Metrology
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Lecture – 23
Screw Thread Production and Terminology

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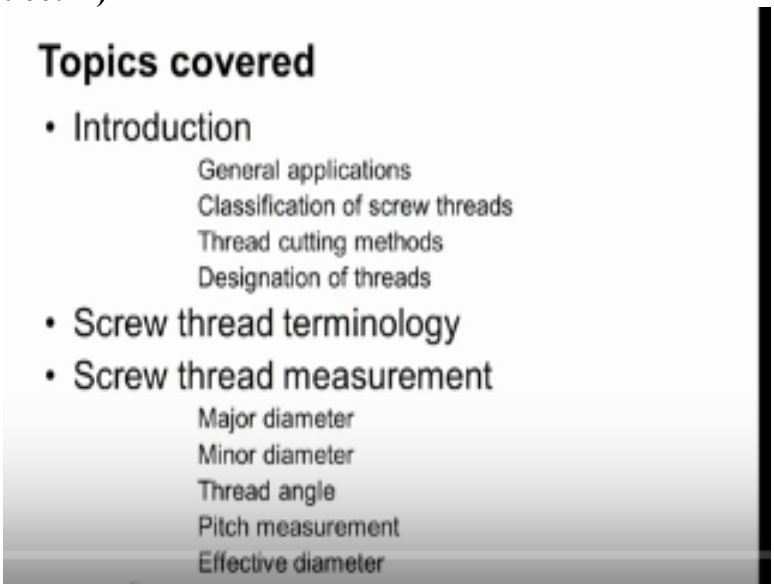

I welcome you for the series of lecture on the metrology, now we will start module number 6 on screw thread metrology. In this module, we will be discussing about the general introduction to screw threads of covering, the threads making the processors and how they are classified and what are the various applications of screw thread those things we will be studying. Then we will also discuss about the various screw thread terminology.

Then we will move on to the measurement of to thread the element in this lecture one we will be covering the general introduction to screw thread. We will cover general applications of screw threads and classification of screw threads, thread cutting methods and how they are designated. Then, we will study the screw thread the terminologies various terms used related to screw thread.

Then we will discuss about the screw thread measurement that is the major diameter, measurement, minor diameter measurement, thread angle measurement, pitch measurement and effective diameter measurement.

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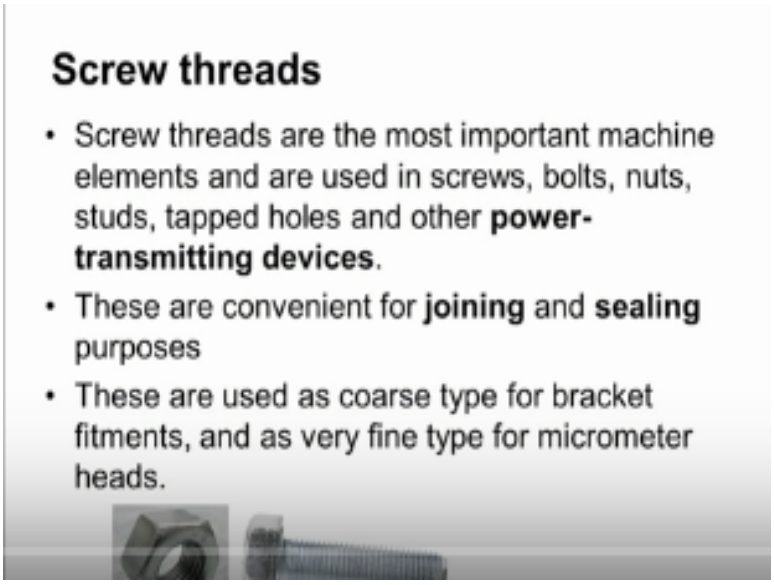

Now briefly we will try to understand the general aspects of screw threads. These are the most important machine elements and are used in screws, bolts, nuts, studs, tapped holes and other power transmitting devices. They are very convenient for joining and ceiling purposes then use the course type for bracket fitment and a very fine type of type for the micrometer head for precision moving the mechanisms.

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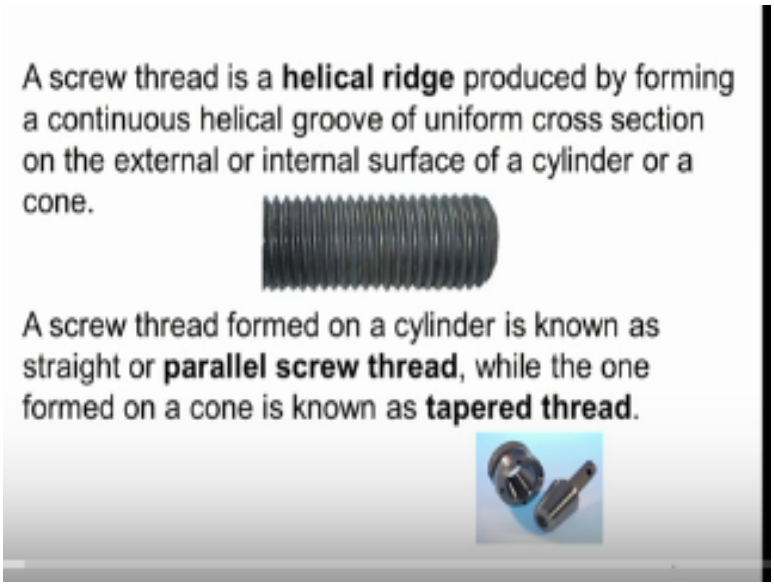

It is basically a helical Ridge produced by forming a continuous helical group of uniform cross section on an external or internal surface of a cylinder or a cone. Now, you can inspect for photo we can see the helical ridge produced and a cross section use the uniform for all the threads now

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

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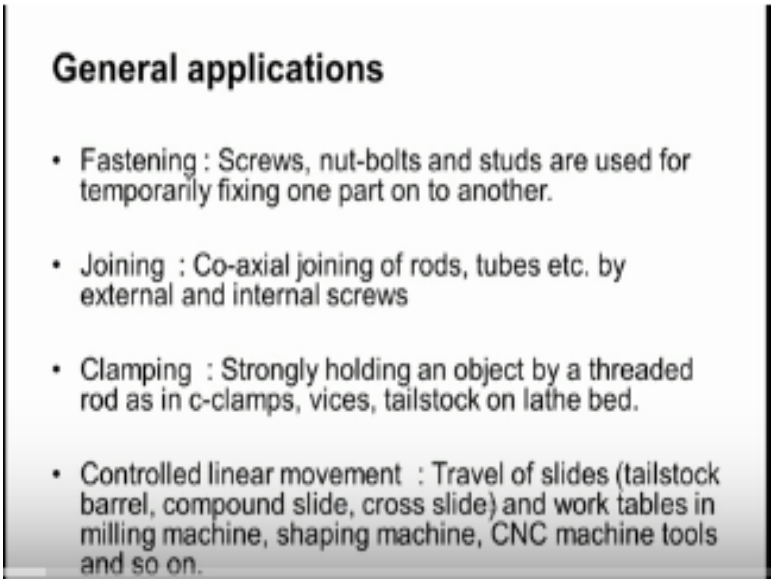

You can see here some tapered threads here these external tapered thread and this is the internal tapered thread. Now what are the general applications of screw threads they are used for fastening purpose screws, nut-bowls and studs are used for temporarily fixing the one part onto the other part and they are used for joining co-axial joining of rods, cubes etc by external and internal screws and are also used for the clamping they strongly to strongly hold an object by a threaded rod as in the c-clamp vices tailstock on the lathe bed.

