digital Vernier Caliper, Digital Micrometer.

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 comparing an 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 interval 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. Outside jaws: used to measure external diameter or width of an object
2. Inside jaws: used to measure internal diameter of an object
3. Depth probe: used to measure depths of an object or a hole
4. Main scale: gives measurements of up to one decimal place (in cm).
5. Main 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)

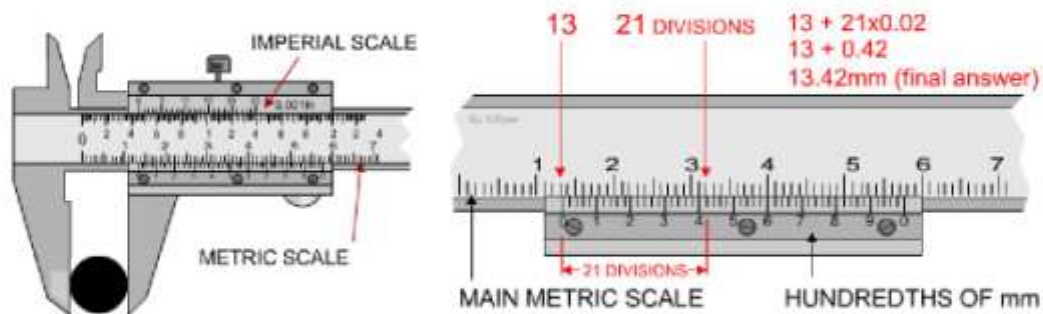
Least country main scale division-vernier scale division.

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

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

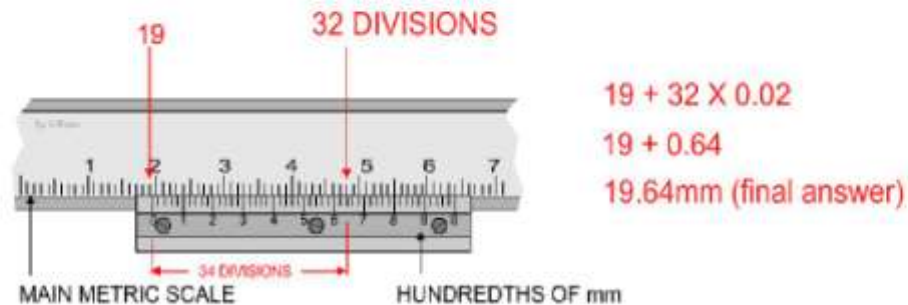
Suppose 50 vernier scale I division coincide with 49 divisions on main scale, and 1 msd=1 mm. Then 1 VSD = 49/50 of MSD = 49/50MM. and LC = 1-49/50= 0.02 mm. Alternatively, it is just as easy to read the 13 on the main scale and 42 on the hundredths scale. The correct measurement being 13.42mm.

1 cm = 10mm



EXAMPLE 2: (To zoom in to see the scale - right click mouse and select zoom)

EXAMPLE 2:



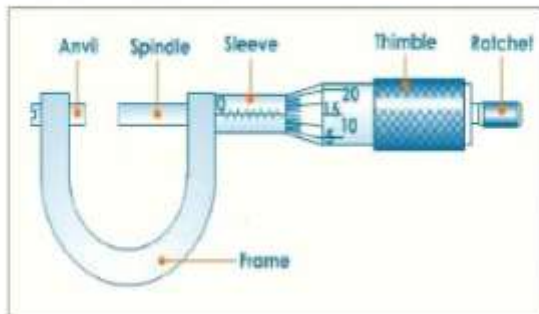
VERNIER HEIGHT GAUGE: This is also a sort of a vernier caliper equipped with a special base back and other attachments which make the instrument suitable for height measurement.

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 gauge 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.



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 revolution of thimble moves 0.5 mm which is the lead of the screw and also the pitch.



$2.5 \text{ mm} + (46 \times 0.01) = 2.96 \text{ mm}$ (for Figure 3)

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.

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.



