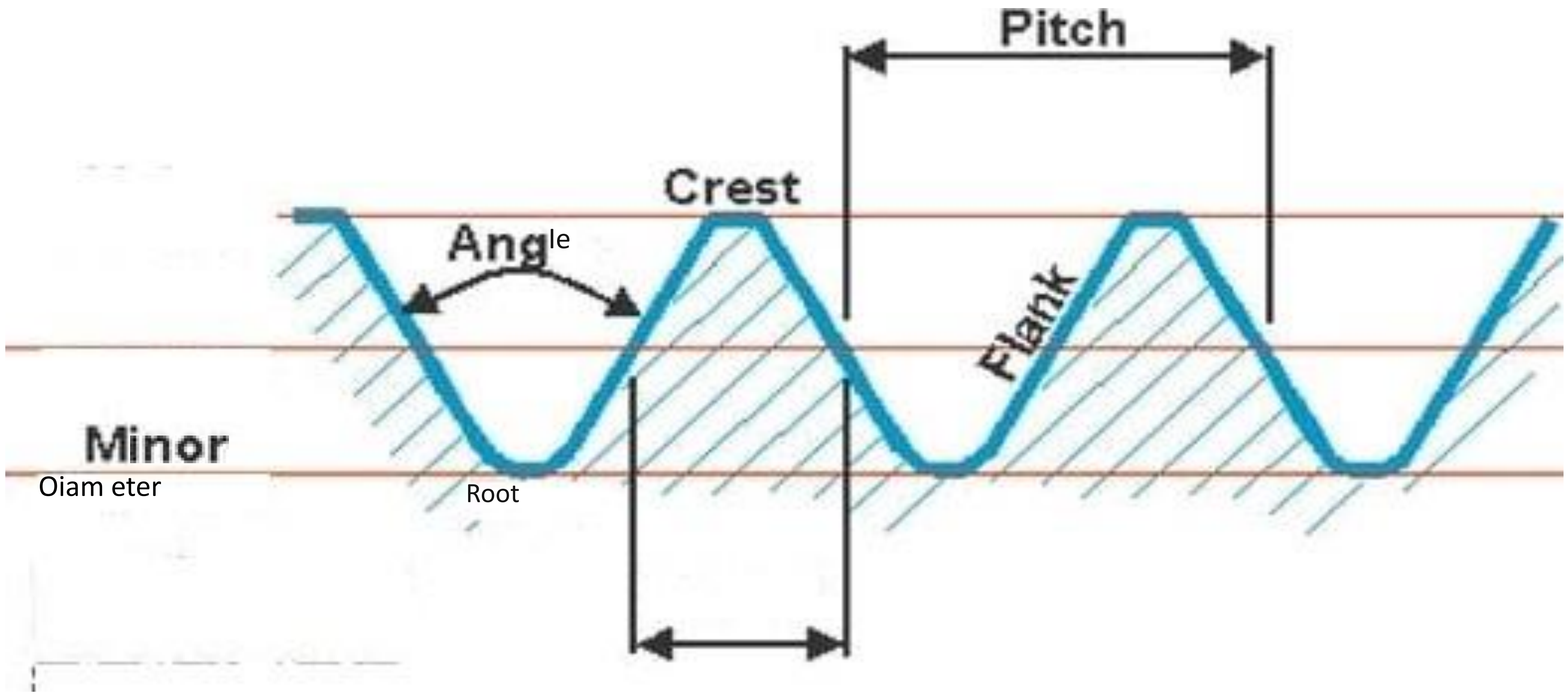
MEASUREMENT OF SCREW THREADS AND GEARS

SCREW THREAD MEASUREMENT:

Screw threads have to perform two functions namely

- Transmission of power and motion
- It converts rotary motion into linear motion.
- It prevents linear motion without the corresponding rotation.
- Acts as a temporary fastener
- External threads
- Internal thread

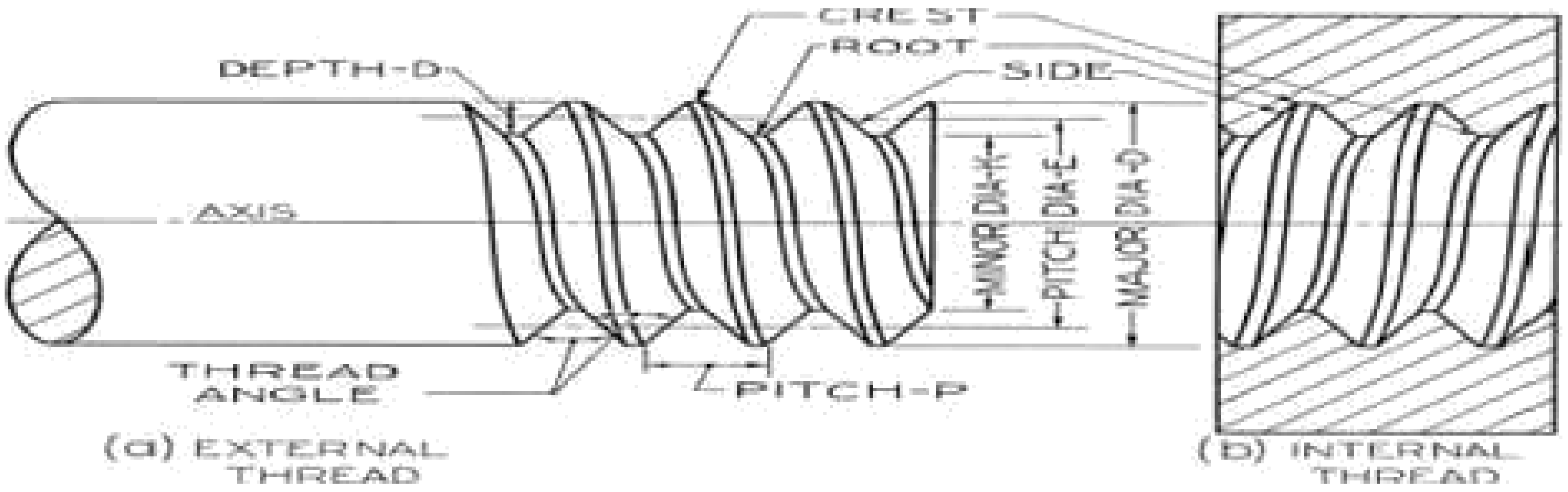
Terminology of screw threads



Screw thread- definition

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

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



Terminology of screw threads:

