Lab Procedure: Effective Diameter of a Screw Thread

Three Wire Method

October 13, 2025

1. Aim

To determine the effective diameter (E) of the given threaded specimen using the three-wire method.

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2. Apparatus Required

- A stand or fixture to hold the specimen
- Threaded specimen
- A set of three identical, hardened steel wires of known diameter (d)
- Micrometer or Vernier Caliper

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3. Theory and Derivation

The three-wire method is an accurate technique for measuring the effective (or pitch) diameter of a screw thread. Three wires of an identical, known diameter are placed in the thread grooves, and a measurement is taken over them using a micrometer. The effective diameter (E) is then calculated from this measurement (M).

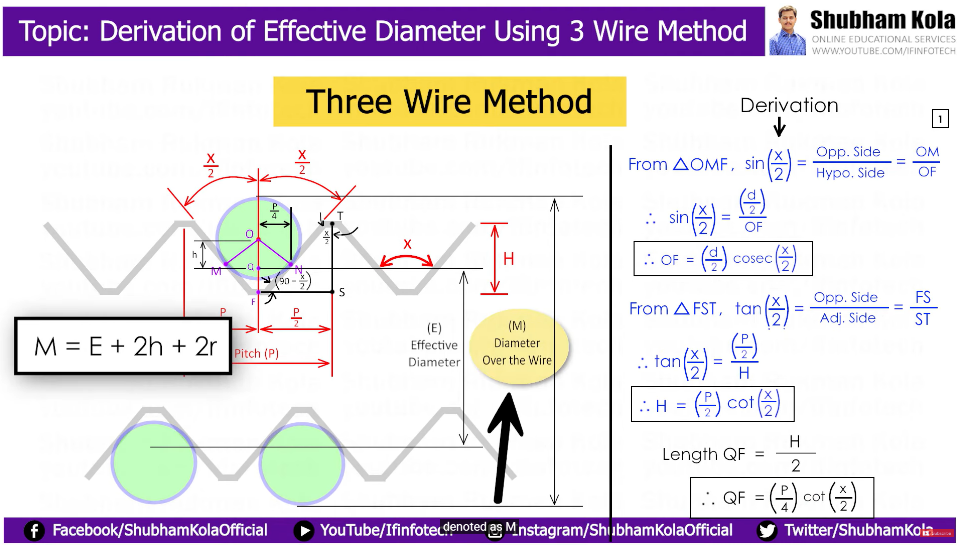


Figure 1: Diagram of the Three-Wire Method.

The relationship between the measurement over the wires (M) and the effective diameter (E) is given by:

$$M = E + 2h + 2r$$

Where:

- M = Measurement over the wires
- E = Effective diameter (to be found)
- h = Height from the pitch line to the center of the wire
- r = Radius of the wire ($d/2$)

To find E, we first need to derive an expression for h. From the geometry in Figure 1:

$$h = OF - QF$$

Step I: Derivation of OF and QF

From the right-angled triangle $\triangle OMF$:

$$\sin\left(\frac{x}{2}\right) = \frac{\text{Opposite}}{\text{Hypotenuse}} = \frac{OM}{OF} = \frac{r}{OF} = \frac{d/2}{OF}$$

$$\therefore OF = \frac{d/2}{\sin(x/2)} = \frac{d}{2}\csc\left(\frac{x}{2}\right)$$

From the right-angled triangle $\triangle FST$:

$$\tan\left(\frac{x}{2}\right) = \frac{\text{Opposite}}{\text{Adjacent}} = \frac{FS}{ST} = \frac{P/2}{H}$$

The total height of the fundamental triangle is $H = \frac{P}{2}\cot\left(\frac{x}{2}\right)$. The length QF is half of the height from the thread crest to the root, which corresponds to $H/2$.

$$QF = \frac{H}{2} = \frac{P}{4}\cot\left(\frac{x}{2}\right)$$

Step II: Derivation of the final formula for E

Now, substitute the expressions for OF and QF to find h:

$$h = OF - QF = \frac{d}{2}\csc\left(\frac{x}{2}\right) - \frac{P}{4}\cot\left(\frac{x}{2}\right)$$

