Metrology Laboratory
Department of Mechanical Engineering

Experiment No. 1A

TOOL MAKER'S MICROSCOPE

Aim: To make use of tool maker microscope for measurement of dimensional parameters of the given workpiece.

Instruments used: Tool maker's microscope, measuring workpiece (Thread gauge).

Theory:

The Tool Maker's Microscope (TMM) essentially consists of the cast base, the main lighting unit, the upright with carrying arm and the sighting microscope. The rigid cast base is resting on

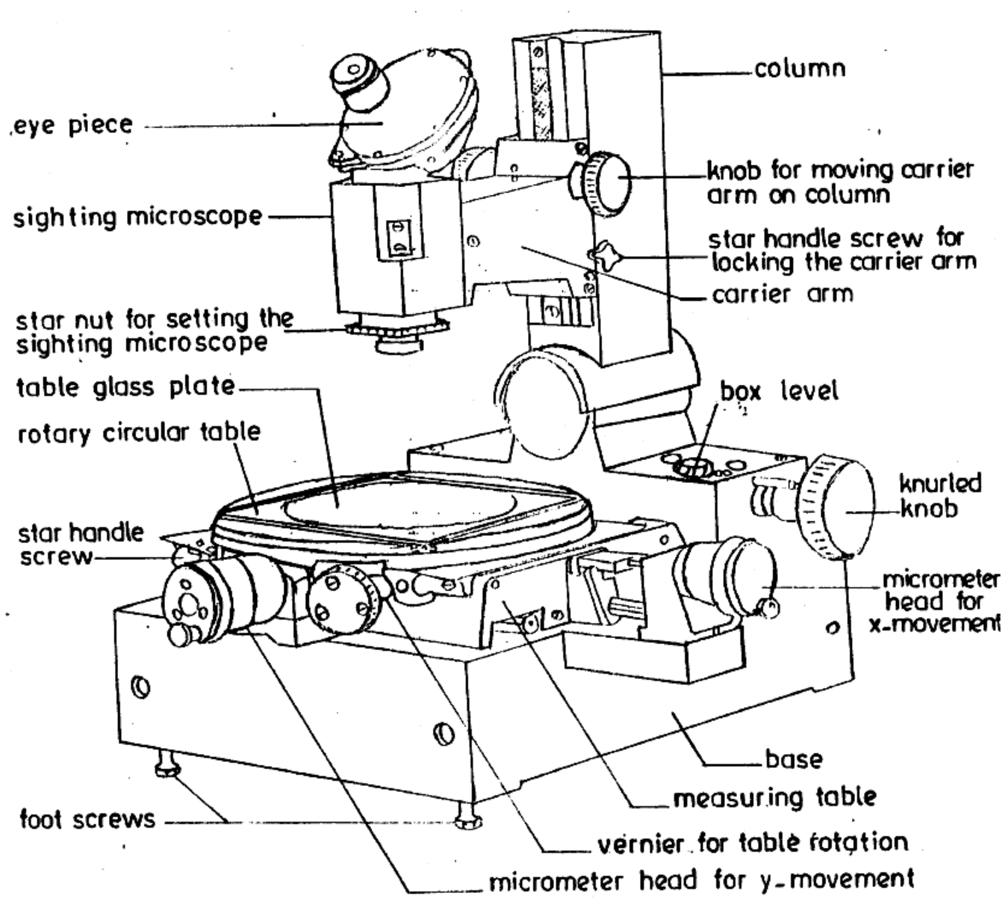

Fig.1 Tool Maker's Microscope

three foot screws by means of which the equipment can be leveled with reference to the built-in spirit level. The base carries the co-ordinate measuring table, consists of two measuring slides: one each for directions X and Y, and a rotary circular table provided with the glass plate. The slides run on precision balls in hardened guide ways warranting reliable travel. Two micrometer screws each of them having measuring range of 0 to 25 mm permit the measuring table to be displaced in the directions X and Y. The range of movements of the carriage can be widened up to 75 mm in the X direction and up to 50mm in the Y direction with the use of gauge blocks. The rotary table has been provided with 360 degrees graduation and with a 60 minute vernier. The rotary motion is initiated by activation of knurled knob. Slots in the rotary table serve for fastening different accessories and completing elements. The sighting microscope has been fastened to column with a carrier arm. The carrier arm can be adjusted in height by means of a rack. The main lighting unit has been arranged in the rear of the cast base and equipped with projection lamp where rays are directed via stationary mounted mirror through table glass plate into the sighting microscope.