Screw thread

Crest

Root

Flank

Depth of thread

Lead

Pitch

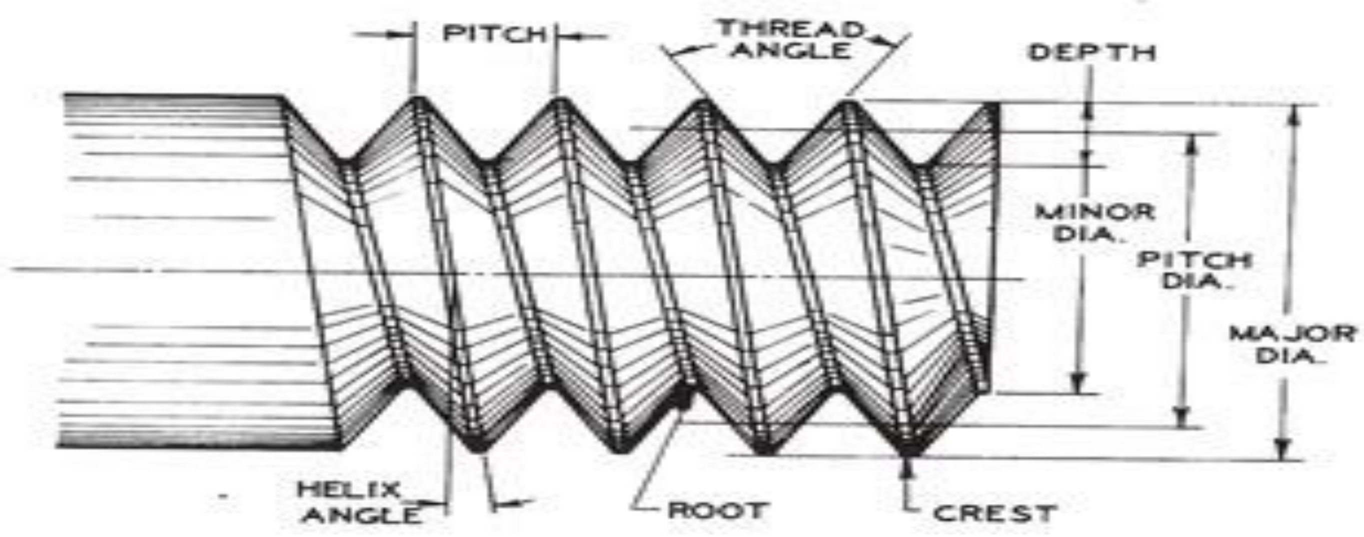
Helix angle

Flank angle

Included angle

Major diameter

Minor diameter



Types of Screw Thread

ISO Metric Screw Threads

Taper Pipe Threads Whitworth Form

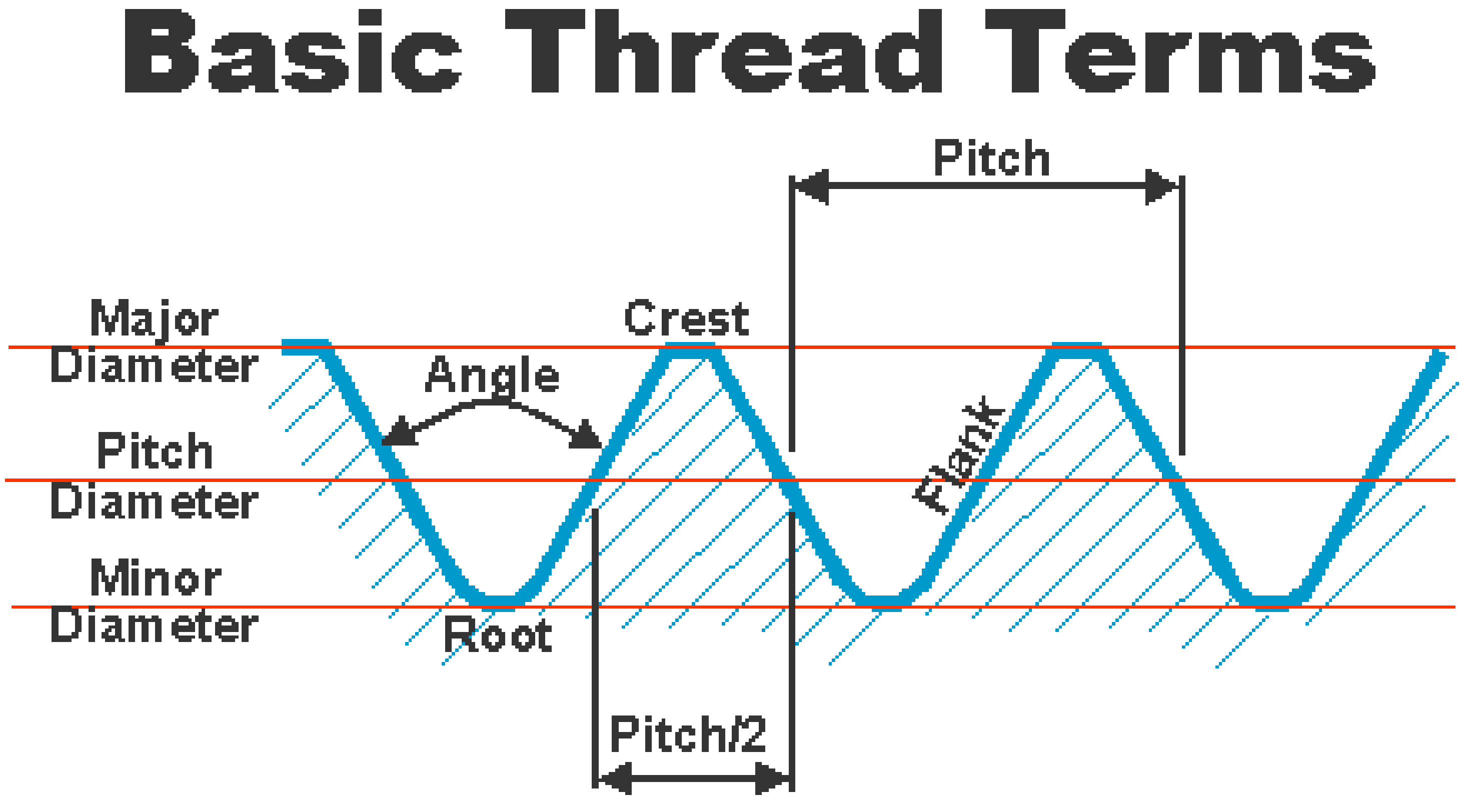
ACME Threads

Trapezoidal Thread

Buttress Screw Thread

Round Threads

Basic Thread Terms



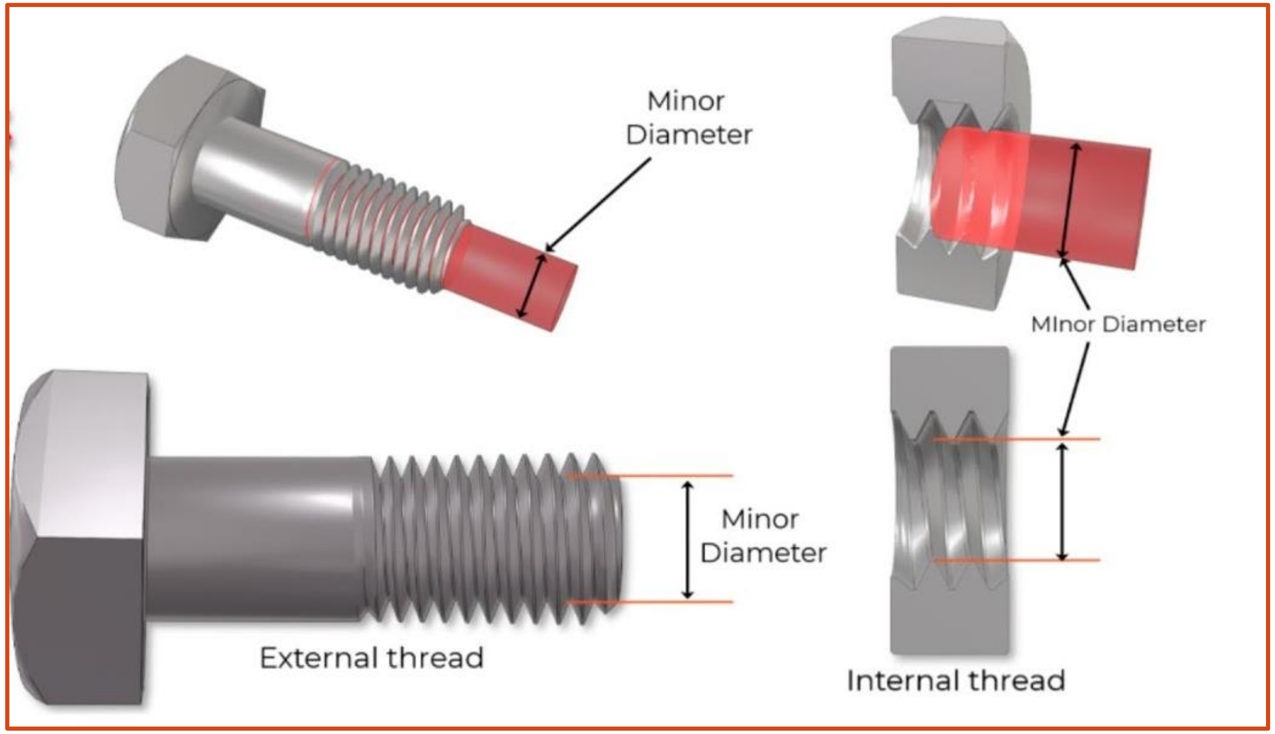
Types of thread

External thread: a thread formed on outside of a work piece is known as external thread.

Example: on bolts or studs etc.

Internal thread: a thread formed on inside of a work piece is known as internal thread.

Example: on a nut or female screw gauge.



USES OF SCREW THREADS

- To hold the parts together (as Fasteners)