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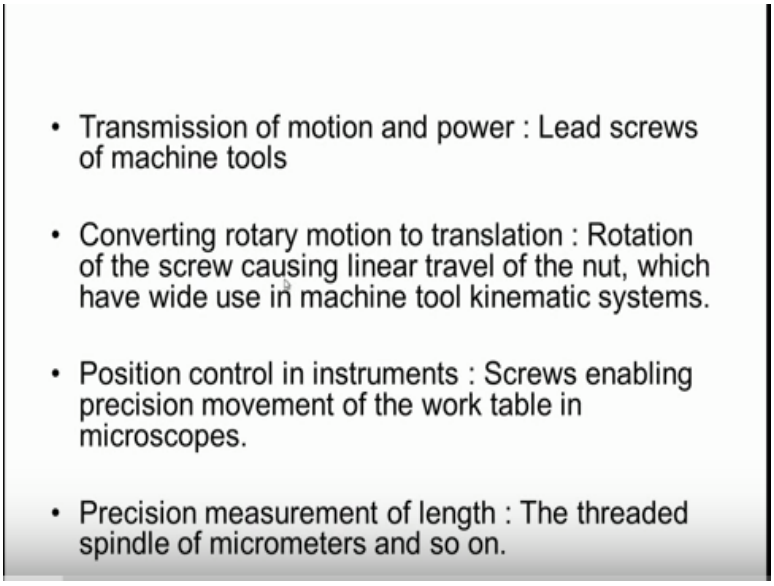

They are used for controlled the linear moment that is for travel of slides and movement of work tables in milling machine, shaping machine, CNC machine tools etc. These screw threads are used for transmission of motion and power for example the lead screws used in a list is used for the transmitting motion and power and they are also used for converting rotary motion to translation that is the rotation of the screw causing linear travel of the nut which have wide used in the machine tool kinematic systems.

Screw threads are used for position control instruments. Screws enabling precision movement of the work table in microscopes are example and screw threads are used in precision movement of precision measurement of length that is the threaded the spindle of micrometer in an example for this.

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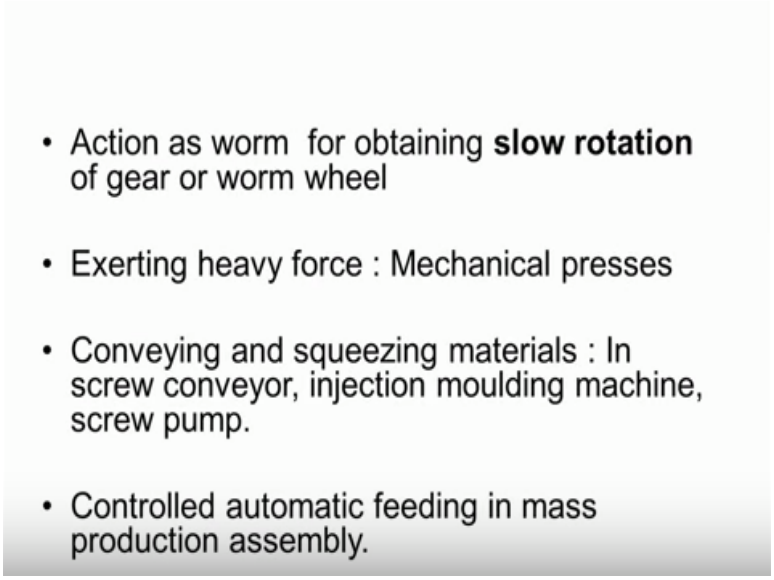

Now to get the very slow rotation we can use the screw threads in the form of as the example of gear or worm wheel and to exert a heavy force all these codes are used example is mechanical process the screw threads are also used in conveying and squeezing the materials, in screw conveyors, injection molding machines, and the screw pump and in controlled automatic feeding in mass production assembly these screw threads are used.

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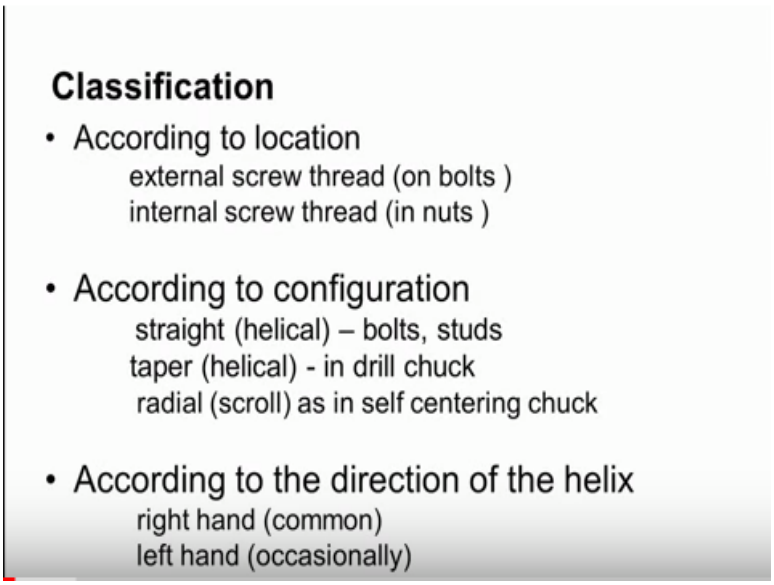

Now, let us study how these the screw threads are classified they are classified according to the location that means that is whether these screw threads are made on the external surface as in bolts or whether they are made on the internal surface of example nuts. These threads are can also be classified according to the configuration.

That is whether they are the straight helical for example bolts but studs a tapered the helical as in drill check also radial on scroll as they self-centering check. Screw threads can also be classified according to the direction of helix that is whether they are right-handed or left-handed.

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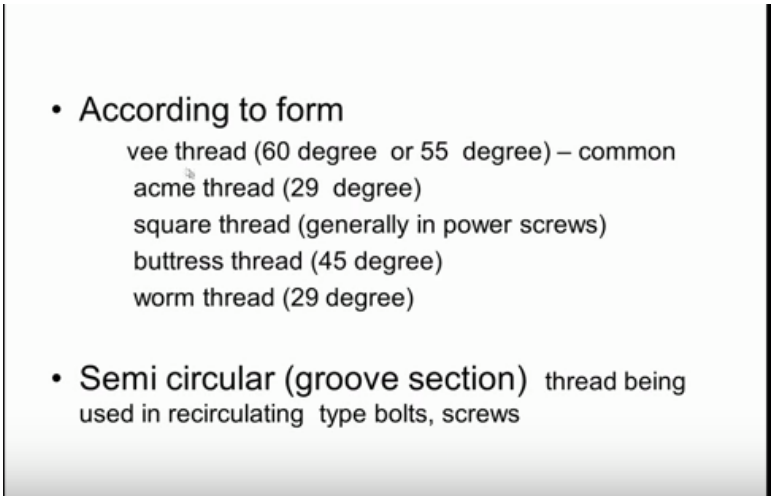

According to the form they are classified as the vee threads normally 60 degree and 55 degree thread angle is used acme thread wherein the angle is 29 degree they are classified as square

thread which are generally used in the power screws buttress thread, worm thread like this depend upon the form they are classified and depending upon whether they are full circle of semi circular thread. So semi circular threads are being used in the circulating the type of bolts and screws.

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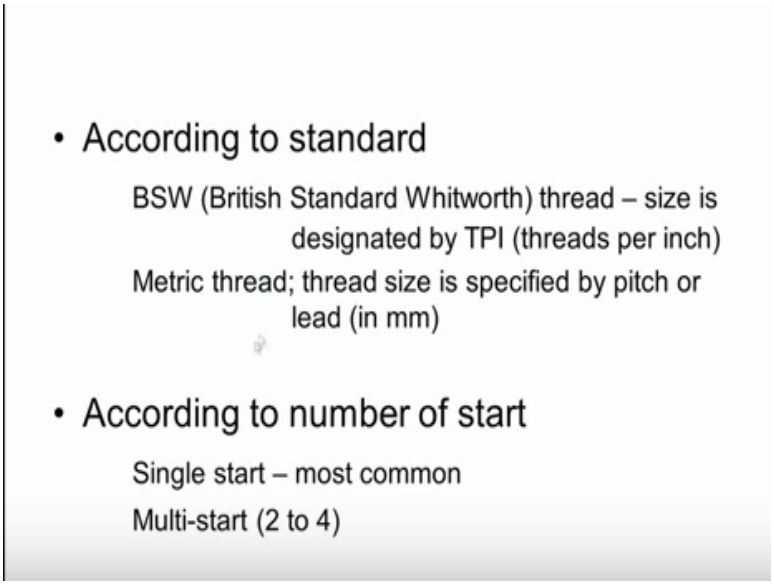

According to the standard BSW British standard Whitworth thread or metric thread according to the number of start ordered a single start or double start like a multi start screw threads.