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 Calliper/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

OBSERVATION TABLE:

For Vernier Calliper:

S. NO.	ACTUAL READING (mm)	MEASURED READING (mm)	ERROR (mm)
1.	20	20.09	0.09
2.	28	27.91	0.09

For Micrometer:

S. NO.	ACTUAL READING(mm)	MEASURED READING(mm)	ERROR (mm)
1.	20	19.89	0.11
2.	28	27.29	0.71

For Digital Height Gauge: LC : 0.001

S. NO.	ACTUAL READING	MEASURED READING	ERROR
1.	100	100.96	0.96
2.	28	27.29	0.71

For Vernier Depth Gauge:

S. NO.	ACTUAL READING	MEASURED READING	ERROR
1.	30	30.10	0.10
2.	50	49.90	0.10

CONCLUSION: Hence we have studied various measuring instruments.

EXPERIMENT NO 2

TITLE: Precision Angular Measurements using sine bar/sine center, Autocollimator/ Angle dekkor.

APPARATUS: Vernier bevel protractor (0° to 360°), least count= $0^{\circ}-5'$, Surface plate 450×450 mm. Holding device to suit particular

job.

THEORY:

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. 1.



Fig. 1 Sine Bar

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).

A Bevel Protractor, a graduated circular protractor having a pivoted arm and used for measuring or marking off angles, is shown in Fig. 2. Sometimes vernier scales are attached to give more accurate readings.



Fig. 2 The Universal Bevel Protractor

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. 3. 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.

PROCEDURE:

- (1) Study the bevel protractor and identify its main parts.
- (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 the angle. And now measure the angles of the sample pieces with the bevel protractor and record the reading.

OBSERVATION:

1. Length of sine bar= $L=200$ mm
2. size, $h=68.6$
3. specimen angle with vernier bevel protractor= 68.6
4. centre distance= 200 mm
5. $\theta = \sin^{-1}(h/L) = 20.097$
6. angle of specimen= 20.1
7. least count of dial indicator= 0.001 mm

CONCLUSION: Hence we have studied various angle measuring instruments.

EXPERIMENT NO 3

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 test 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 the geometry of various shapes is based on 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 guideways 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

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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<=O<=1000 0.02 local tolerance. 0.075 for any length of 250>O>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 for any 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 frontward	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

METROLOGY AND QUALITY CONTROL - LABORATORY MANUAL

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 $D \geq 0.5 Da/8$ $t = 0.05Da$ 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 $D \geq 0.5 Da/8$ $L = Da/8$ 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	$D_c \leq 2000$ a. 0.04 for any measure length b. 0.015 any length of 50	0.03 0.05

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

EXPERIMENT NO 4

TITLE: Measurements of screw threads using Floating Carriage Micrometer.

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 $D = D_m + (R_2 - R_1)$ 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 centre'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 centre.
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,

$T = S - (R_1 - R_2)$

$D =$ 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, $BC = 0.5 \text{ pitch} = 0.5P$

$OP = dx \text{ cosec}(x/2) \times 0.5$ $PA = a(\text{cosec}(x/2 -$

$1))/2$ $PQ = 2 \text{ cosec}(x/2) = 0.25P \cot(x/2)$

$AQ = PQ - AP = 0.25P \cot(x/2) = 0.5d \text{ cosec}(x/2 -$

$1)$ AQ is half value of P.

$P = 2AQ = 0.5 \cos(x/2) - d \text{ cosec}(x/2 - 1)$

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

OBSERVATIONS:

Best wire diameter=1.333 mm

Master cylinder diameter=19.995 mm

Reading over specimen=4.3076 mm

Reading over master cylinder=3.7658 mm

Floating Carriage Micrometer



CALCULATIONS:

R_1 =Standard specimen reading, R_2 =reading over the wire with specimen
 $R_1=4+0.306+0.0001 \times 6$, ($R_1=4.3076$ mm), ($R_2=3.7658$ mm), Master cylinder diameter, $D=19.995$ mm, $M=D+(R_2-R_1)$, $=19.995+(3.7658-4.3076)$, $=19.4577$
Now, $T=M-2.7$, ($T=16.7577$ mm), $E=T+P$, $M-3w+0.8666P$, $=19.4577-3(0.577P)+0.866P$, Where $P=2.49$, ($E=17.30385$ mm)

RESULT:

Diameter over wire $M=19.4577$ mm

Major diameter $D=18.92$ mm

Effective diameter $E=17.3035$ mm

$T=16.7577$ mm

$D=15.46$ mm

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

EXPERIMENT NO 5

TITLE: Measurement of gear tooth thickness by gear tooth Vernier Calliper/Constant Chord/Spam micrometer.