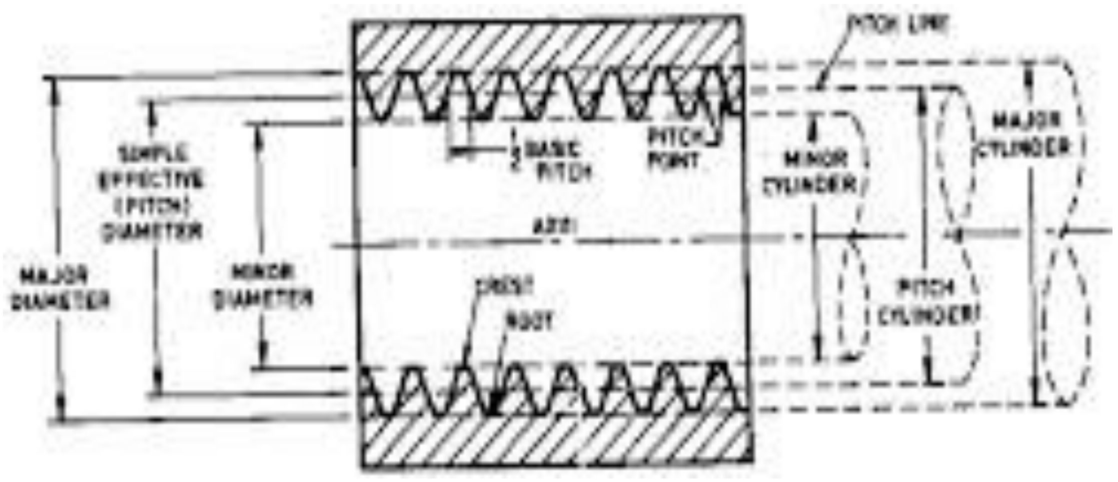
  Ex : V-threads

- To transmit motion and power

  Ex : Screw threads
  ACME threads

SCREW THREAD TERMINOLOGY

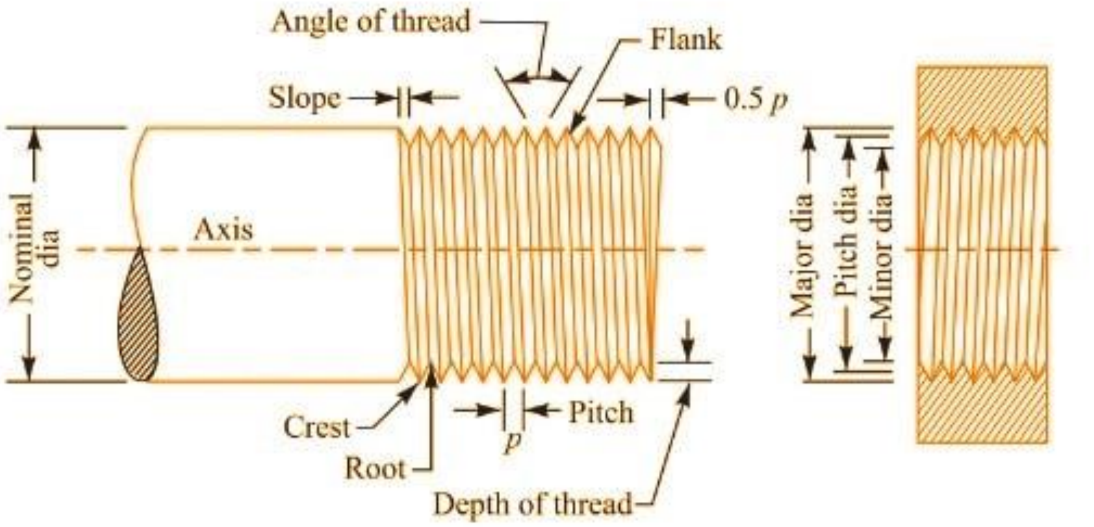
SCREW THREAD TERMINOLOGY

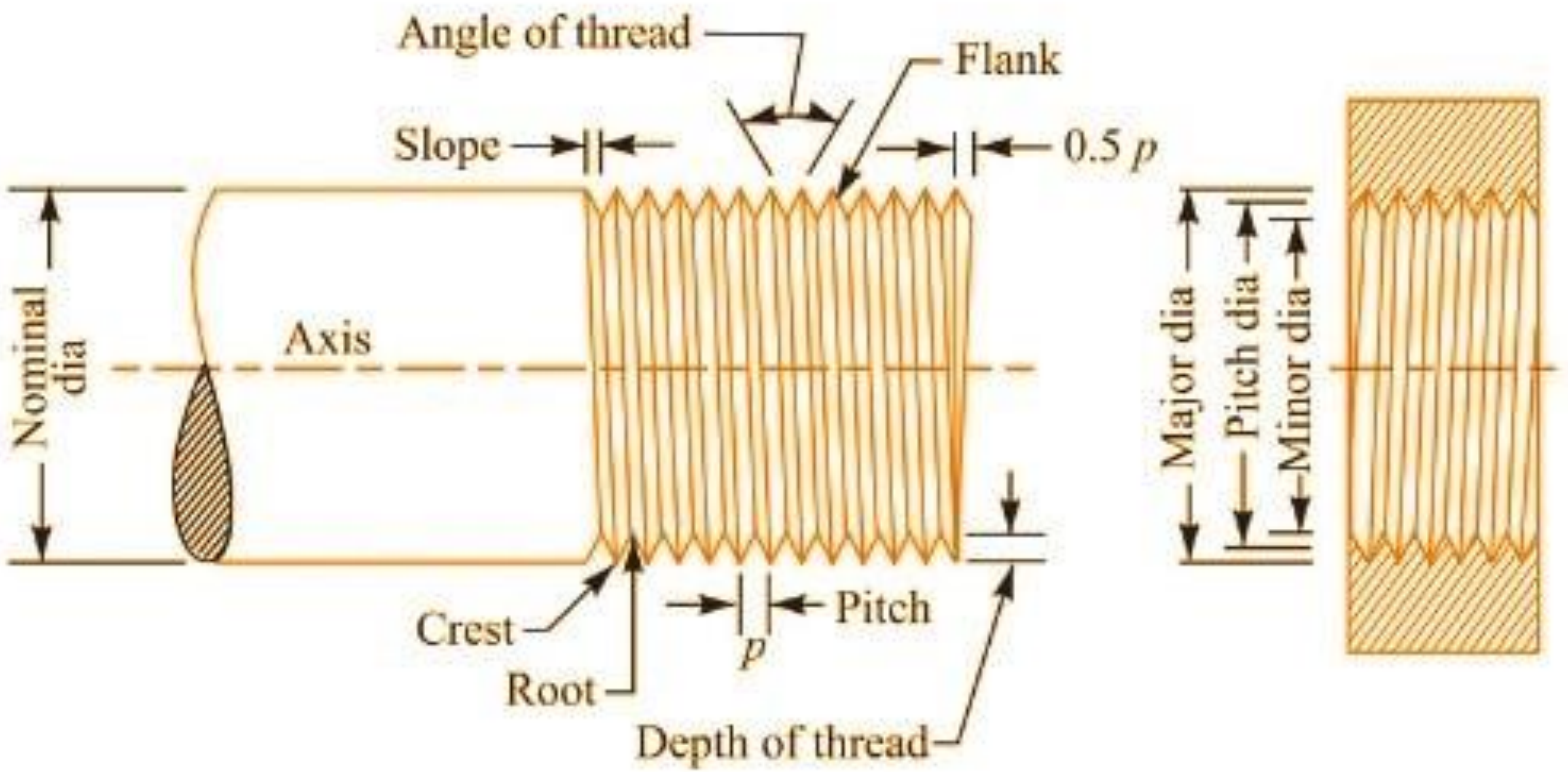


- **Thread Form:** Cross section of thread cut by a plane containing the axis
- **Major/ Nominal Diameter**: Diameter of an imaginary cylinder, co- axial with the screw, which just touches the crests of an external thread or roots of an internal threads.
- **Minor/ Root Diameter:** Diameter of an imaginary cylinder, co-axial with the screw which just touches the roots of an external thread or the crest of an internal thread.

SCREW THREAD TERMINOLOGY

- **Effective/ Pitch Diameter:** Diameter of an imaginary cylinder coaxial with the axis of the thread and intersects the flanks of the thread such that width of the threads & width of spaces between threads are equal.
- **Depth of thread**: Distance between crest & root measured perpendicular to axis of screw
- **Pitch:** Distance from a point on a thread to a corresponding point on the next thread measured parallel to the axis.
- **Addendum**: Distance between the crest and the pitch line measured perpendicular to axis of the screw.





Angle of thread
Flank
Slope
0.5 p
Nominal dia
Axis
Major dia
Pitch dia
Minor dia
Crest
Root
p
Pitch
Depth of thread

SCREW THREAD TERMINOLOGY

- **Dedendum:** Distance between the pitch line& the root measured perpendicular to axis of the screw
- **Lead:** Distance advanced by a screw in one turn.
  - For a single start threads: **lead = pitch**,
  - For double start: **lead=2 x pitch**, & so on
- **Flank:** Thread surface that connects crest with root.
- **Flank angle:** It is half the included angle of the thread.
- **Angle of thread:** Included angle between sides of thread measured in axial plane
- **Helix Angle:** Angle that the thread makes with the plane perpendicular to the thread axis

Elements of Threads

Parameter	Equipment/ Method
Major diameter	Bench Micrometer
Minor diameter	Bench Micrometer
Effective or Pitch diameter	Screw thread micrometer Two or three wire method Floating carriage micrometer
Pitch	Screw pitch gauge Pitch error testing machine
Thread angle and form	Optical profile projector Pin measurement

Measurement Using Bench Micrometre

- Used as comparator for measuring the major diameter.
- Fiducial Indicator ensures measurements at same pressure
- It has a micrometer head with a Vernier scale (accuracy of 0.002mm).

Procedure:

1. Reading is taken with a calibrated cylinder between anvils (R1)
2. The cylinder is replaced by the threaded work piece and the new reading is taken (R2)

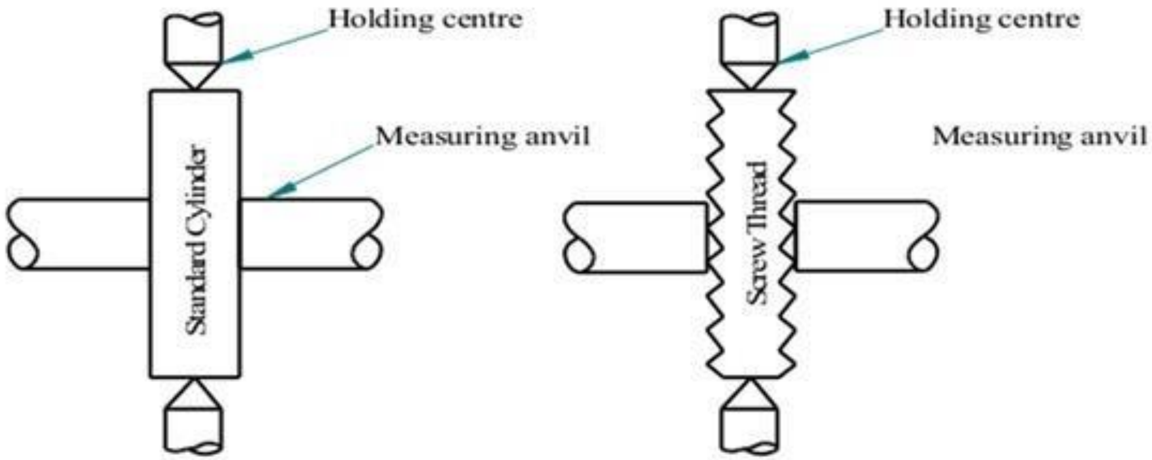
Thus, Major diameter D = S + (R1 - R2)

Where S = Size of setting Gauge

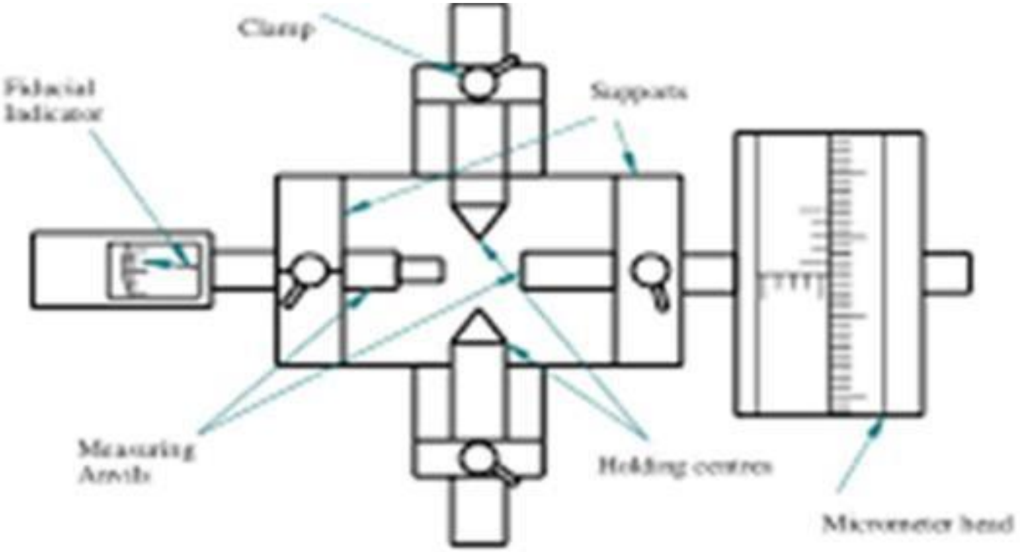
Bench Micrometer

Bench Micrometre

Measurement of Major Diameter using Floating Carriage Micrometer



Measurement of Major diameter



Measurement of Minor Diameter

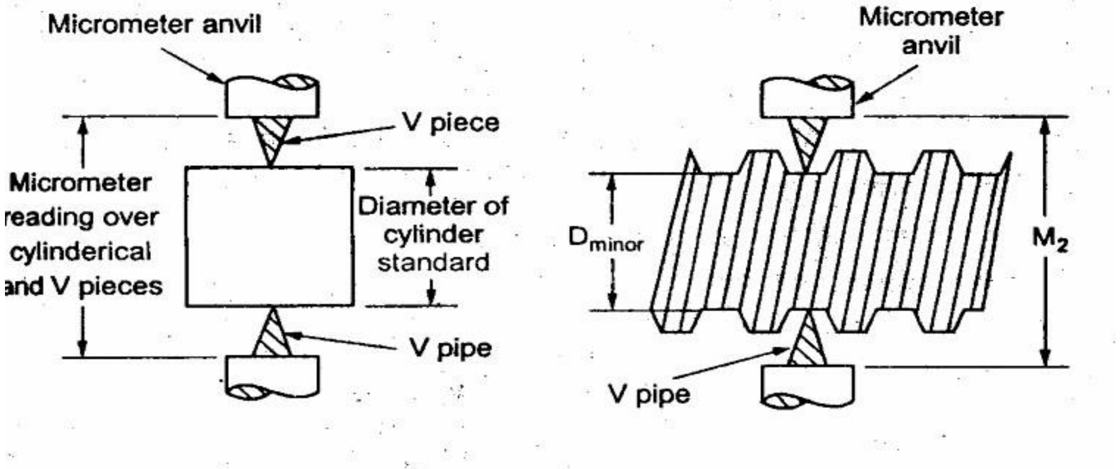
- Measured using floating carriage micrometer, used as a comparator
- Small V pieces made of hardened steel make contact with the root of the thread.
- V pieces are given a suitable radius at the end
- Major diameter of internal thread = D + (R2 – R1)

Where:

D = Diameter of standard cylinder

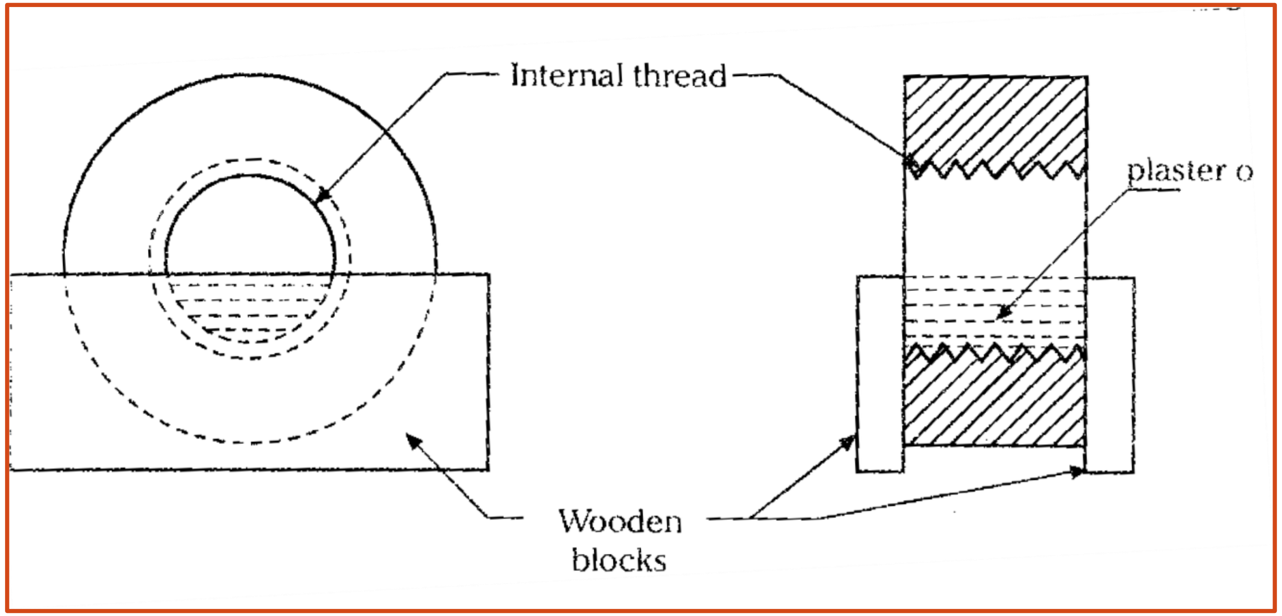
R_2 = Micrometer reading on thread

R_1 = Micrometer reading on cylindrical gauge



Anvils being set　　*Thread being measured*

Measurement of Major Diameter of an Internal Thread



- Major diameter is obtained by measuring a cast of the thread.
- Major diameter of internal thread = $D \pm (R_2 - R_1)$

Where:

D= Diameter of standard cylinder

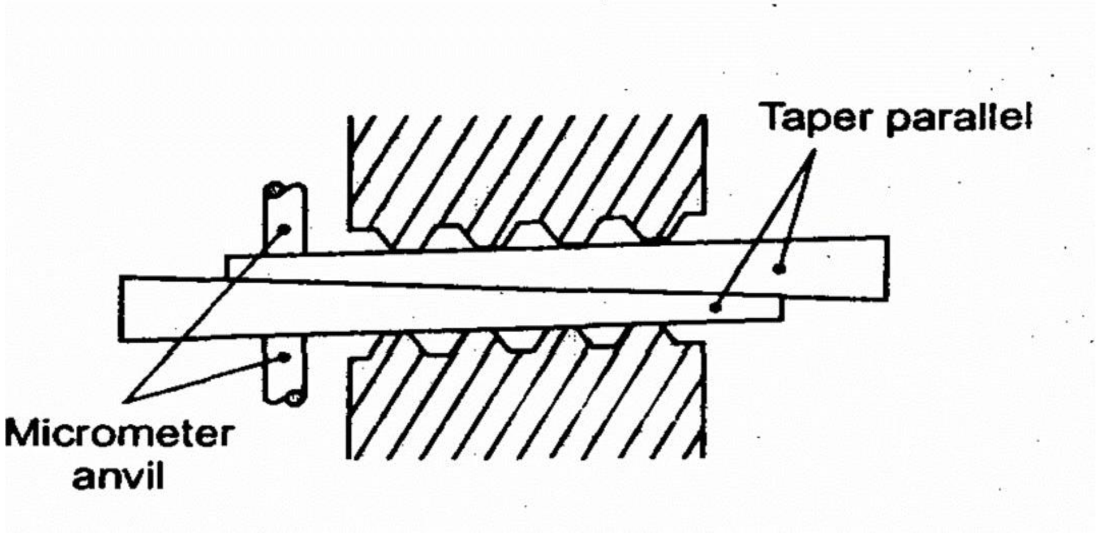
R_1 = Thread reading

R_2 = Dial indicator reading on standard

Measurement of Minor Diameter of Internal Threads

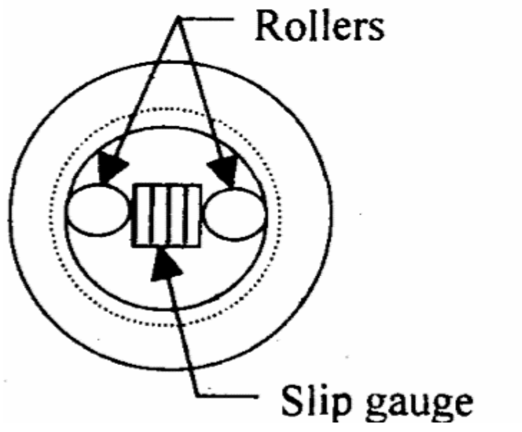
Using Taper parallels

- Used for diameters less than 200mm.
- Taper parallels are pairs of wedges having parallel outer edges.



Using Rollers

- Used for more than 200mm diameter.
- Precision rollers are inserted inside the thread and proper slip gauge(s) are inserted between the rollers.
- The minor diameter is then the length of slip gauges plus twice the diameter of roller



Pitch Errors

Types of Pitch Errors:

- **Progressive errors:**

  The result of constant but incorrect tool work velocity

- **Periodic Pitch Errors:**

  Caused by changes in tool work velocity

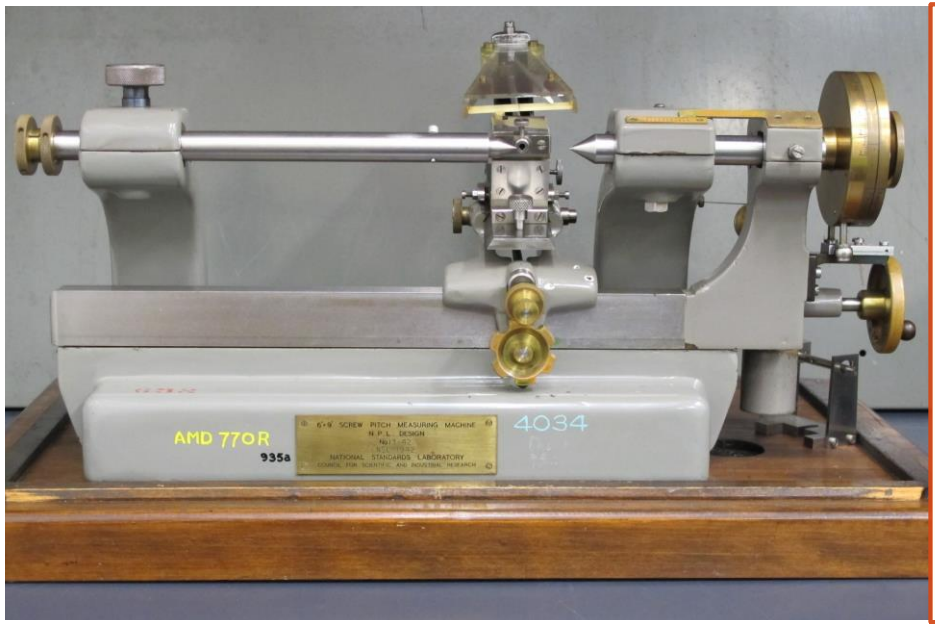
- **Drunken threads:**

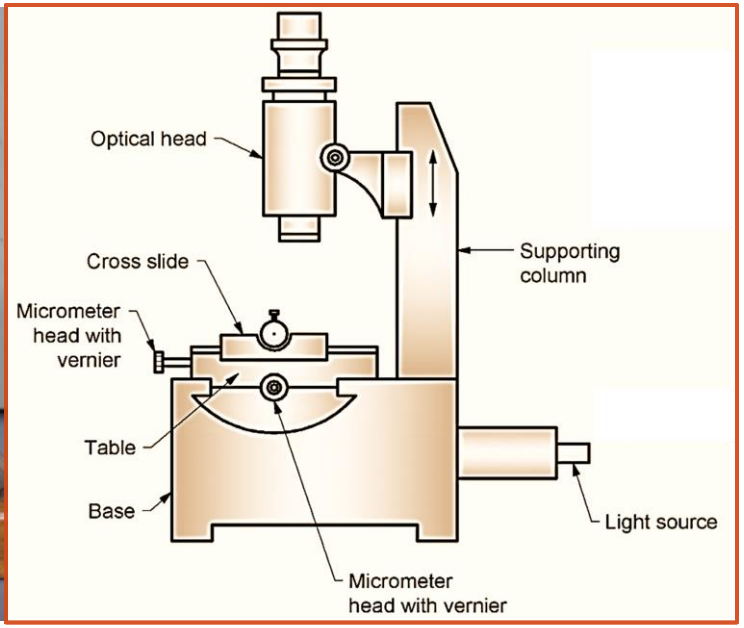
  Thread is not a true helix, it is a curve instead of a straight line

  Generally occur at an interval of one pitch

Methods of Measurement:

- Pitch measuring Machine
- Tool makers microscope
- Screw pitch gauge





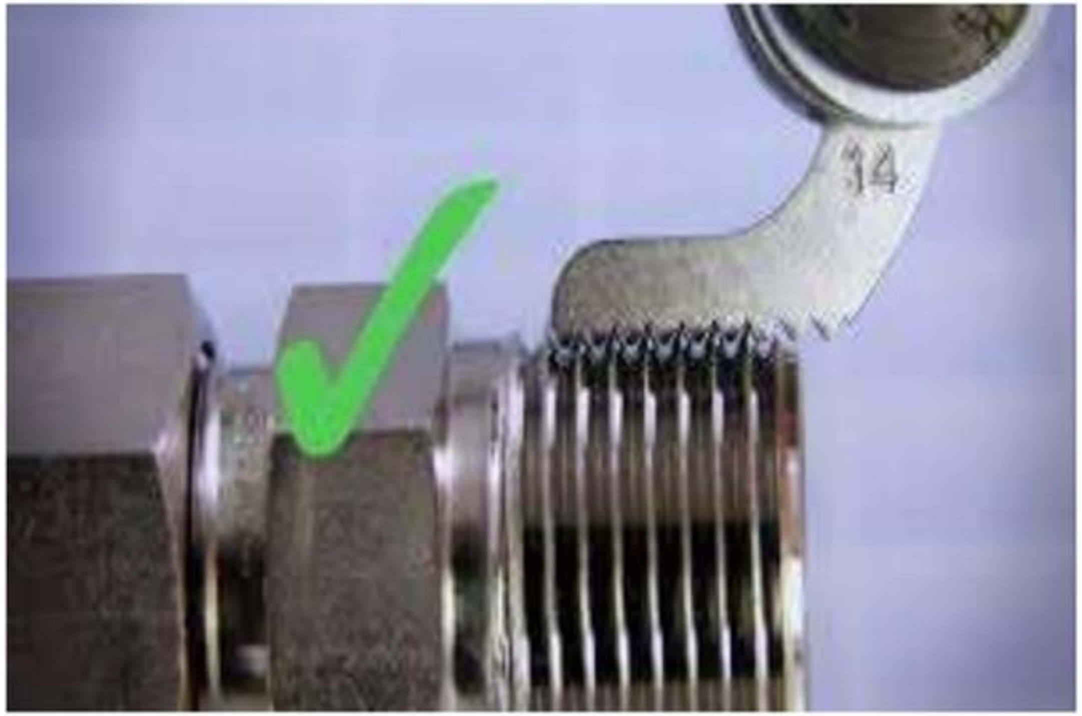
Pitch measuring Machine

Tool makers microscope

Screw pitch gauge

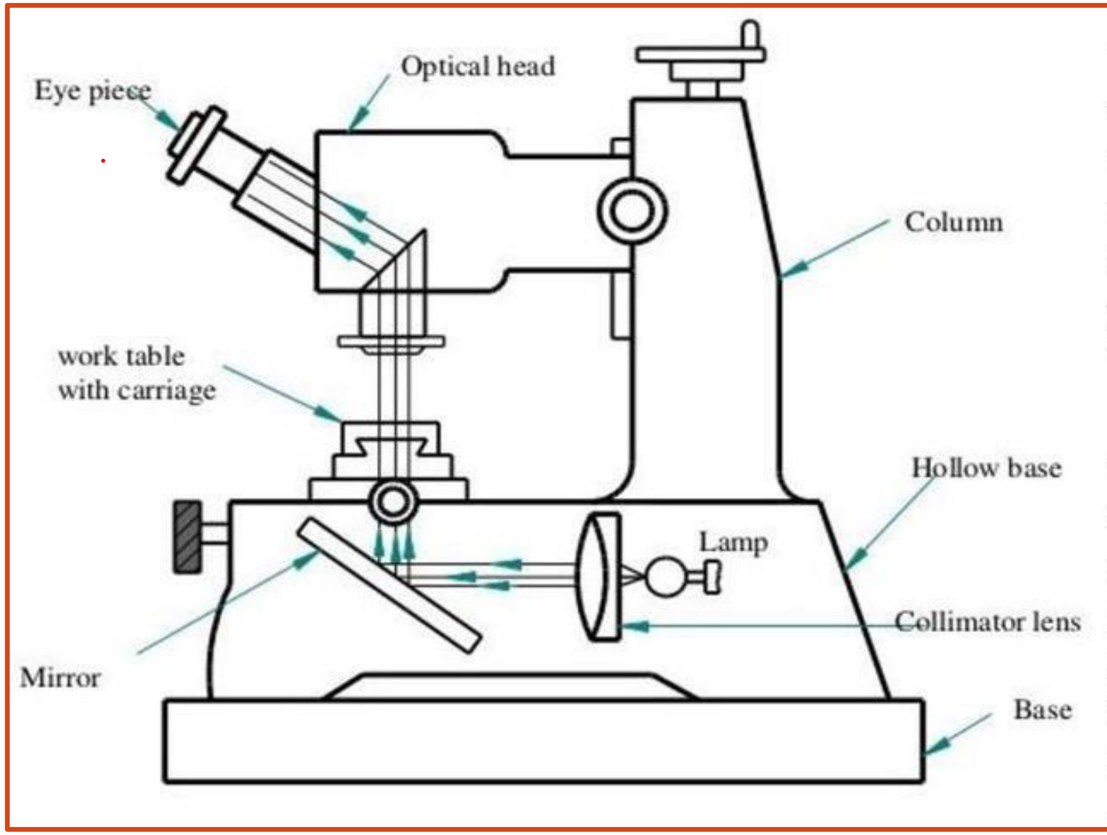
SCREW PITCH GAUGE

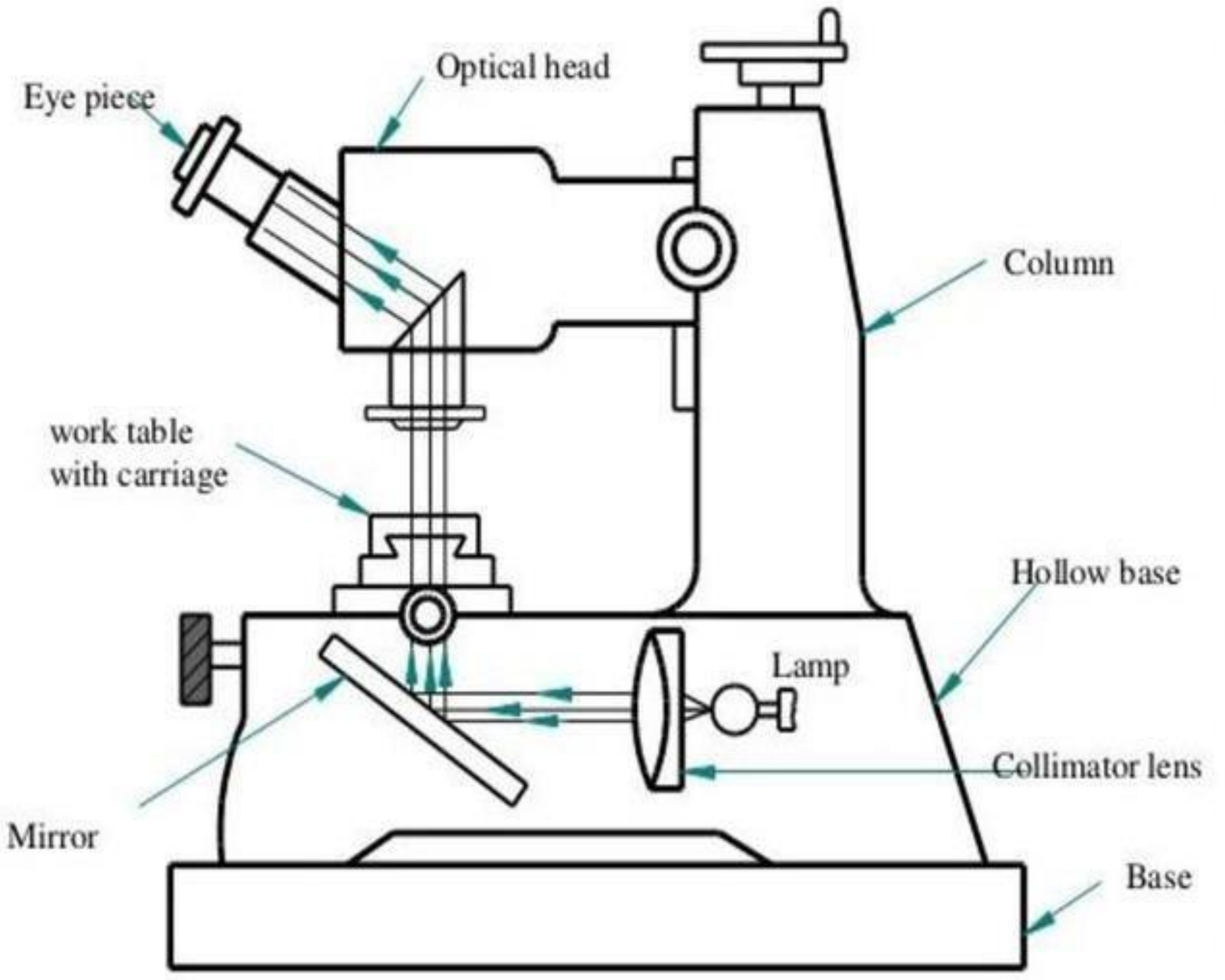
- Screw pitch gauges are used in picking out a required screw and for checking the pitch of the screw threads.
- They consist of a number of flat blades which are cut out to a given pitch and pivoted in a holder.
- Each blade is stamped with the pitch or number of thread per inch and the holder bears an identifying number designing the thread it is intended for.



Tool Makers Microscope

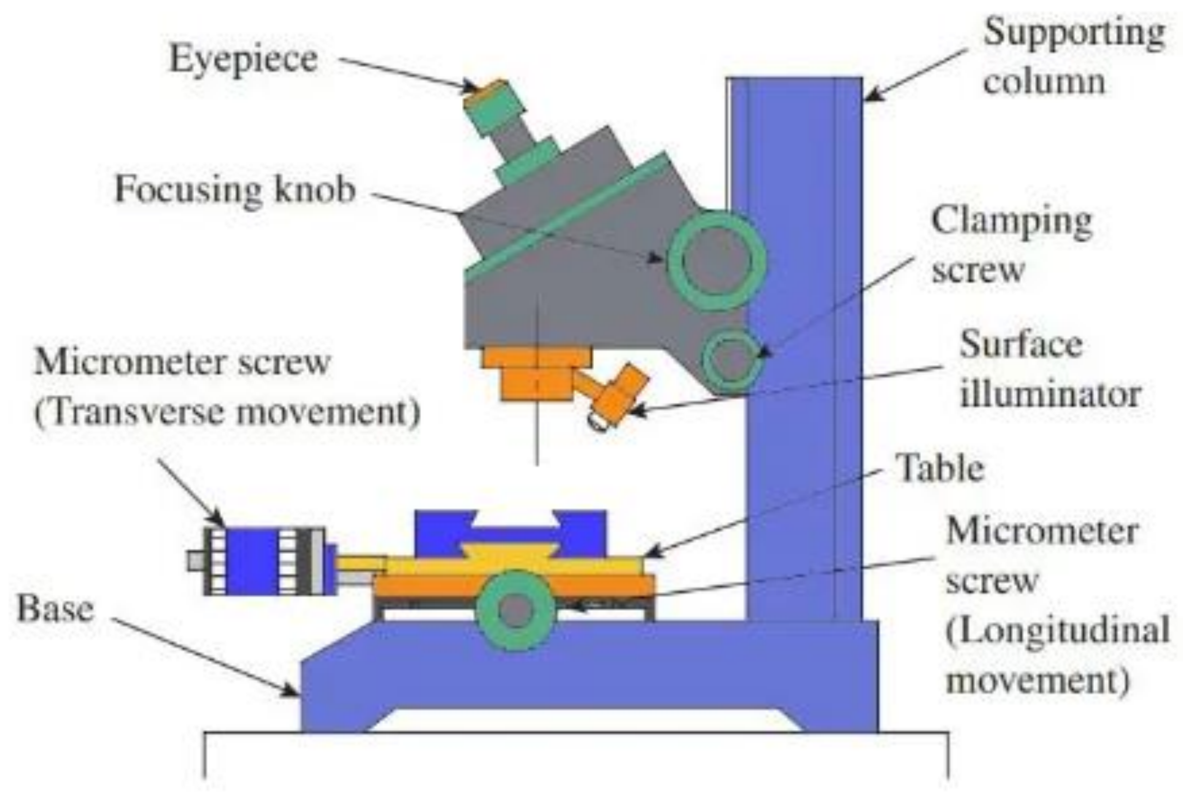
- Work piece is mounted on a glass plate.
- A light source provides horizontal beam of light which is reflected from a mirror by 90° upwards towards the table.
- Image of the outline of contour of the work piece passes through the objective of the optical head.
- The image is projected on a ground glass screen by a system of prisms. The screen can be rotated through 360°.