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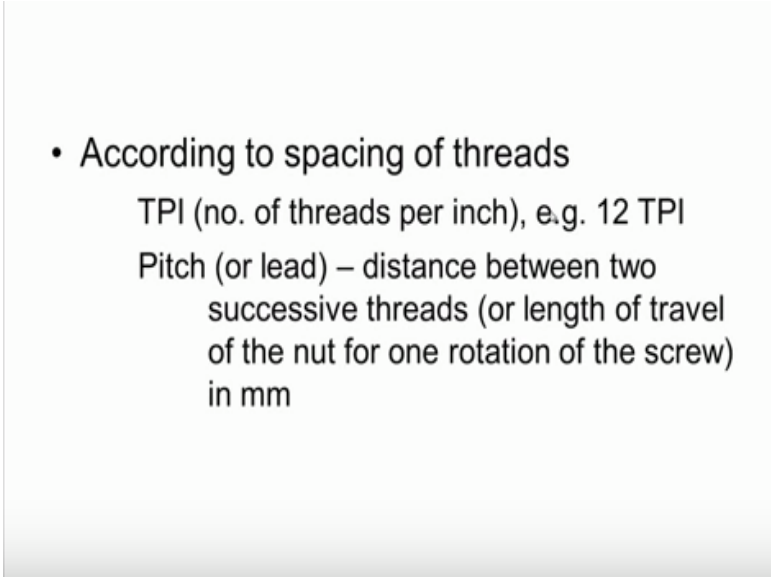

According to the standard BSW British standard Whitworth thread or metric thread according to the number of start ordered a single start or double start like a multi start screw threads.

According to the spacing of threads I can say TPI thread number of threads per inch, whether it is 60 TPI or 12 TPL like that we can classify and depending upon the pitch also.

We can classify so pitch is pitch or lead it is the distance between 2 successive threads or length of travel of net for one rotation of the screw so pitch can be one millimeter pitch or 2 millimeter pitch or 3 millimeter like that.

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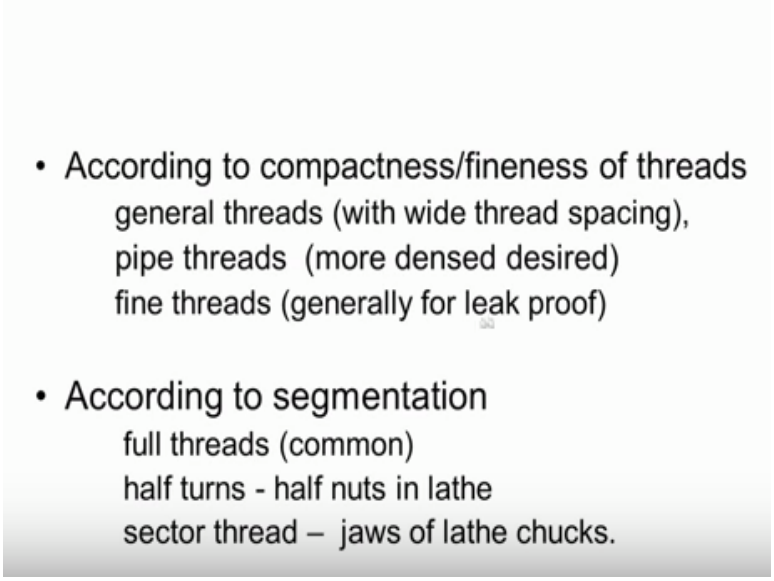

According to the compactness or fineness of threads we can classify them as general threads and pipe threads and fine threads which are used for leak proof applications and according to the segmentation. Whether they are full form thread or half turn threads example is half nuts used in lathe and then sector threads which are used in the jaws of lathe chucks.

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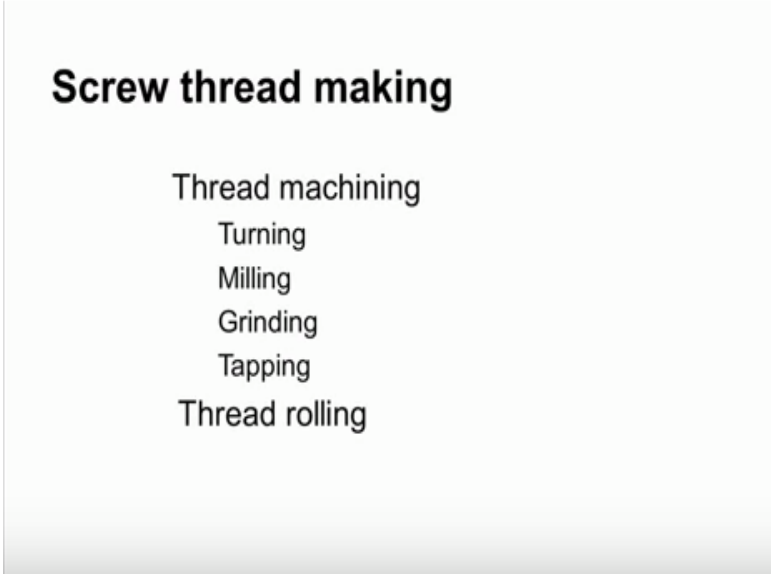

Now, how these threads are made there are many methods. The very common method is the thread machining they can be turned, they can be milled and thread grinding thread, tapping, so these are some trade machining methods and the threads can also be made by a thread rolling operation.

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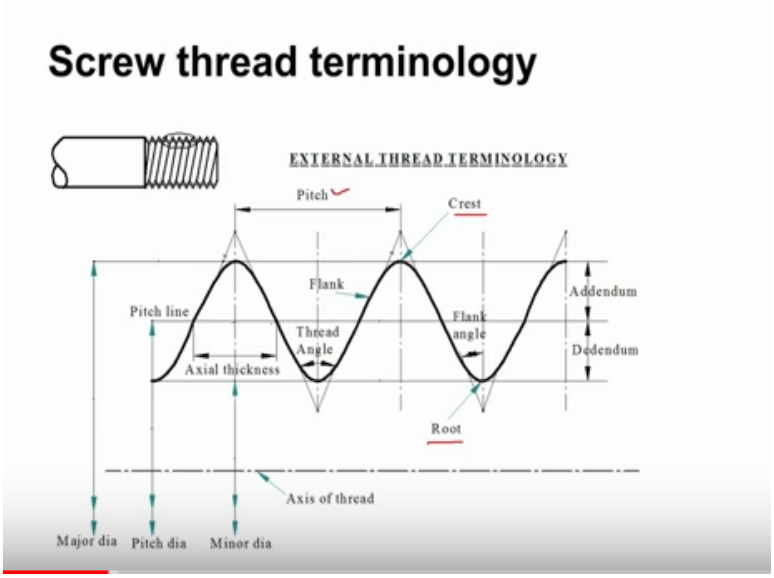

Now let us move to the screw thread terminology various terms are used in the respective screw threads internal screw threads and external screw threads Now this picture shows some of the terminologies you can see the profile of the screw thread and the distance between one point on the screw thread to the corresponding point on the next thread this is the known as pitch.

Then, this the peak portion of the thread is called crest and in the bottom most that is the lowest point on the screw thread profile is known as the root, and then we have this sloping surface which connects the crest with a root is called the flank, and then the angle between the perpendicular line perpendicular to the axis and the flank is called flank angle, and double the flank angle is known as the thread angle.