Measuring principle:

Tool Maker's Microscope is a precision Optical Microscope that consists of single or multiple objective lenses, which magnifies the object under observation and by the help of eyepiece lens the object is focused and viewed. A high precision micrometric X-Y stage and the Z axis travel are used to measure the three dimensions [Length (X), Width (Y), Depth (Z)]. The angle is measured with the help of a rotating stage and eyepiece graduation.

Applications:

The tool maker's microscope is an essential part of engineering inspection, measurement and calibration in metrology labs. Hence is used to the following,

- Examination of form tools, plate and template gauges, punches and dies, annular grooved and threaded hobs etc.
- Measurement of glass graticules and other surface marked parts.
- Elements of external thread forms of screw plug gauges, taps, worms and similar components.
- Shallow bores and recesses.

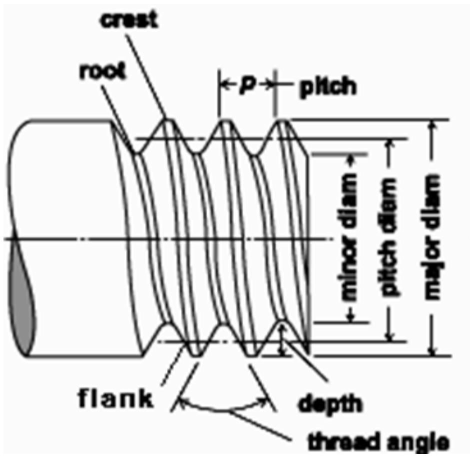

Fig.2 Screw thread nomenclature

Fig.3 Thread gauge

Procedure:

Switch on the projection lamp. Get familiar with the least count, linear and angular readings of the tool maker's microscope and nomenclature of the thread shown in Fig.2. Place the given specimen (thread gauge shown in Fig.3) on the glass table plate. Viewing through the eyepiece, rotate the knob for moving carrier arm on column to get the sharp image of the specimen kept on the glass plate. Position the specimen such that the table movement in the X direction is parallel to the direction of the pitch measurement. This is checked by ensuring the crosswire touching the tips (crests) of all the teeth during table movement in the X direction.

- *To measure the pitch:* Rotate micrometer head for X direction to touch the intersection point of the crosswire to the crest of the thread as seen from the eye piece. Note down the reading of the micrometer. Again rotate the micrometer head to move the specimen so that the next successive crest will come in contact with the crosswire intersection point. Note down the reading. The difference in reading will give the pitch.
- *To measure the depth of the thread:* Similarly rotate micrometer head for Y direction to touch the intersection point of the crosswire (along with the horizontal dotted line) to the root of the thread, as seen from the eye piece. Note down the reading of the micrometer. Again rotate the micrometer head to move the specimen so that the horizontal dotted line touches all the crests. Note down the reading. The difference in reading will give the depth of the thread.

- *To measure the thread angle:* Rotate the crosswire by the silver colour knob located behind the eye piece to match the flank of the thread with the cross wire. Make use of both the micrometer heads for X and Y direction to move the flank, and note down the angle by viewing through the lens below the eye piece. Now rotate only the crosswire to match the opposite flank and note down the angle. The difference will give the thread angle.
- Represent all the measured readings of the given specimen (thread gauge) with a neat diagram.

Observations:

Sl No.	Pitch *(p)*, mm	Height *(h)*, mm	Angle *(θ)*, deg
1			
2			
3			

Average *p*	Average *h*	Average *θ*

Questions:

1. What is the working principle of a tool maker's microscope?
2. What are the applications of the tool maker's microscope?

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Experiment No. 1B

MICROMETER CALIBRATION

Aim:

- To study various types of micrometers.
- To calibrate the given micrometers, using slip gauge as standard.
- To study use of combination set.

Apparatus:

- Set of Micrometers
- Set of Slip gauges
- Combination set

Theory:

A micrometer is a device used widely in mechanical engineering and machining for precision measurement, along with other metrological instruments such as dial calipers and vernier calipers. Micrometer screw-gauge is used for measuring accurately the diameter of a thin wire or the thickness of a sheet of metal. It consists of a U-shaped frame, fitted with a screwed spindle which is attached to a thimble, as shown in Fig. 1.