The effective diameter E can be expressed by rearranging the initial formula:

$$E = M - 2h - 2r = M - 2h - d$$

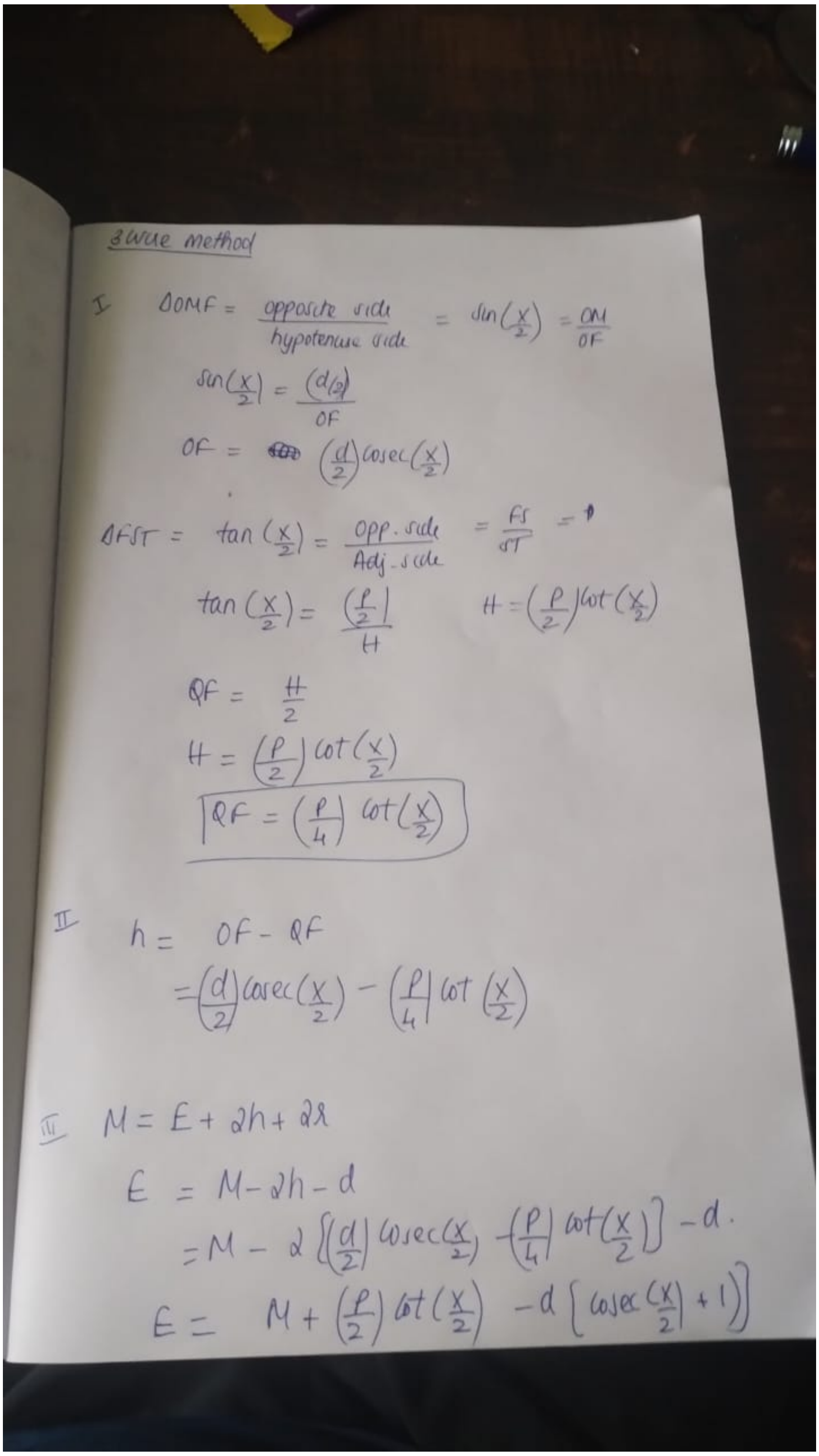
Substituting the expression for h:

$$E = M - 2\left[\frac{d}{2}\csc\left(\frac{x}{2}\right) - \frac{P}{4}\cot\left(\frac{x}{2}\right)\right] - d$$

$$E = M - d\csc\left(\frac{x}{2}\right) + \frac{P}{2}\cot\left(\frac{x}{2}\right) - d$$