Now this is the pitch line so this pitch line it bisects the thread such a way that the thread material space. So this line is called pitch line and this diameter is known as the pitch diameter and addendum so the distance between the pitch line under the crest point is known as the addendum and similarly the distance between the root and the pitch line is called dedendum.

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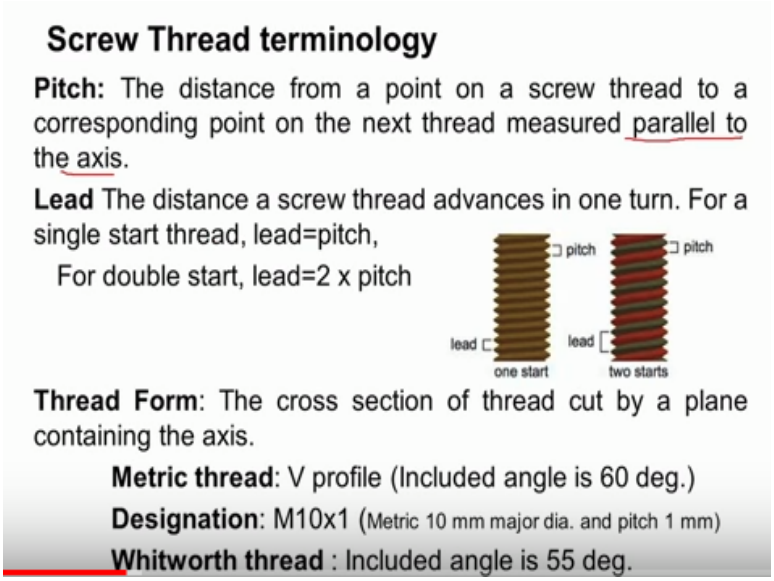

Now pitch it is a distance from a point on a screw thread to a corresponding point on the next thread measured parallel to the axis this is very important when they measure the pitch measurement should be made parallel to the axis. Now you can see here this is a single start screw thread so we are in the lead = pitch.

Now what is lead it is a distance screw thread advances in one ton when we rotate screw thread by one ton what is the distance mode at moment of the thread that is called lead. For a single start lead = pitch whereas in the case of 2 start screw threads lead = twice the pitch.

Now the thread form is the cross-section of the thread cut by a plane containing the axis for example in the case of metric thread, we will be having a V profile like this. So this is the thread the form of thread profile in case of metric thread this included angle which is known as a thread angle = 60 degrees and in the case of Whitworth threads the included angle is 55 degrees.

How these the screw threads are designated the metric threads they are designated in this fashion one example is shown here M10x1 so M indicates that the thread is metric type and 10 indicates the 10mm major diameter and this 1 indicates a pitch of 1 millimeter.

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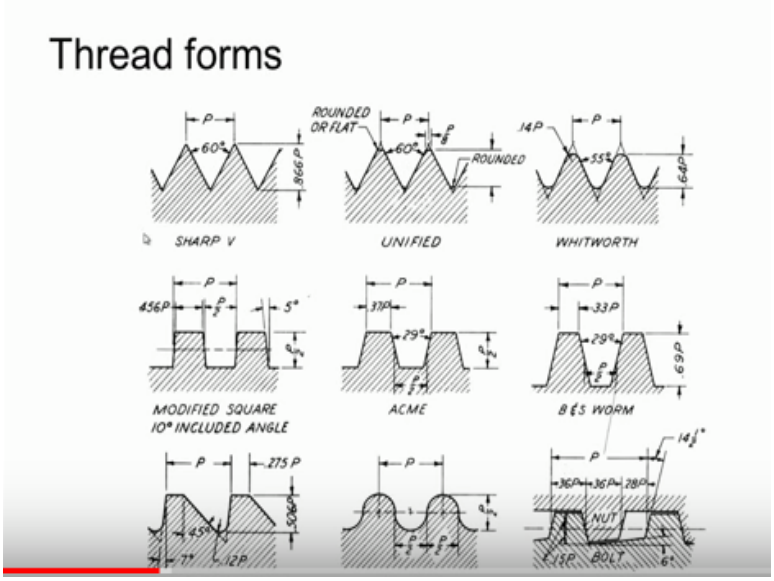

Now various thread the forms are used in the practice is sharp v, we have a sharp crust here, so it is a slightly modified it is made rounded or flat then it is called unified thread and then the in 2 cases a sharp and in unified the included angle is 60 degree, whereas in the case of whit worth thread the included angle is 55 degree and then modify the square 10 degree included angle these are modified square threads used in power screws.

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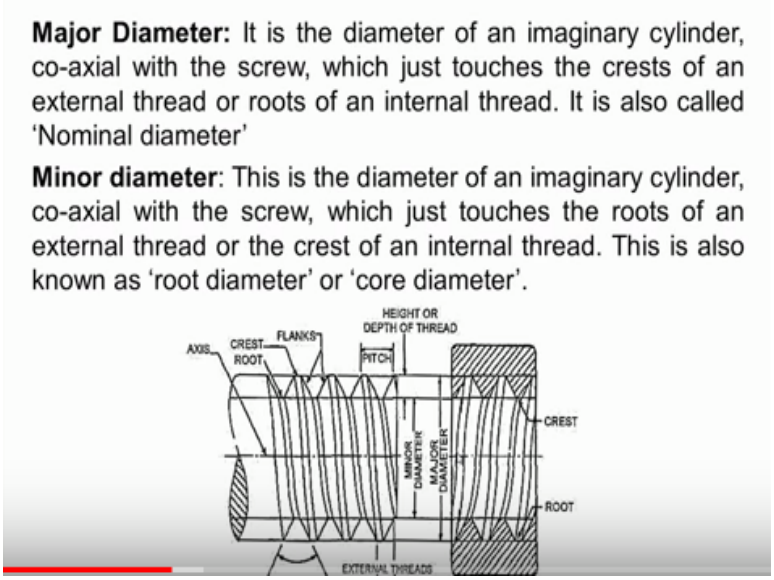

Acme matrix wherein the included angle is 29 degrees, similarly we have modified buttress and the knuckle threads so like this different threads forms are available. Now what is the major diameter, we can understand from this diagram the it is the measure diameter is the diameter of an imaginary cylinder co-axial with the screw which just touches the crests of an external thread you can see here we have the crest points here.

And we have the crust here. So the imaginary cylinder will pass over these crest points just touches the crests of an external thread or roots of an internal thread it is also known as the nominal diameter. In case of internal thread you can see these are the roots and this is root. Now the distance between root, root here and root at this place so this distance is a minor diameter and distance between the crust to crust, so this is a major diameter.

So minor diameter is the diameter of an imaginary cylinder co-axial with the screw which just touches the roots of an external thread or crest of an internal thread so this is also known as root diameter or the core diameter.

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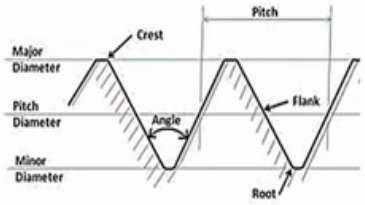
Effective diameter or Pitch diameter: It is the diameter of an imaginary cylinder coaxial with the axis of the thread and intersects the flanks of the thread such that width of the threads and width of spaces between threads are equal.



Flank: It is the thread surface that connects crest with root.

Depth of thread: It is the distance between crest and root measured perpendicular to axis of screw

Now let us understand what is a meaning of effective diameter or pitch diameter it is the diameter of an imaginary cylinder co-axial with the axis of the thread and intersects the flanks of the thread such that width of thread and width of spaces between the threads are equal, so this is the line which is passing through the thread the profile and it cuts the flank such that the width of thread = width of space.

So if you pass the line in such a manner then that is called pitch line and the from pitch line to the other pitch line on the other side, so this diameter is the pitch diameter and flank is the thread surface that connects the crust with root. So the crust is connected with the root this sloping surface is known as a flank.