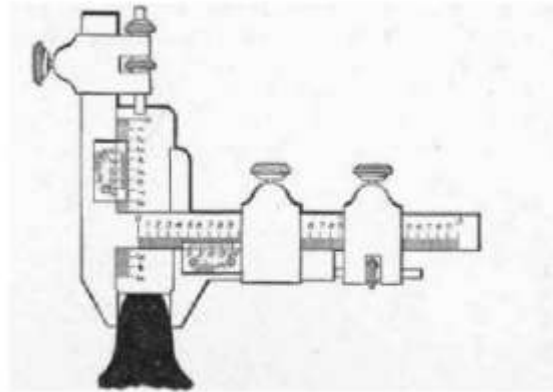
APPARATUS: Gear tooth vernier caliper, vernier caliper 12" 300 mm, bench vice.

THEORY:

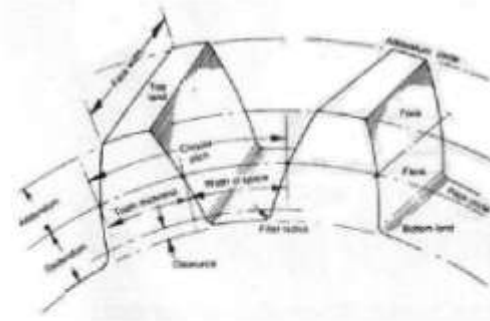
Brief description of different characteristics of measuring of tooth thickness by gear truth vernier is given. It consists of a horizontal and a vertical vernier scale. It is based on the principle of vernier scale. The thickness of a tooth at pitch line and the addendum is measured by an independent 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 $D = (T \times OD) / (T+2)$ 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 $CP = \pi D / T = \pi m$.
- (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)
- ii) 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.



VERNIER TOOTH CALIPER



GEAR TOOTH DETAILS

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 $D=(T \times OD)/(T+2)$
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= 40

TABLE FOR SETTING GEAR TOOTH CALLIPER FOR SPUR GEAR

NO. OF	30	32	34	36	38	40	42	TEETH					
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 (DIGITAL VERNIER CALIPER)
1.	4	8	$4 + 8*0.02 = 4.16$	4.49
2.	4	9	$4 + 9*0.02 = 4.18$	4.32

.HEIGHT OF THE TOOTH:

S NO	M.S.R	V.S.R	CHORDAL THICKNESS (M.S.R+V.S.R*L.C)	VERIFICATION (DIGITAL VERNIER CALIPER)
1.	4	7	$4 + 7*0.02 = 4.14$	4.26
2.	4	6	$4 + 6*0.02 = 4.12$	4.10

CALCULATIONS:

1. Pitch circle diameter, $D=(T \times OD)/(T+2)=$
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.

EXPERIMENT NO 6

TITLE: Study of circularity/ Roundedness using mechanical comparator.

APPARATUS: . Mechanical comparator-with Dial indicator and Work piece- Any 10 jobs of size within the range of comparator and master jobs.

THEORY:

The comparator is a device which takes a dimension of standard job as reference dimension, and gives a reading to a pointer on a scale, the variation in such dimension of the job to be compared.

At the upper end of the vertical beam, an adjusting screw is provided for final zero setting of the scale. A new patented feature is shown at K. This is a magnetic counter balance which serves to neutralize the positive 'rate' of spring reaching on the measuring tip. In this way a constant pressure over the whole scale range is achieved. The instrument is available with vertical capacities of 6', 12', and 24', and magnification of 500, 1000, 500, 3000 and 5000. The scales are graduated both in English and Metric systems. The least count is of order of 10R Inch. A work table on the base of this comparator stand is used to keep the job on. Special attachments are used for typical jobs like screw thread effective/outside diameter.

Dial indicator type of mechanical comparator consists of a sensitive dial indicator mounted on a horizontal arm on a stand. The arm is capable of coarse and fine adjustment movements in the vertical direction for initial setting of the Instrument. The base is heavy so that stability and rigidity of the instrument is ensured. Different attachments are available depending upon the type or job.

PROCEDURE:

- (i) Clean the comparator with a flannel cloth or chamoise leather.
- (ii) Wipe the standard job clean of dust etc.
- (iii) After lifting anvil by pressing the trigger, mount the standard jobs/slip gauges on the work table.
- (v) Adjust the screw at the top of vertical beam to zero pointer reading.
- (v) Replace the standard job with sample job and record the reading on scale.
- (vi) Repeat the comparisons for a set of sample jobs. Classify the jobs into acceptable/not acceptable and give code number for selective assembly.