Optical head
Eye piece
Column
work table
with carriage
Hollow base
Lamp
Collimator lens
Mirror
Base

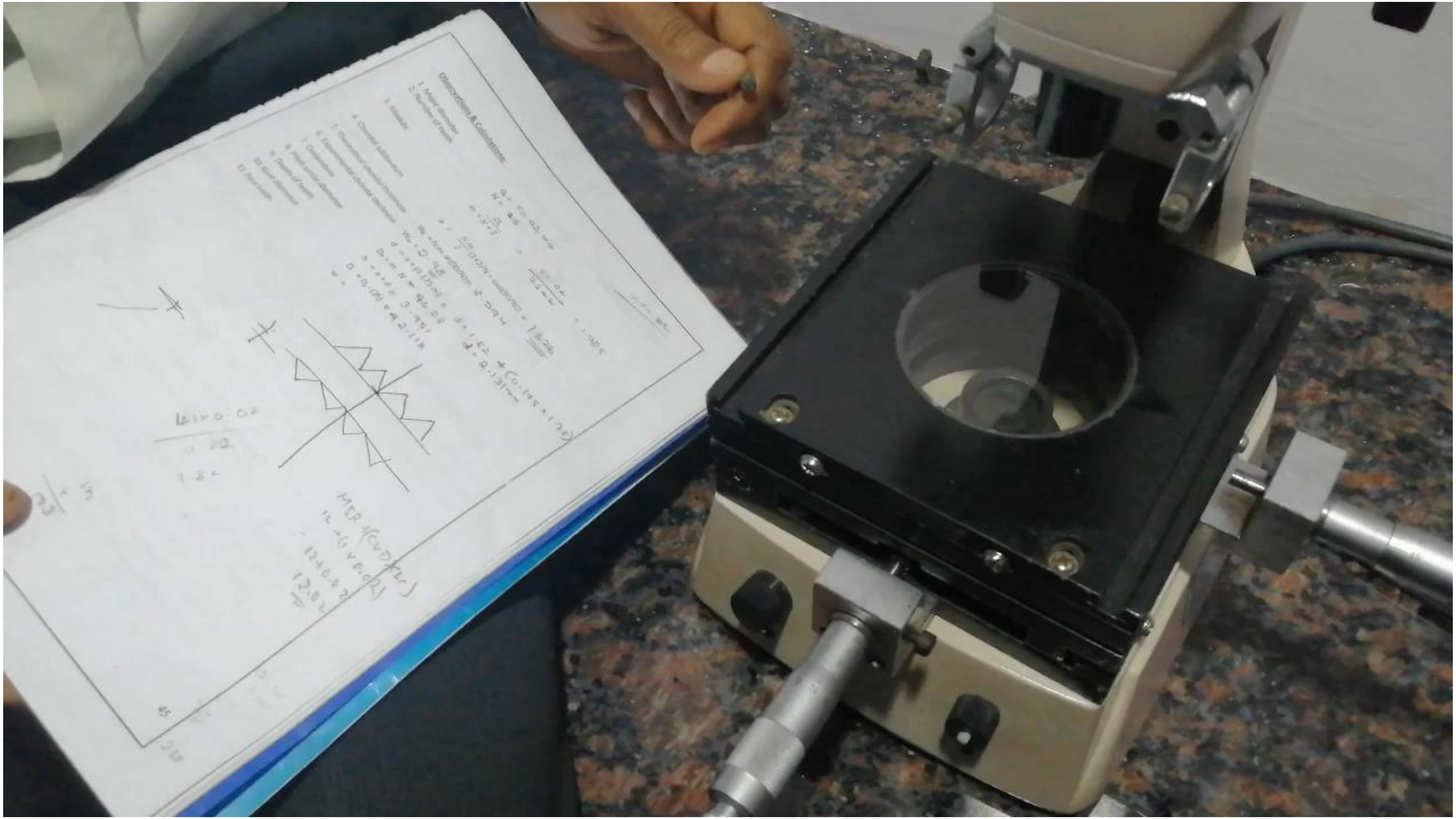
Tool Makers Microscope

- Measurements are made by means of cross lines engraved on the ground glass screen.
- Different types of graduated screens and eyepieces are used



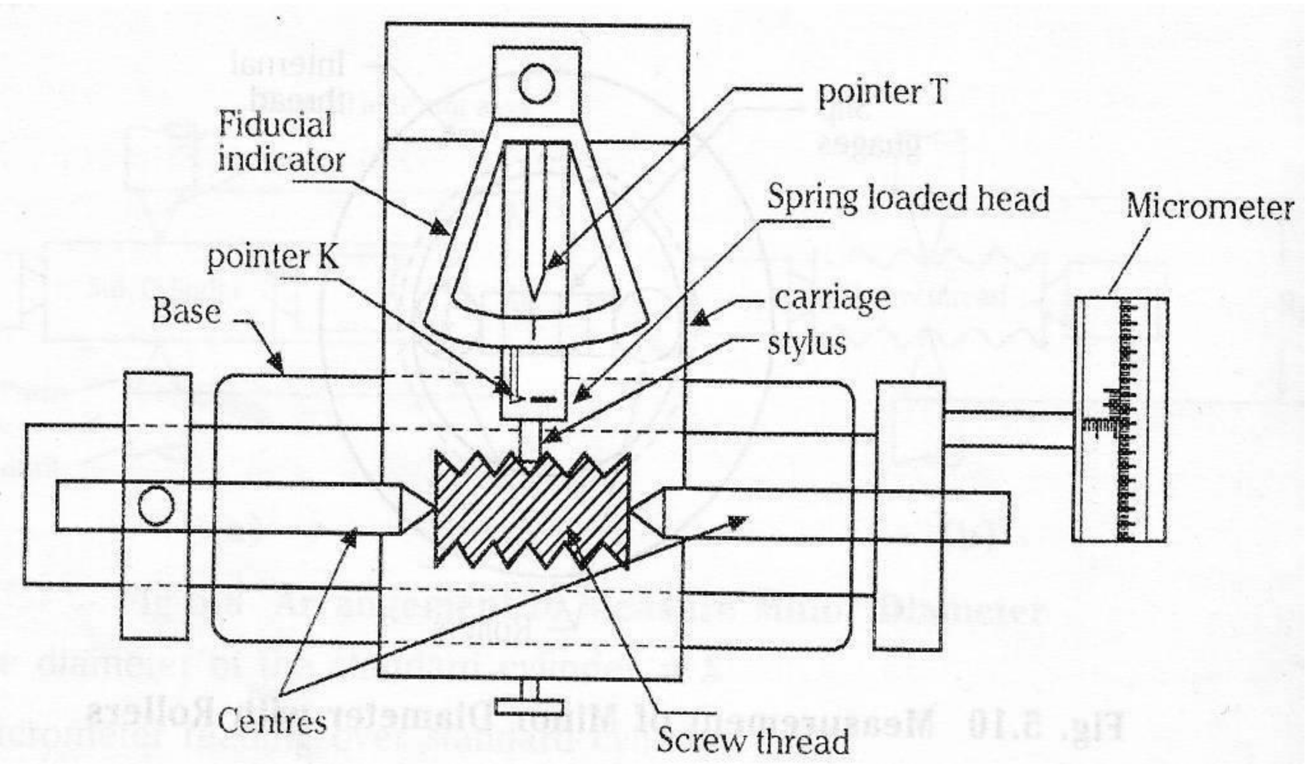
Tool maker's microscope

Tool Makers Microscope



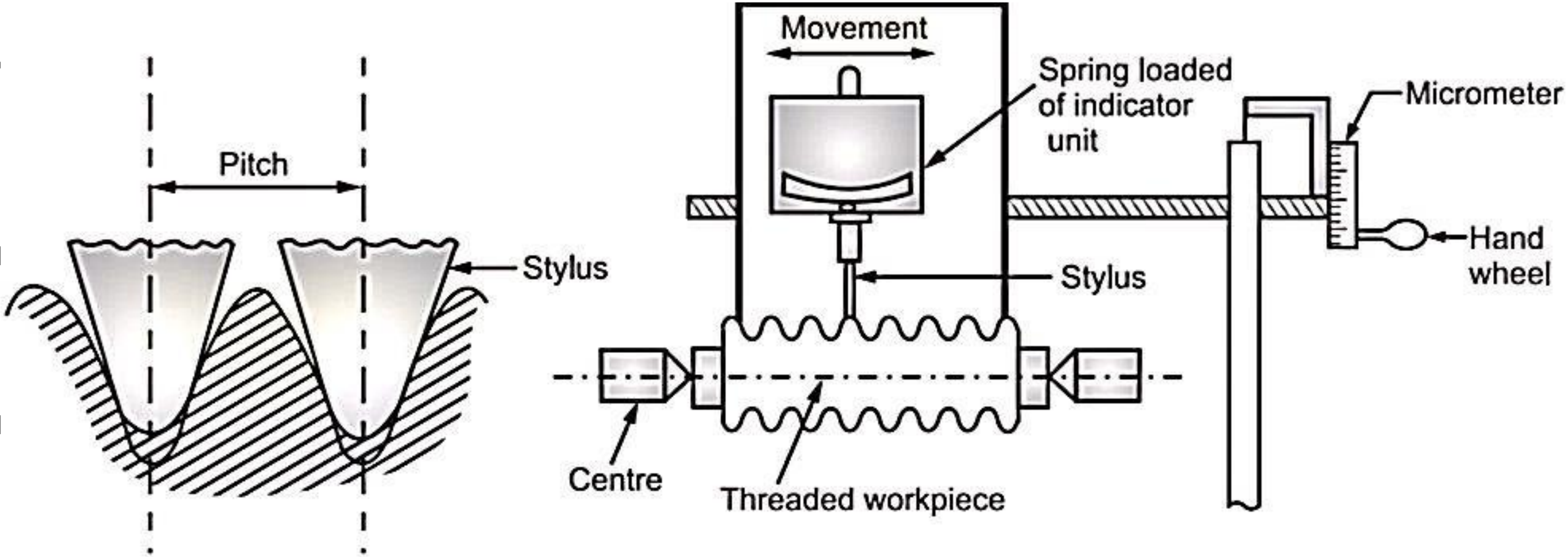
Pitch Measuring Machine

- Spring loaded head permits the stylus to move up the flank of the thread and down into the next space as it is moved along
- Accurate positioning of the stylus between the two flanks is obtained by ensuring that the pointer T is always opposite to its index mark when readings are taken.