Then that depth often it is a distance between crust and root measured perpendicular to the axis of screw. So the axis of screw will be somewhere here and we have to pass a line perpendicular to the axis and the distance between the root and the crust so this is the depth of thread the depth of thread.

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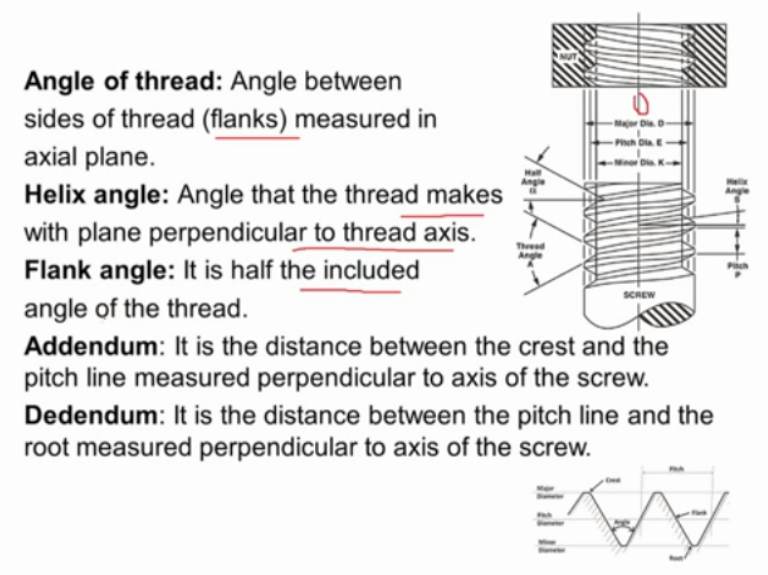

Now angle of thread so angle it is the angle between sides of thread that means angle between 2 flanks measured in axial the plane you can see here we have a flank, flank here. We have another flank here so the included angle between 2 flanks is known as thread angle and helix angle is the angle that the thread makes when with planes perpendicular to the thread axis. So this is the thread axis so we have the thread axis here and then this is the ridge or the thread okay.

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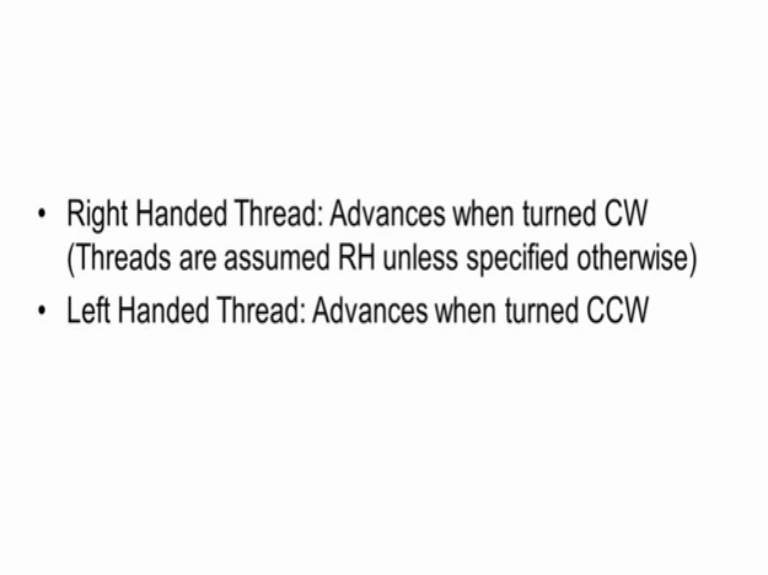

It makes an angle with this perpendicular so this angle is known as helix angle and flank angle is half the included angle of the thread and then we discussed about the addendum and dedendum. Then sometimes we say right-handed the thread so when the screw thread advances when turn

the clockwise it is called right-handed thread and when it advances when turned in the counterclockwise direction it is called left-handed thread.

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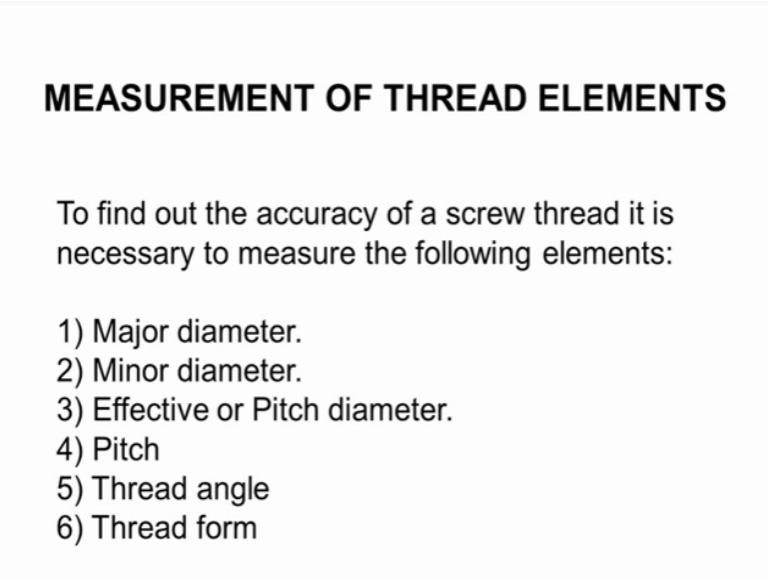

Now let us move to the measurement of thread elements. In order to find the accuracy of screw thread reduce it is necessary to measure the various thread element, so thereby we can say whether the thread produced is as per the specification or not. So normally these are the element measured or to check whether the screw thread is okay or not.

The measurement of measure diameter, measurement of minor diameter, and measurement of pitch diameter or effective diameter each measurement thread measurement and thread form is also measured.

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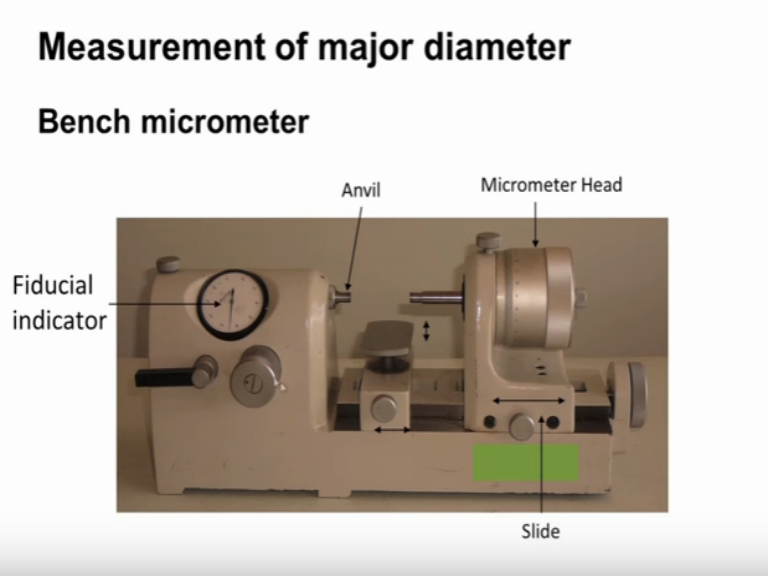

Now let us the study how the major diameter of a screw thread is measured this instrument is known as bencher micrometer, we can see the very rugged caster and the base of the instrument wherein there is a slide which can be moved or parallel to the axis of the bench micrometer this is slide the body which houses the micrometer head a large diameter micrometer is fitted and is a anvil so when they rotate this symbol the anvil moves in or out.

Then we have a table so this table also can be moved in this direction to accommodate the work pieces and if the table surface is a flat surface which can be moved up and down again to accommodate the work pieces of different sizes so left hand side we have the body which houses for the anvil this anvil also can be moved in and out to accommodate the pieces for different sizes.

We can see there is a fiducial indicator so when we place the work piece between these 2 anvils and they rotate the micrometer head the anvil will move and then it will act some pressure on the work piece that is transmitted to this anvil and finally it is transmitted to the fiducial indicator.