Factoring out $-d$, we get the final working formula:

$$\mathbf{E} = \mathbf{M} + \frac{\mathbf{P}}{\mathbf{2}}\cot\left(\frac{\mathbf{x}}{\mathbf{2}}\right) - \mathbf{d}\left(\mathbf{1} + \csc\left(\frac{\mathbf{x}}{\mathbf{2}}\right)\right)$$



3wire method

I $\Delta OMF = \frac{\text{opposite side}}{\text{hypotenuse side}} = \sin\left(\frac{x}{2}\right) = \frac{OM}{OF}$

$\sin\left(\frac{x}{2}\right) = \frac{(d/2)}{OF}$

$OF = \left(\frac{d}{2}\right)\operatorname{cosec}\left(\frac{x}{2}\right)$

$\Delta FST = \tan\left(\frac{x}{2}\right) = \frac{\text{Opp. side}}{\text{Adj. side}} = \frac{FS}{ST} =$

$\tan\left(\frac{x}{2}\right) = \frac{\left(\frac{P}{2}\right)}{H}$ $\quad H = \left(\frac{P}{2}\right)\cot\left(\frac{x}{2}\right)$

$QF = \frac{H}{2}$

$H = \left(\frac{P}{2}\right)\cot\left(\frac{x}{2}\right)$

$\boxed{QF = \left(\frac{P}{4}\right)\cot\left(\frac{x}{2}\right)}$

II $h = OF - QF$

$= \left(\frac{d}{2}\right)\operatorname{cosec}\left(\frac{x}{2}\right) - \left(\frac{P}{4}\right)\cot\left(\frac{x}{2}\right)$

III $M = E + 2h + 2r$

$E = M - 2h - d$

$= M - 2\left\{\left(\frac{d}{2}\right)\operatorname{cosec}\left(\frac{x}{2}\right) - \left(\frac{P}{4}\right)\cot\left(\frac{x}{2}\right)\right\} - d.$

$E = M + \left(\frac{P}{2}\right)\cot\left(\frac{x}{2}\right) - d\left[\operatorname{cosec}\left(\frac{x}{2}\right) + 1\right]$

Figure 2: Derivation of the Final Formula.

4. Procedure

1. Clean the threaded specimen and the three wires to ensure they are free from dust and grease.

2. Identify the thread parameters: Determine the pitch (P) and the thread angle (x) of the specimen. For standard metric threads, $x = 60°$.

3. Securely mount the threaded specimen on the stand.
4. Place two wires in the thread grooves on one side of the specimen.
5. Place the third wire in a thread groove on the opposite side, directly between the first two wires.
6. Carefully bring the anvils of the micrometer into contact with the wires and measure the dimension over the wires (M). Ensure the micrometer is held perpendicular to the axis of the screw thread to get an accurate reading.
7. Record the reading. Repeat the measurement at least three times at different locations along the thread to minimize errors and calculate the mean value of M.
8. Use the final formula to calculate the effective diameter E.

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5. Observations and Calculations

Given Data:

- Pitch of the thread, $P =$ ________ mm
- Angle of the thread, $x =$ ________ degrees
- Diameter of the wire, $d =$ ________ mm

Measurement Table:

Trial No.	**Measurement over wires, M (mm)**
1	
2	
3	
Mean	$\bar{M} =$

Calculation: The effective diameter (E) is calculated using the formula:

$$E = \bar{M} + \frac{P}{2}\cot\left(\frac{x}{2}\right) - d\left(1 + \csc\left(\frac{x}{2}\right)\right)$$

$$E = \_\_\_\_\_\_ + \frac{\_\_\_\_\_}{2}\cot\left(\frac{\_\_\_\_\_}{2}\right) - \_\_\_\_\_\_\left(1 + \csc\left(\frac{\_\_\_\_\_}{2}\right)\right)$$

$$E = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \text{ mm}$$

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6. Result

The effective diameter of the given threaded specimen was found to be _______________ mm.