OBSERVATION TABLE:

ROUNDNESS

A. STAGE 1

S NO	READING
1	0.0000
2	0.012
3	0.014
4	0.016
5.	0.015
6.	0.009
7.	0.01
8.	0.01

B. SATGE 2

S NO	READING
1	0.0000
2	0.009
3	0.007
4	0.017
5.	0.005
6.	0.006
7.	0.004
8.	0.007

CONCLUSION: Hence we have measured the roundness using the mechanical comparator.

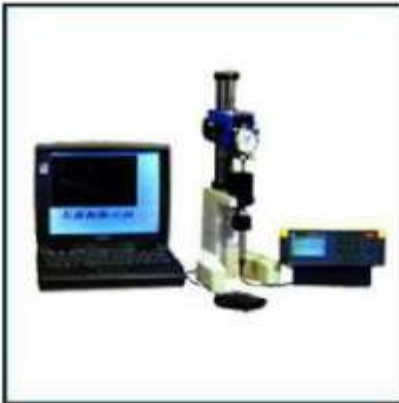
EXPERIMENT NO 7

TITLE: Study of Dial Gauge using Dial Calibration Tester.

APPARATUS: Dial Calibration Tester.

THEORY: Dial indicators, also known as dial gauges and probe indicators, are instruments used to accurately measure small linear distances, and are frequently used in industrial and mechanical processes. They are named so because the measurement results are displayed in a magnified way by means of a dial.

Dial indicators may be used to check the variation in tolerance during the inspection process of a machined part, measure the deflection of a beam or ring under laboratory conditions, as well as many other situations where a small measurement needs to be registered or indicated. Dial indicators typically measure ranges from 0.25 mm to 300 mm (0.015 in to 12.0 in), with graduations of 0.001 mm to 0.01 mm (metric) or 0.00005 in to 0.001 in (imperial)



Applications

- To check for run out when fitting a new disc to an automotive disc brake. Run out can rapidly ruin the disc if it exceeds the specified tolerance (typically 0.05 mm or less).
- In a quality environment to check for consistency and accuracy in the manufacturing process.
- On the workshop floor to initially set up or calibrate a machine, prior to a production run.
- Dial indicators help users measure the distance between two plates, but the readings given by the tool could be faulty.

PROCEDURE:

1. Wipe the surface plate, the gauge blocks and the tip of the dial indicator's plunger to remove any dirt or debris.

Lock the dial indicator in place on its stand, resting the indicator high enough to allow the plunger to travel its full length and still be able to touch off against the surface plate.

2. Rest the tip of the plunger directly on the surface plate. Rotate the indicator's face until the "0" marking aligns with the dial.

3. Raise the plunger and slip a 0.020-inch gauge block underneath. Lower the plunger onto the surface of the gauge block. Check that the indicator reads 0.020-inch. Raise and lower the plunger two more times to check that the dial indicator gives the same measurement in the same spot repeatedly.

4. Repeat the process with 0.025-inch, 0.050-inch, 0.100-inch, 0.250-inch, 0.400-inch and 1-inch gauge blocks. Check each block three times to ensure the dial indicator's repeatability. If the indicator's plunger reaches a 2-inch depth, stack the blocks to check the dial indicator at 1.025-inch, 1.050-inch,

ELECTRONIC DIAL GAUGE TESTER

[I.C: 0.0001 mm] in association with sylvan sa, Switzerland. It meets the iso 9000 requirements for periodic calibrations of one micron least count dial gauges [I.C: 0.001]. The equipment is useful for periodic calibration of plunger type dial gauge and lever types dial gauges and bore gauges. It includes rigid stand having dial gauge fitting arrangement on upper holder and micro screw with probe in the holder below the same. The dial gauge holding system is having mechanism of fine adjustment for setting the dial gauge. This is the specialty of the design. The digital unit indicates movement of probe that is fitted in micro screw. The digital indication unit is having a required operating switch for setting different modes that consists of change of resolution either 0.0001, 0.001, or 0.01 mm.

CONCLUSION: Hence we have studied Dial gauge calibration..

EXPERIMENT NO 8

TITLE: Study of optical surfaces using optical flat interferometer.

APPARATUS: Optical Flat, Mercury lamp etc.