This indicator will indicate what is the pressure or force applied onto the what is it is very essential to conduct the experiments measurement experiments at the same pressure always. It is very essential that we should not over pressurize the screw threads, so the anvils when they

should just touch the crust if you over pressurize the screw thread what happens is anvil will try to crush the crest and the screw thread gets deformed and we do not get the proper reading.

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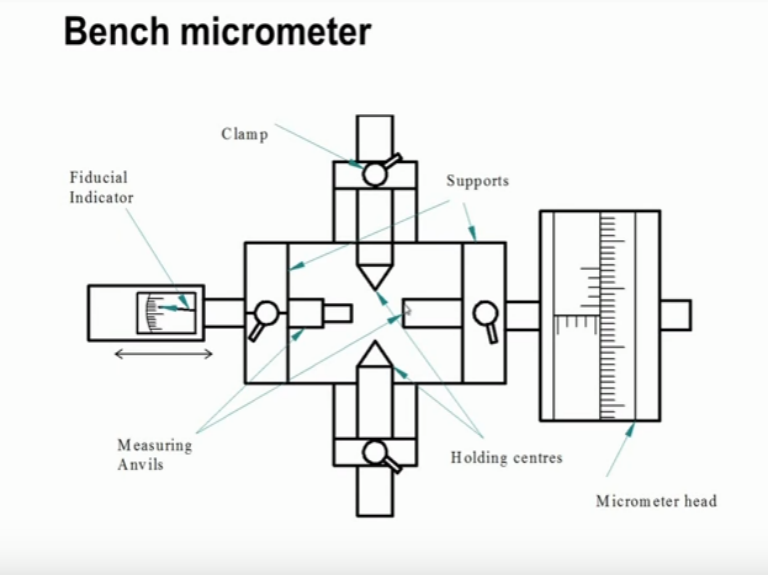

So to apply even pressure for all the work pieces this fiducial indicator is provided and on this table surface we can put some fixture to hold the work pieces. Now this shows a schematic diagram of for bench micrometer. The micrometer head with the scale on the thimble and we will scale on the barrel and then we have the measuring anvils and clamps for measuring anvils fiducial indicator the anvil and fiducial indicator it is slide.

So that we can accommodate the work piece of different sizes we can also see there is a fixture holding Center to holder the crew threads. Now it is very essential that the axis of these holding centers should be perpendicular to the axis of this venture micrometer.

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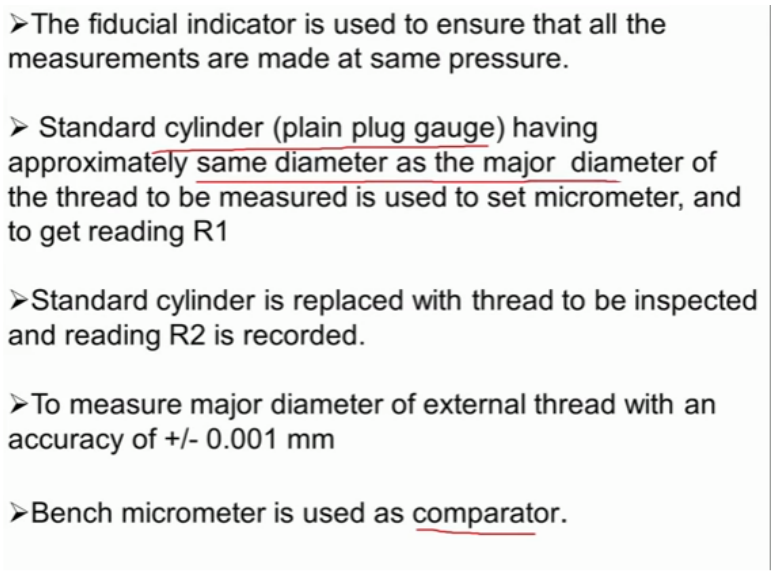

Now in order to use this bench micrometer to measure the measure diameter normally the bench micrometer it is used as a comparator that means a standard the cylinder normally plain plug gauge having approximately same diameter as the major diameter of the thread to be measured is used as the standard cylinder for setting the micrometer and over the standard cylinder micrometer reading is taken and it is recorded as R1.

So we use the standard cylinder to establish for the comparative measurement in order to reduce the possible errors and then after taking the reading R1 we have to remove the standard cylinder from the bench micrometer and they have to insert the thread to be inspected between the centre and again the micrometer reading R2 is noted down.

So, using these bench micrometer it is possible to measure the major diameter to an accuracy of +/- 0.001 millimeter such a fine accurate measurement is possible with the bench micrometers.

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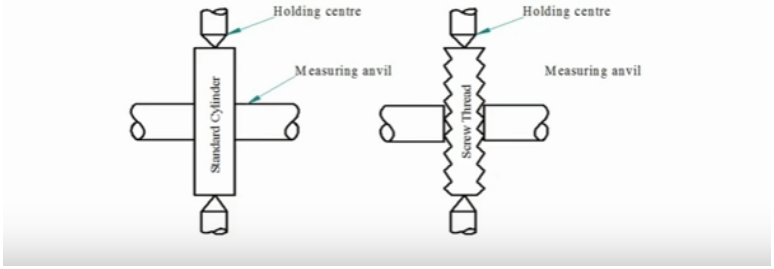
S = Diameter of standard cylinder, mm
R1 = Reading on standard cylinder, mm
R2 = Reading on thread to be inspected, mm
D = Major diameter of thread = S ± (R1-R2)



Now I can see here, S is the diameter of the standard cylinder normally plain plug gauges are used as standard cylinder and R1 is the reading on the standard cylinder and R2 is reading on the thread to be inspected and then D the major diameter of thread can be calculated using this relationship S+ or –R1-R2. Whether we use + or - it depends on whether the standard the cylinder diameter is > the major diameter of thread or < the major diameter of thread.

You can see here the measurement process initially we have to take the measurement using the standard cylinder and the reading that is obtained is R1 and then we have to remove the standard cylinder place they thread to be inspected and then again you take the reading so this reading will be R2.

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Outside micrometer

The outside micrometer is quite suitable for measuring the external major diameter.

It is first adjusted for a cylindrical size (S) having approximately the same diameter as of screw thread to be inspected. This process is known as 'gauge setting'

Micrometer reading (R1) is taken on standard cylinder. After this, reading (R2) is taken on the major diameter of the thread.

D = Major diameter of thread = S ± (R1 – R2)

Then, we can conveniently use an outside the micrometer also for measurement of major diameter so the care should be taken to see that the crests of the thread are not over-pressurized. So when we move the anvil we should take care that as soon as to the anvil just to touches the crest of thread we should stop the rotation.

So again procedure is the same reading is taken with the standard cylinder that is the R1 we get and then the standard cylinder is removed and the screw thread is placed between anvils and reading R2 is taken and again using this relationship. We can calculate the major diameter of the thread.

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Numerical Problem

While measuring the major diameter of an external thread, a 35.5 mm diameter plain plug gauge is used as standard. The micrometer readings over the plug gauge and thread are 9.376 and 11.876 mm respectively. Calculate the thread **major diameter**.

R1 = 9.376 mm

R2 = 11.876 mm

S = 35.5 mm

Normally smaller diameter standard than screw is used

D= S + (R2-R1) = 35.5 + (11.876 – 9.376) = 38 mm

Now we will have a numerical problem or while measuring the major diameter of an external thread a 35.5 millimeter diameter line like gauge is used as standard the micrometer readings over the plug gauge and the screw thread are 9.376 millimeter and 11.876 millimeter respectively. Now we have to find the thread the major diameter. Now the data that is given is R1 is 9.376 millimeter.

This is a micro meter reading on the standard cylinder and then we have R2=11..876 millimeter this is very micro meter reading on the thread gauge screw thread and then S that is the standard cylinder diameter is 35.5 millimeter. Now in the measurement process of this type normally smaller diameter standard is used that is the diameter of standard is < the major diameter of screw.