Pitch Measuring Machine

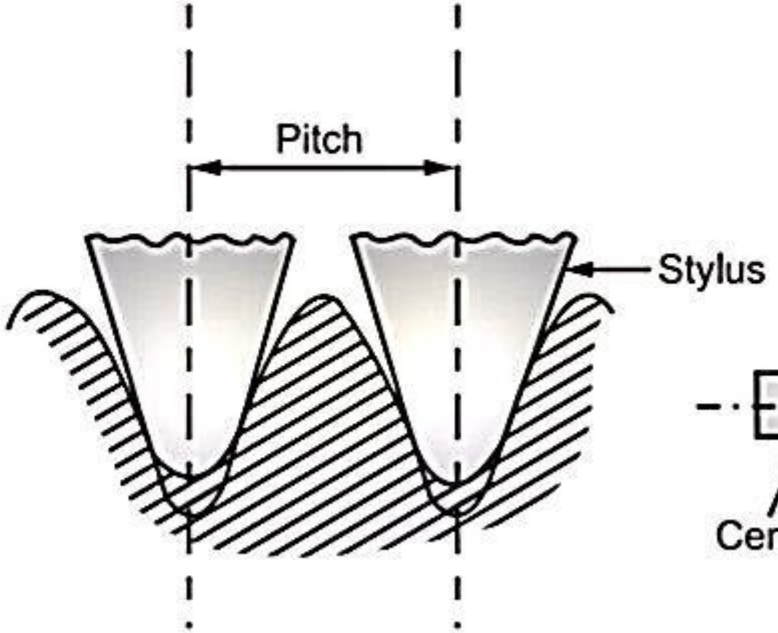
Procedure:



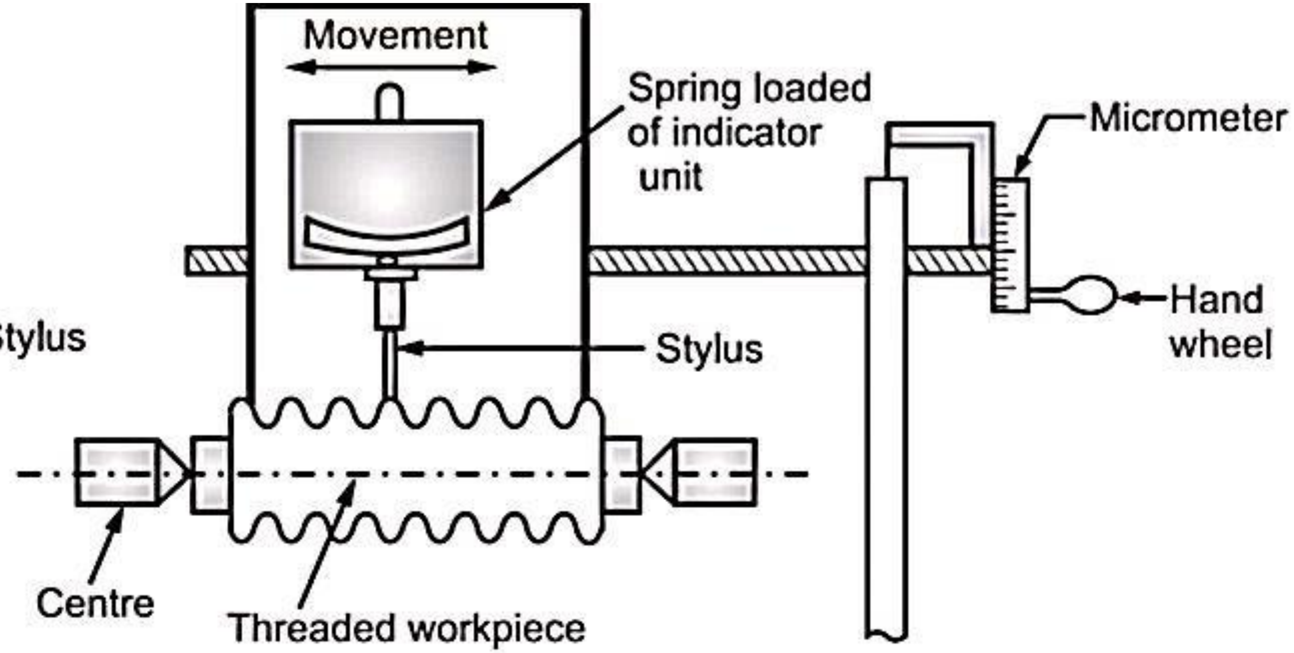
(a) Position of stylus at roots of two adjacent threads

(b) Pitch measuring machine

Pitch Measuring Machine



(a) Position of stylus at roots of two adjacent threads

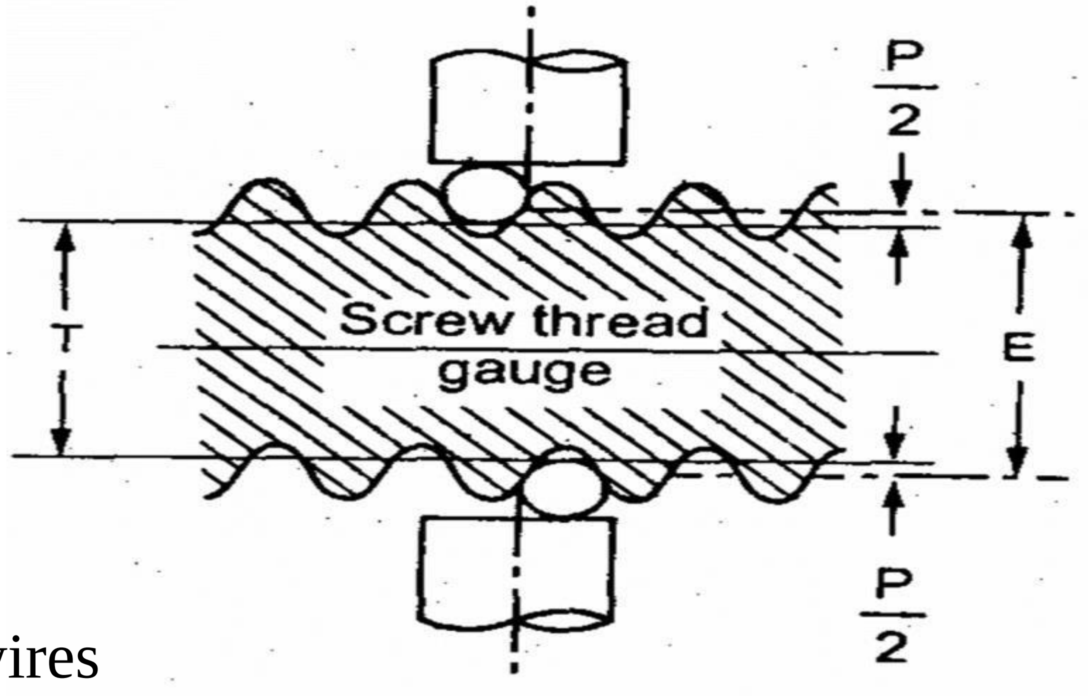


(b) Pitch measuring machine

Measurement of Effective Diameter

- Effective diameter can not be measured directly but can be calculated from the measurements made.
- It may be measured by the following methods:
    - Two wire method
    - Three wire method
    - Micrometre method

TWO WIRE METHOD



- Wires of exactly known diameters are chosen such that they contact the flanks at their straight portions.
- Screw thread is mounted between the centres & wires are placed in the grooves and reading M is taken.

Effective diameter

E =T+P

– Where, • T =M-2d (distance under the wires)

• P depends on diameter of wire, pitch & angle of the screw thread.

TWO WIRE METHOD

The P value can be derived in terms of P (Pitch), d (Diameter of wire) and x thread angle is as follows

BC lies on the effective diameter.

$$\therefore BC = \frac{1}{2} Pitch = \frac{1}{2} P$$

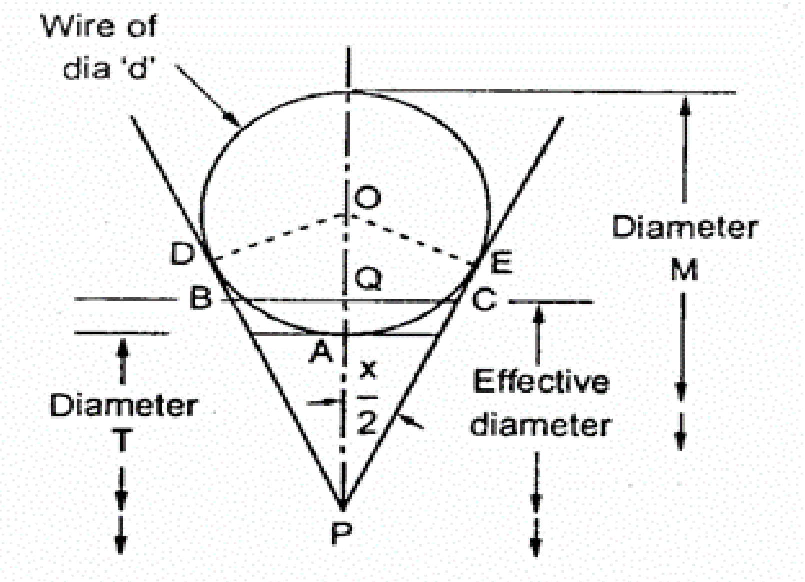
$$\text{Next } OP = \frac{d\,Co\sec(x/2)}{2}$$

And $AQ = PQ - AP$

Where,

$PQ = QC\ Cot\ (x/2) = P/4\ Cot\ (x/2)$

$$\boxed{PQ = \frac{P}{4} Cot(x/2)}$$



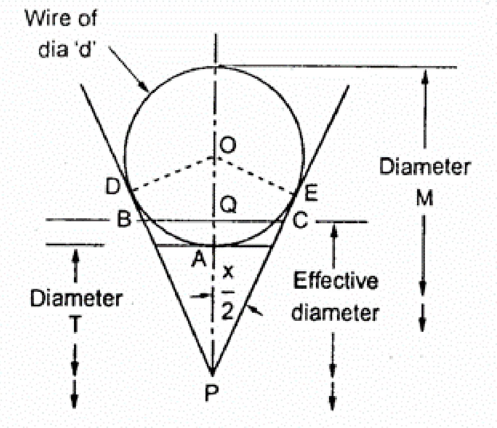
TWO WIRE METHOD

$$\therefore AQ = \frac{}{4} Cot(x/2) - AP$$

P

Here, $\boxed{AP = \frac{d(Co\sec x/2 - 1)}{2}}$ $\Longrightarrow$

AP=OP-OA



$$\therefore AQ = \frac{P\,Cot(x/2)}{4} - \frac{d(Co\sec x/2 - 1)}{2}$$

and

AQ is half the value of P

$\therefore$ P value = 2AQ

$$\boxed{P = \frac{P}{2} Cot\frac{x}{2} - d\left[Co\sec\frac{x}{2} - 1\right]}$$

TWO WIRE METHOD

- Difference between effective diameter & diameter under the wires is given by:
  - $P = 0.9605*P' - 1.1657d$ For Witworth threads For
  - $P = 0.866*P' - d$ Metric threads