THEORY: Light can be considered as an electromagnetic wave of sinusoidal form. High point and low point of the wave are called as crest and trough resp. the distance between a consecutive crest and a trough is called as wavelength ' λ '. Maximum displacement of the wave is called as "amplitude". Velocity of transmission is λ/T where T is the time provided. Wavelength has a precise value and form.

INTERFFERANCE OF TWO RAYS:

Let us consider effect of combining two monochromatic rays of light of intensity having amplitude A_1 and A_n .

1. If they have combined with each other, the resultant effect is production of maximum illuminator and the resultant amplitude of addition of A_1 and A_n .
2. If they combine in such a way that the crest of one and trough of other are simultaneous then they are said to out of phase by λ/p or 180° .

LIGHT SOURCE INTERFEROMETER

For simple applications like testing of surfaces, it is used. However satisfactory operation requires use of light sources such as mercury, Krypton, Thallium, Helium and gases in this sources discharge lamp is charged with one particularly element excited elastically so that they radiate at a certain wavelength.

INTERFEROMETER APPLIED TO FLATNESS TESTING:

The essential equipment is monochromatic light source and a set of optical flats having its 2 plane surfaces flat and parallel and surfaces are finished to an optical. The importance of optical flat is operation in light wave measurement because all inspection operation are performed with reference to the surface of optical flat.

If an optical flat is placed upon another optical flat facing the reflecting surface, it will not form an important contacting but will lie at some angle making and if optical flat now be illuminated by monochromatic surface of light , eye placed in proper position will observe number of bonds produced by interference of light wave reflected from lower surface of other flat through thin layer of air between two flats is monochromatic light of surface of wave of incident beam from 5 is particularly reflected thus recommended by the eye having traveled path whose length will differ by an amount ACD .

OPTICAL FLAT:

They are cylindrical in form with working surfaces and are of two types Type A: Only one surface flat.

Type B: Both surfaces flat and parallel to each other.

PROCEDURE:

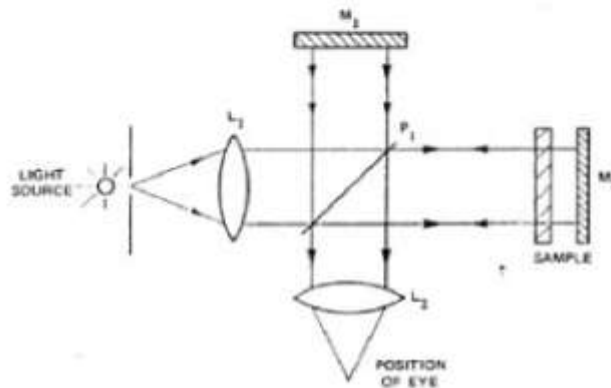
FLATNESS TEST:

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 leveling arrangement.

FIGURES:



CONCLUSION: Hence we have studied about surface flatness using optical flat for different surfaces we got different patterns as follows: Flat surface:

Straight lines

Concave surface: Concentric circles moving away from center.

EXPERIMENT NO 9

TITLE: Study and applications of profile projector and Tool maker's microscope.

APPARATUS: Tool maker's microscope

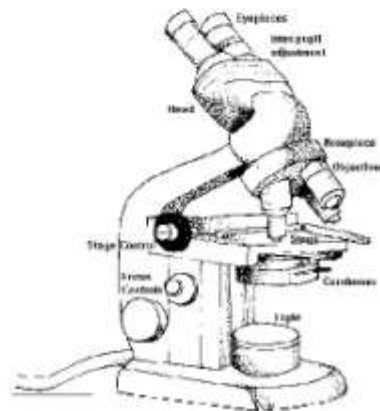
THEORY: A general view of the small model of tool maker's microscope giving its design and its optical system is shown in figure. This is designed for measurement of parts of complex figure profiles of external threads, tool templates and gauges. It can be used to measure center to center difference 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; The main applications of load room are as follows:

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



PROCEDURE:

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.

(ii) 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.

(iii) 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.

(iv) Comparison of the enlarged projected image with a tracing drawn on exact number of times full size and affixed to the projection screen.

OBSERVATION TABLE:

Observations	Initial Reading	Final Reading	Actual Reading
Major Diameter	9.52	13.61	4.09
Minor Diameter	10.12	13.03	2.91
Pitch	181°50'	241°	59°5'
Angle	19.24	19.63	1.41

APPARATUS: Profile Projector

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.