So in that case we use this relationship D=S+(R2-R1) so the S value is 35.5 and R2 value is 11.876 millimeter and R1 value is 9.376 millimeter so the calculation will give us the major diameter of screw threads as38 millimeter.

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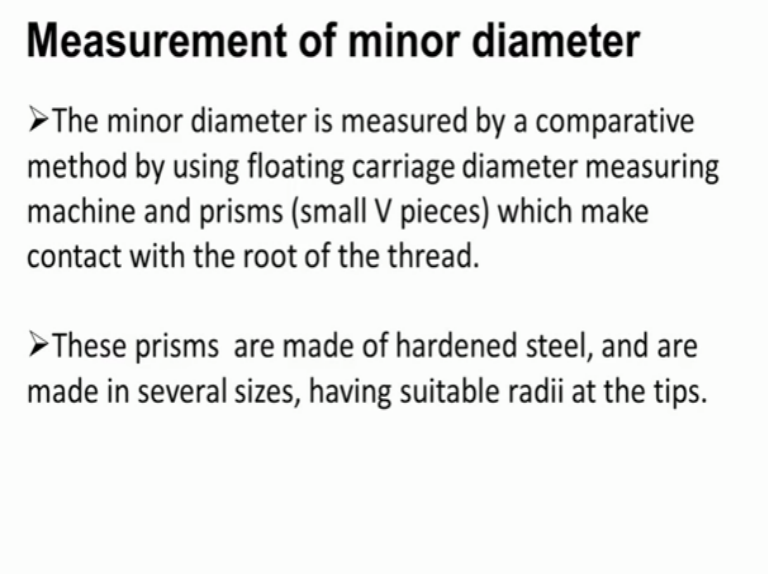

Now we will move to measurement of minor diameter the minor diameter is measured again by a comparative process. That means we use a standard cylinder and we take the measurement and then we put the screw thread to be inspected again we take the reading and then the using the

relationship. We calculate the minor diameter and floating carriage diameter measuring the machines can be conveniently used for measurements measurement of minor diameter.

The details about the floating carriage mission we will discuss after some time so use of prisms is made while measuring the minor diameter these prisms way look like the small V pieces and they make contact with the root of the thread the prisms are made of hardened steel and all made in the several sizes having suitable radii after the tips.

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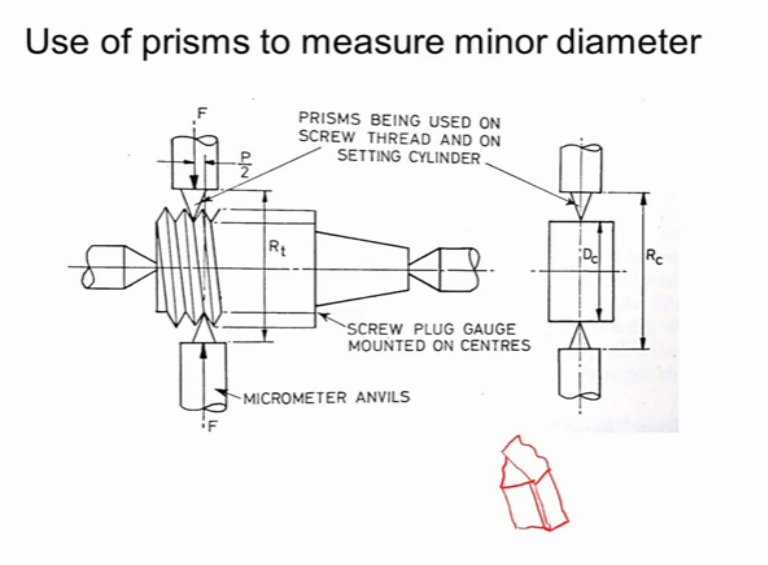

I can see here these are the prisms so this is the prism being used on screw thread as well as on the setting cylinder the prisms will look like this yeah so the, the asymmetric view of the prism model I have written here so this the sloping surface of the prism will not make any contact with the flank of thread as we can see here so this portion I am enlarging so this is the V prism and then we have a small radii here at the tip and then we have the screw thread profile.

So the sloping surface of the prism will not make any contact with the flank of the screw thread. The contact will be there only at the root using these prisms. You can conveniently measure the minor diameter of external screw threads there is an arrangement in a floating carriage machine. There is an arrangement to place these prisms hooks are provided using hooks they can suspend this prism and we can conveniently measure the minor diameter.

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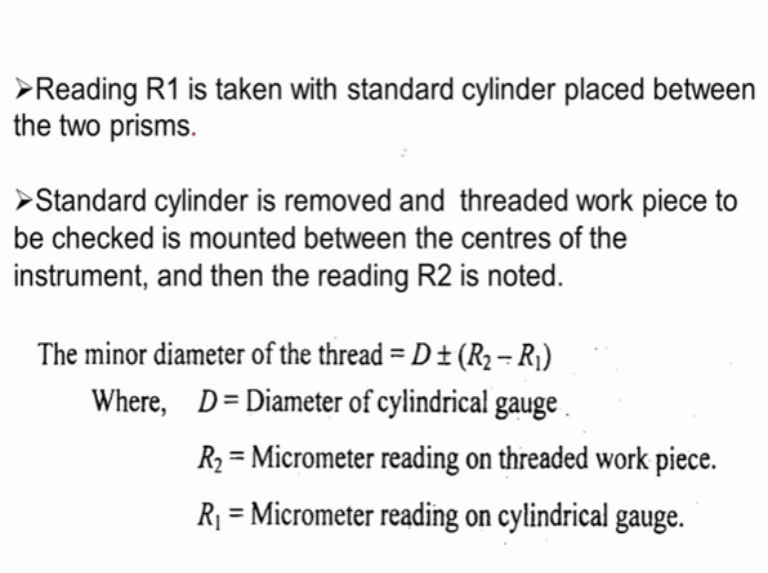

Now the procedure is similar to the measurement of the major diameter reading the R1 is taken with a standard cylinder placed between 2 prism and then the standard cylinder is removed and threaded the work piece which is to be inspected is mounted between the centre of the instrument and then reading micro meter reading R2 is noted down and then using this relationship we can find the minor diameter of the thread again.

Whether we use +or- symbol depends upon the size of for the standard cylinder whether it is the diameter is > the minor diameter or the diameter is < the minor diameter. Now using this relationship we can find out the minor diameter of a screw thread.

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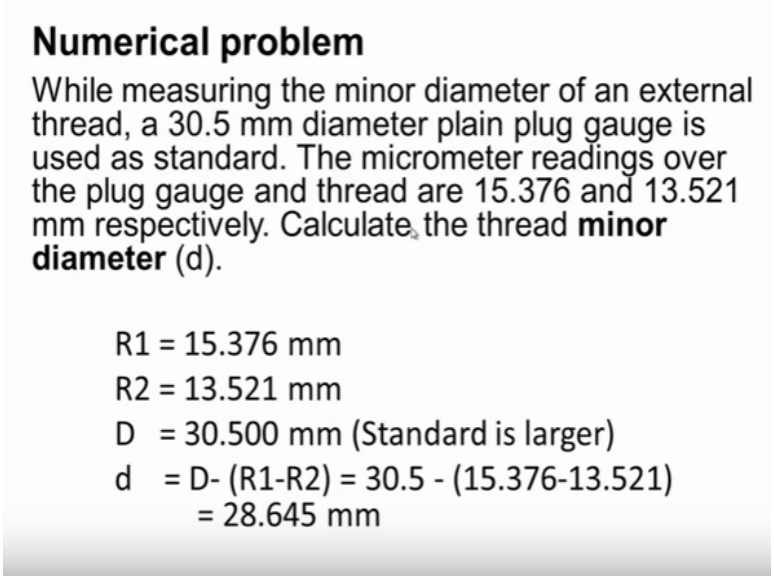

Now we will have a numerical problem here while measuring the minor diameter of an external thread 30.5 millimeter diameter plain plug gauge is used as a standard the micro meter readings over the plug gauge and thread are 15.376 millimeter and 13.521 millimeter respectively. We are required to calculate the minor diameter that is small d. Now the data that is given is R1=15.376 millimeter and R2 is 13.521 millimeter and diameter of the standard is 30.500 millimeter.