Where

P’: Pitch of the thread

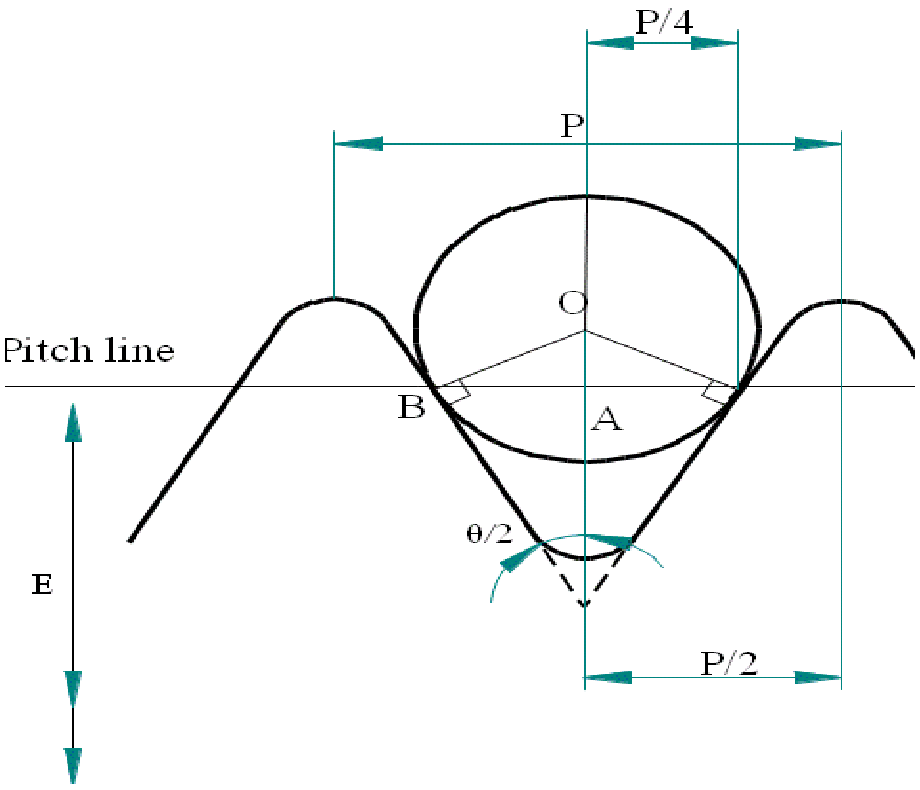
d= diameter of wire

BEST SIZE WIRE

- Best size wire is the one which makes contact at the pitch line or effective diameter of the screw thread
- For best size wire, OB is perpendicular to the flank
- In triangle AOB

  Sin (BOA) = AB/OB

  - But Angle BOA = 90 – θ/2
  - AB = P/4
  - OB = Radius of the wire= d/2



Where,

P = Pitch of the thread

d = Diameter of best size wire

$$\text{Sin}\,(90 - \theta/2) = \frac{(P/4)}{(d/2)}$$

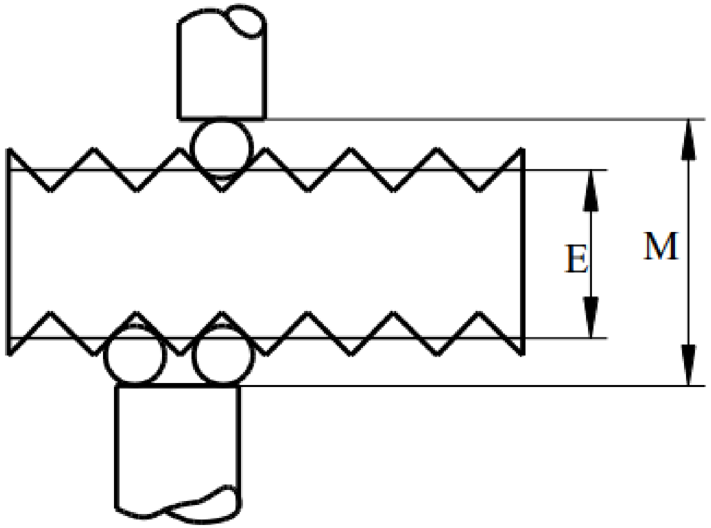
$$\text{Or} \qquad d = \frac{2 * (P/4)}{\text{Cos}\,(\theta/2)}$$

$$\boxed{\mathbf{d = (P/2) * Sec\,(\theta/2)}}$$

THREE WIRE METHOD

- Three wires of equal & precise diameter are used.
- One wire is placed on one side and two on the other side in the groves of the screw.
- The wires either may held in hand or hung from a stand
- Three-wire method is more accurate as it ensures proper alignment of micrometer anvil faces parallel to the thread axis.

THREE WIRE METHOD



M= Diameter over the wires

E= Effective Diameter (to be evaluated)

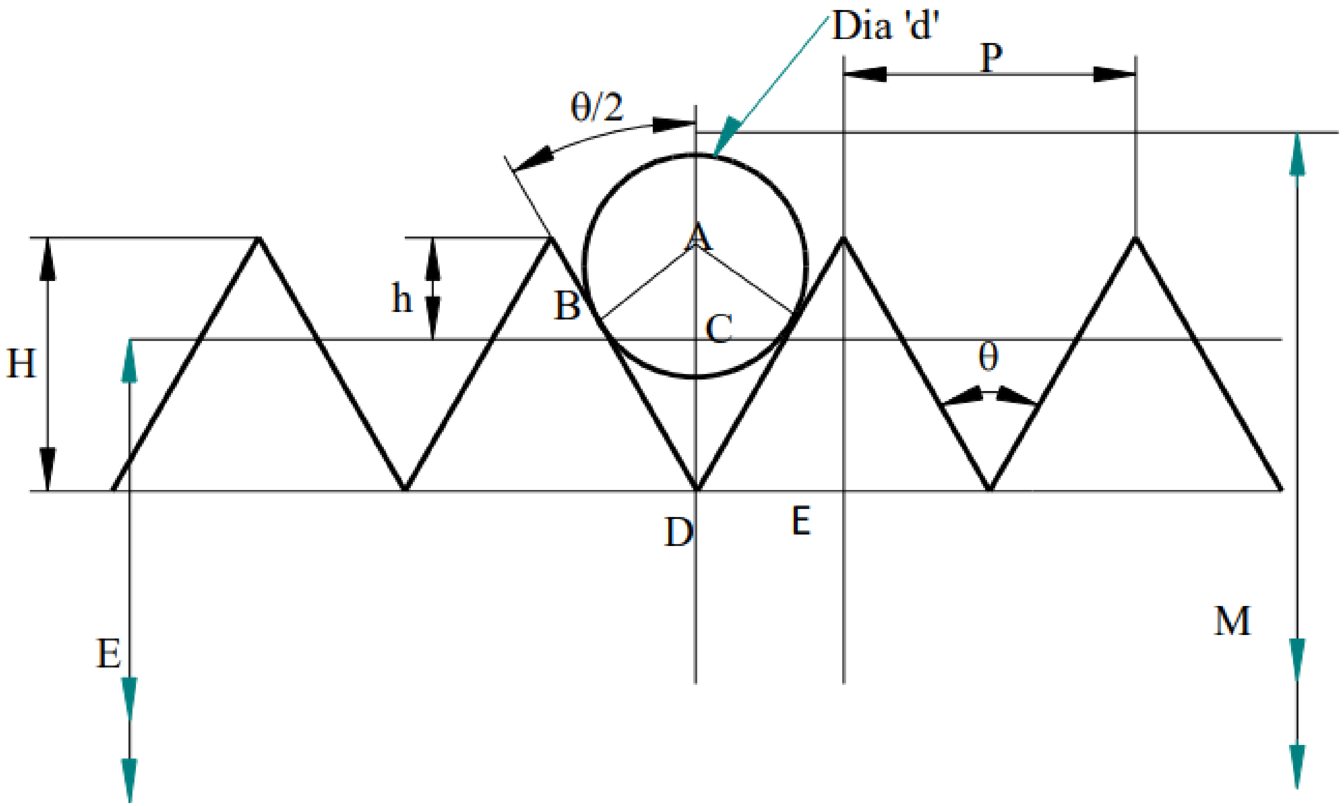
d= Diameter of wire

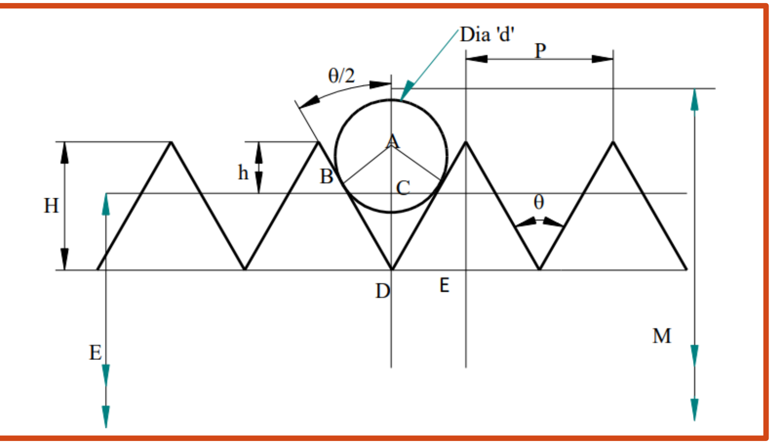
h = Height of wire center above the pitch line

r = Radius of wire

H = Depth of thread

D = Major diameter of thread





Three Wire method

$$\textit{From the triangle ABD,}\quad \mathrm{AD} = \mathrm{AB}\,\mathrm{cosec}\frac{\theta}{2} = \frac{d}{2}\,\mathrm{cosec}\frac{\theta}{2}$$

$$\mathrm{CD} = \frac{\mathrm{H}}{2} = \frac{P}{4}\cot\frac{\theta}{2}$$

$$\textit{Further}\quad h = (AD - CD) = \left[\frac{d}{2}\,\mathrm{cosec}\frac{\theta}{2}\right] - \left[\frac{P}{4}\cot\frac{\theta}{2}\right]$$

$$\text{Distance over the wires, } \mathrm{M} = \mathrm{E} + 2\mathrm{h} + 2\mathrm{r}$$

$$\text{i.e. } \mathrm{M} = \mathrm{E} + 2\left\{\mathrm{r}\,\mathrm{cosec}\frac{\theta}{2} - \frac{P}{4}\cot\frac{\theta}{2}\right\} + 2r = E + 2r\left\{1 + \mathrm{cosec}\frac{\theta}{2}\right\} - \frac{P}{2}\cot\frac{\theta}{2}$$

$$\text{Or } \boxed{\mathrm{M} = \mathrm{E} + \mathrm{d}\left\{1 + \mathrm{cosec}\frac{\theta}{2}\right\} - \frac{P}{2}\cot\frac{\theta}{2}}$$