OBSERVATION TABLE:

SPECIMEN 1

S NO	PARAMETER	INITIAL READING (mm)	FIANL READING (mm)	ACTUAL READING (mm)
1.	MAJOR DIAMETER	23+(26x0.01)= 23.26	7+(7x0.01)= 7.07	16.19
2.	BORE DIAMETER	13+(45x0.01)= 13.45	16+(34X0.01)= 16.34	2.89
3.	THICKNESS OF SLOT	16+(77X0.01)= 16.77	10+(45X0.01)= 10.45	6.32
4.	LENGTH OF SLOT	10+(15X0.01)	3+(15X0.01)=7 3.15	

S NO	PARAMETER	INITIAL READING (MM)	FINAL READING (MM)	ACTUAL READING (MM)
1.	MAJOR DIAMETER	18	13+(39X0.01)= 13.39	4.61
2.	MINOR DIAMETER	17+(41X0.01)= 17.41	14+(1X0.01)= 14.01	3.4
3.	PITCH	17+(33X0.01)= 17.33	19+(25X0.01)= 19.25	1.92
4.	ANGLE	131°50'	241°0'	59°5'

CONCLUSION: Thus diameter of given component thread pitch etc of the component is measured by tool maker's microscope amd profile projector.

EXPERIMENT NO 10

TITLE: Study and applications of profile projector and Tool maker's microscope.

APPARATUS: Study of Inspection of Production job by Statistical Process Control SPC software

THEORY: There are many forms of QA processes, of varying scope and depth.

The application of a particular process is often customized to the production process. A typical process may include:

- test of previous articles
- plan to improve
- design to include improvements and requirements
- manufacture with improvements
- review new item and improvements
- test of the new item

Many organizations use statistical process control to bring the organization to Six Sigma levels of quality, in other words, so that the likelihood of an unexpected failure is confined to six standard deviations on the normal distribution. This probability is less than four one-millionths. Items controlled often include clerical tasks such as order-entry as well as conventional manufacturing tasks. Traditional statistical process controls in manufacturing operations usually proceed by randomly sampling and testing a fraction of the output. Variances in critical tolerances are continuously tracked and where necessary corrected before bad parts are produced.

How to Use SPC :Statistical Process Control may be broadly broken down into three sets of activities: understanding the process, understanding the causes of variation, and elimination of the sources of special cause variation.

In understanding a process, the process is typically mapped out and the process is monitored using control charts. Control charts are used to identify variation that may be due to special causes, and to free the user from concern over variation due to common causes. This is a continuous, ongoing activity. When a process is stable and does not trigger any of the detection rules for a control

chart, a process capability analysis may also be performed to predict the ability of the current process to produce conforming (i.e. within specification) product in the future.

When excessive variation is identified by the control chart detection rules, or the process capability is found lacking, additional effort is exerted to determine causes of that variance. The tools used include Ishikawa diagrams, designed experiments and Pareto charts. Designed experiments are critical to this phase of SPC, as they are the only means of objectively quantifying the relative importance of the many potential causes of variation.

Once the causes of variation have been quantified, effort is spent in eliminating those causes that are both statistically and practically significant (i.e. a cause that has only a small but statistically significant effect may not be considered cost-effective to fix; however, a cause that is not statistically significant can never be considered practically significant). Generally, this includes development of standard work, error-proofing and training. Additional process changes may be required to reduce variation or align the process with the desired target, especially if there is a problem with process capability.

In practice, most people (in a manufacturing environment) will think of SPC as a set of rules and a control chart (paper and / or digital). SPC ought to be a PROCESS, that is, when conditions change such 'rules' should be re-evaluated and possibly updated. This does not, alas, take place usually; as a result the set of rules known as "the Western Electric rules" can be, with minor variations, found in a great many different environs (for which they are very rarely actually suitable).

For digital SPC charts, so-called SPC rules usually come with some rule specific logic that determines a 'derived value' that is to be used as the basis for some (setting) correction. One example of such a derived value would be (for the common N numbers in a row ranging up or down 'rule'); derived value = last value + average difference between the last N numbers (which would, in effect, be extending the row with the to be expected next value).

CONCLUSION: Hence we have studied SPC.

REFERENCES: "Metrology and Quality control - R.K.Jain.