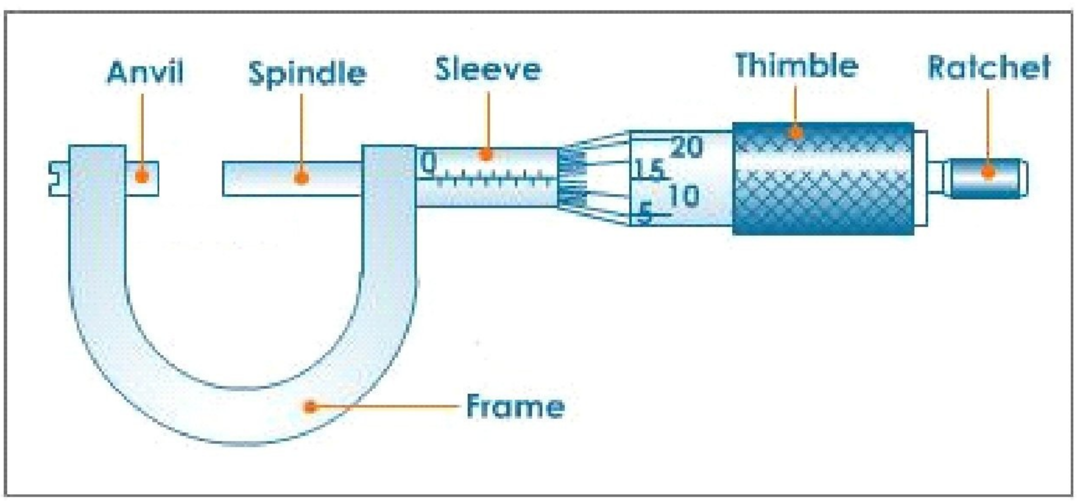

Fig. 1 Screw gauge

Micrometers use the principle of a screw to amplify small distances that are too small to measure directly into large rotations of the screw that are big enough to read from a scale. The accuracy of a micrometer derives from the accuracy of the threadform that is at its heart. The basic operating principles of a micrometer are as follows:

The amount of rotation of an accurately made screw can be directly and precisely correlated to a certain amount of axial movement (and vice versa), through the constant known as the screw's pitch (for single start screw thread). A screw's pitch is the distance it moves forward or backward axially with one complete turn. The screw has a known pitch such as 0.5 mm. Hence in this case, for one revolution of the screw the spindle moves axially by 0.5 mm. This movement of the spindle is shown on an engraved linear millimeter scale on the sleeve. On the thimble there is a circular scale which is divided into 50 or 100 equal parts.

When the anvil and spindle end are brought in contact, the edge of the circular scale should be at the zero of the sleeve (linear scale) and the zero of the circular scale should be opposite to the datum line of the sleeve. If the zero is not coinciding with the datum line, there will be a positive or negative zero error as shown in Fig. 2.

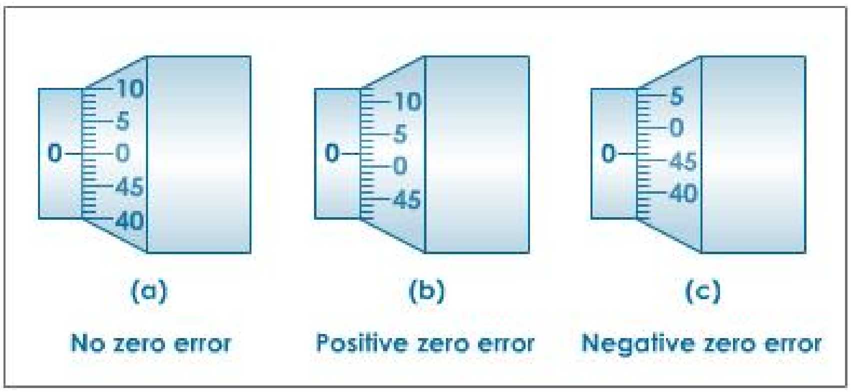

Fig. 2 Zero error in case of screw gauge

The least count of the micrometer screw can be calculated using the formula given below:

Least count =Pitch/ Number of divisions on the circular scale =0.5 mm/50 =0.01 mm

- As an example, to determine the diameter of a wire, the wire is to be placed between the anvil and spindle end, and the thimble is rotated till the wire is firmly held between the anvil and the spindle. The ratchet is provided to avoid excessive pressure on the wire. It prevents the spindle from further movement. The diameter of the wire could be determined from the reading as shown in Figure 3.

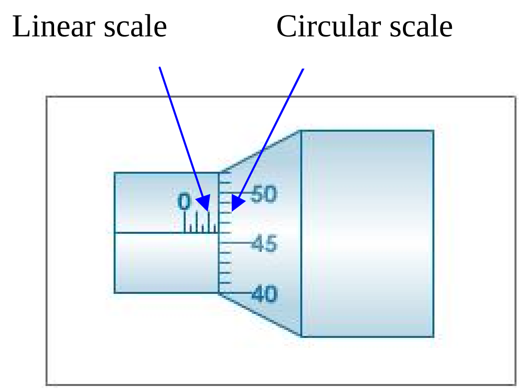

Fig. 3 Linear and circular scales of screw gauge

- Reading = Linear scale reading + (coinciding cicular scale * Least count)
  = 2.5 mm+ (46*0.01) = 2.96 mm (for Figure 3)

Accuracy of the measured reading is the degree of veracity while precision is the degree of reproducibility. The analogy may be used to explain the difference between accuracy and precision is the target comparison. In this analogy, repeated measurements are compared to arrows that are shot at a target as shown in Figure 4. Accuracy describes the closeness of arrows to the bullseye at the target center. Arrows that strike closer to the bullseye are considered more accurate. The closer a system's measurements to the accepted value, the more accurate the system is considered to be.

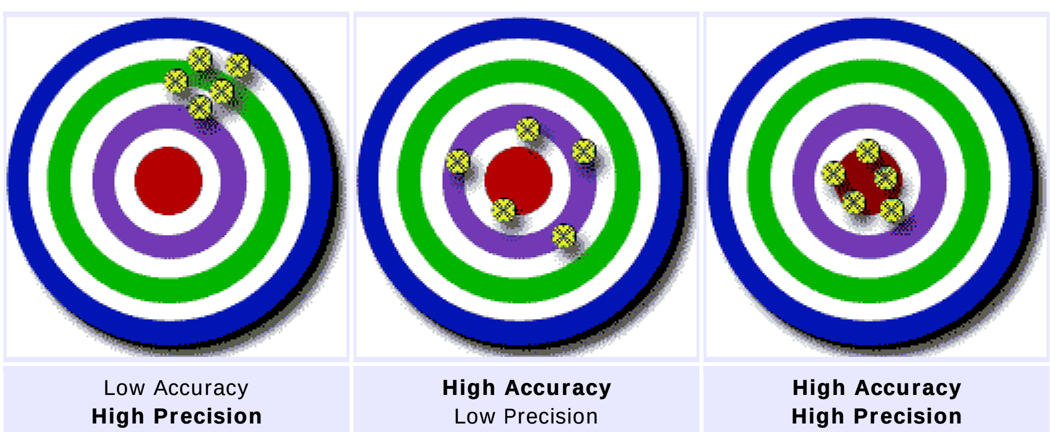

Fig. 4 Difference between accuracy and precision

Gauge block or slip gauge is a precision ground and lapped length measuring standard. It is used as a reference for the setting of measuring equipment used in machine shops, such as micrometers, sine bars, and dial indicators (when used in calibration or inspection role).

These gauges consists of a set of steel blocks, each of which has one pair of opposite faces lapped flat and parallel accurately to a few millionths of an inch. They are used to check the accuracy of workshop and similar gauges, which in use arc subjected to wearing action; slip gauges should never be used as ordinary measuring gauges, but as reference or master standards. They arc generally employed in connection with comparator instruments when workshop gauges have to be checked.

The slip gauges are supplied in sets, the number in each set varying according to the purpose in view. The most widely employed set consists of 81 gauges of differing thickness made up as fallows:

- Nine pieces with range of 0.1 001 to 0.1009 in. in steps of 0.0001 in.
- Forty-nine pieces with a range of 0.101 to 0.149 in. in steps of 0.001 in.
- Nineteen pieces with a range of 0.05 to 0.95 in. in steps of 0.05 in.
- Four pieces of parallel width, 1 in, 2 in, 3 in, and 4 in. respectively.

Metric unit sets of 103 pieces are made up as follows:

- Forty-nine pieces with a range of 1.01 to 1.09 mm. in steps of 0.01 mm.
- Forty-nine pieces with a range of 0.50 to 24.50 mm. In steps of 0.50 mm.
- Four pieces of25, 50, 75, and 100 mm respectively.
- One extra piece of 1.005 mm.

Smaller sets of 76, 56, 48, and 31 pieces are also supplied in the metric sizes, and sets of 49, 41, 35 and 28 in English sizes.

Before using these gauges they should be wiped with a piece of soft linen cloth. If the presence of any grease is suspected, or in the case of new gauges having a protective coating, the surface should be wiped over with a piece of soft linen moistened with benzole or petrol. The removal of any grease including that from the fingers is important since; otherwise, dirt may be picked up more easily. In a dustless atmosphere however, a trace of grease on the surface assists in obtaining a satisfactory wringing action.

Fingering of slip gauges should be avoided as much as possible since it tends to promote tarnishing and thermal expansion effects. A change of only in temperature causes a length change of about 1 /1, 00, 000 in. per inch thickness of gauge.

It is important for fine precision measurements to use slip gauges in a room thermo-statistically controlled at 20^0 C and to allow, the work and the gauges sufficient time to attain this temperature if taken into heat-regulated room. Gauges after use should be wiped off carefully at once and returned to their storage case, closing the lid of the latter as soon as possible.

Wringing is the process of sliding two blocks together so that their faces lightly bond. When combined with a very light film of oil, this action excludes any air from the gap between the two blocks. The alignment of the ultra-smooth surfaces in this manner permits molecular attraction to occur between the blocks, and forms a very strong bond between the blocks along with no discernible alteration to the stack’s overall dimensions.

- The recommended procedure for wringing a pair of slip gauges together is as follows and shown in the Fig. 5.
  - First clean the surfaces as desired previously, and then place one gauge centrally across the other gauge at right angles to form a symmetrical cross. Finally rotate the upper gauge over the lower one to its final coincident position. This method results in appreciably less rubbing action than the upper gauge is slid lengthwise over the lower one.

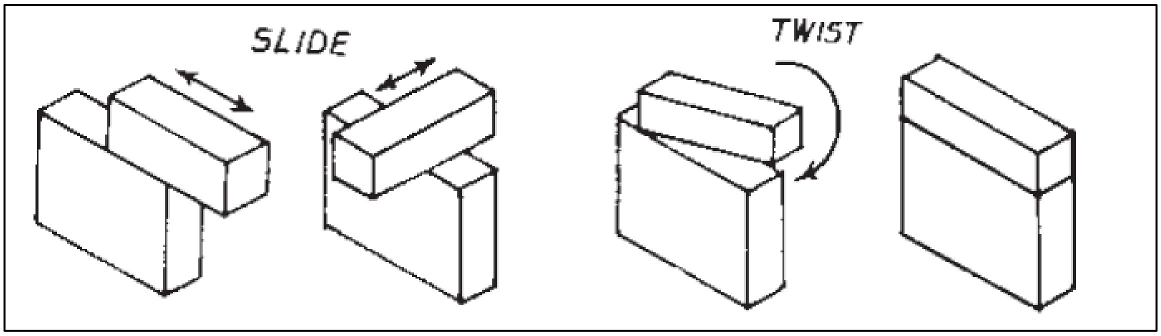

Fig. 5 Wringing of slip gauges

Procedure:

For calibration of micrometers

1. Check the range of measurement of the micrometer.
2. Note down zero error of the micrometer, if any.
3. Select a number of slip gauge combinations.
4. Measure each slip gauge combination with the micrometer and note down micrometer reading (M) and slip gauge combination length (G) in tabular form.
5. Plot a calibration chart for the micrometer taking M on the X-axis and (M-G) on the Y-axis.
6. Repeat the steps l-5 for other micrometers.

Precautions:

! While making slip gauge combination, do the wringing correctly, so that no foreign particles are entrapped.
! While taking micrometer reading, care should be taken to clamp the spindle in position, before taking it away from the block, as due to friction the Spindle will rotate and give a wrong reading.
! Turn the spindle always in the clockwise direction to avoid backlash error.

Observations & Result:

Micrometer Details	Sl. No. of reading	Slip Gauge reading (G)	Micrometer Reading (M)	Error (M-G)
Range: No.: Make: Zero error:	1 2 3			

Discussion:

Sources of measurement errors

Questions:

1. Discuss functions and principle of ratchet drive in case of a micrometer.
2. Why does zero error occur in a micrometer?
3. Differentiate among terms accuracy, precision, sensitivity, & readability.
4. When is an instrument required to be calibrated?
5. What is the use of calibration chart?
6. What do you mean by Protector Slip Gauge?
7. What is wringing? How is it done?
8. Sketch the type of anvil required for measuring the thickness of a paper, chip thickness?