So in this case the larger diameter standard is used and minor diameter = D - since the diameter of standard is larger we are using this negative when D-(R1-R2) = we have to feed these values and finally we get the minor diameter that is 28.645 millimeters.

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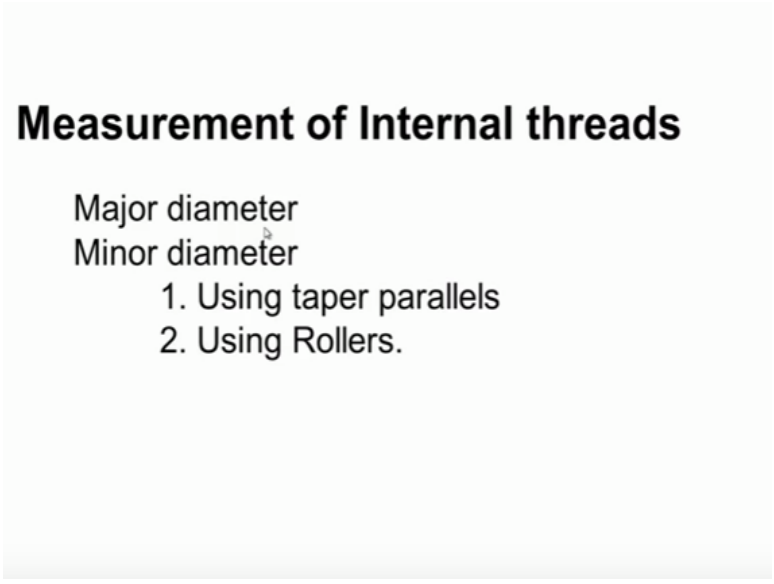

Now we will move on to the measurement of internal thread. Let us understand how to measure the major diameter of internal thread and minor diameter of internal metric the minor diameter can be measured by using tapered parallel and also by using the roller.

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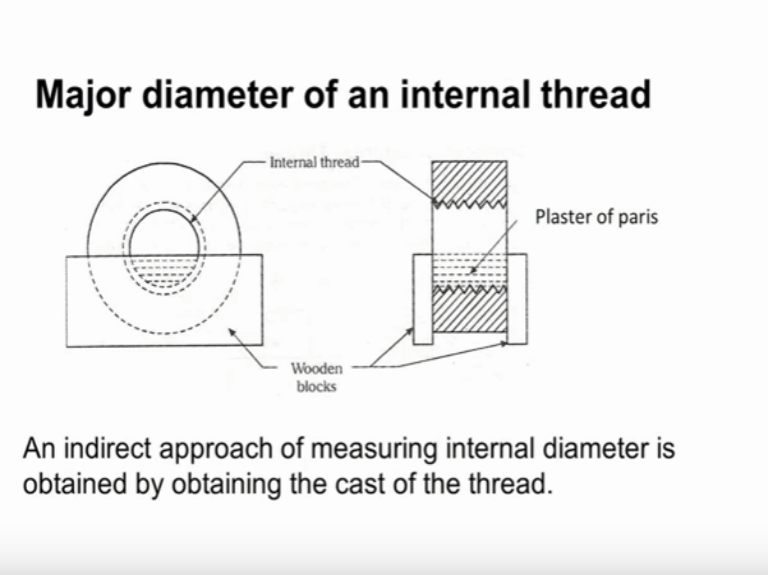

Now measurement of major diameter of internal thread, so for this we use a method called casting method you can see in this diagram this is a work piece having internal threads, whose measure diameter is to be measured. Now we have to take a replica of for this internal thread, so how do we get the replica of internal thread, you can see rearrangement.

The work piece with the internal thread on both sides of work piece like this we have to keep wooden blocks and then we have to pour either plaster of paris or dental wax or sulfur also can be used we had to put the plaster of Paris mixed with water or dental wax into this cavity and we should allow it to settle and then once it dries.

We have to remove the wooden blocks and then we have to remove the solidified plaster of Paris without rotating the plaster of Paris we have to just lift it we should take care that while pouring the plaster of paris it is the so this is the Center of the work piece you can see the level of this is a level of plaster of paris it is not crossing the center of or it is not crossing the radius of the workplace such care should be taken so that we can easily remove the solidified plaster of paris.

Now this casting will have the thread profile and then we using a bench micrometer they can measure the measure diameter of the internal thread.

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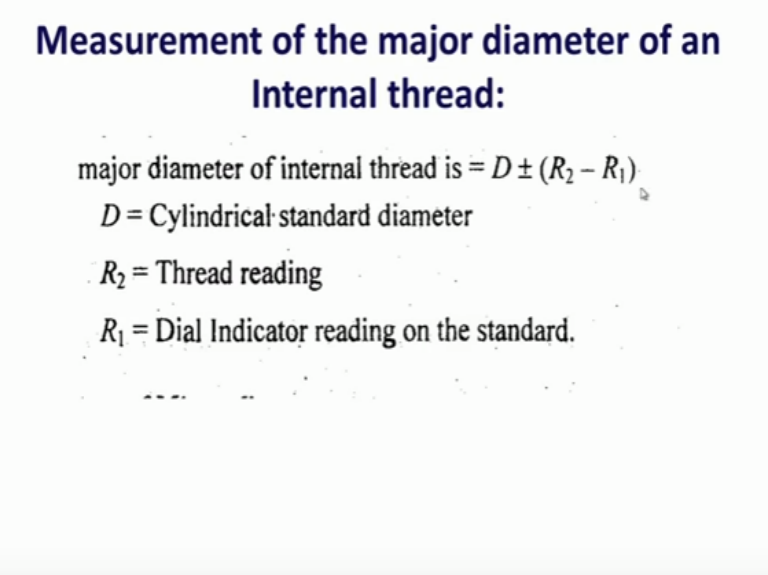

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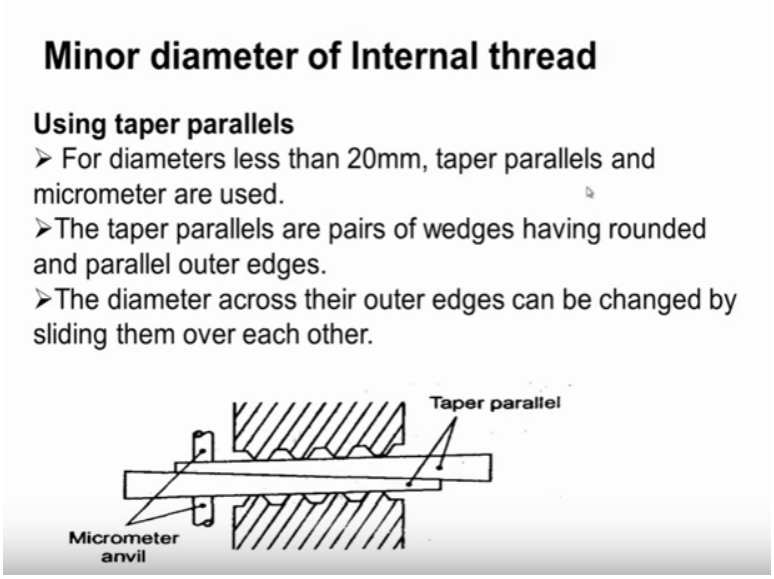

Again in the cast that is obtained we should measure R1 and R2 and then we should use this equation to find out the measure the diameter. Now how do we find the minor diameter of internal thread for that 2 methods are suggested so first method is using the taper parallels this is used when the diameter < 20 millimeter so taper parallel and micrometers are used for measurement of internal thread, so these taper parallels are pairs of wedges having rounded and

parallel outer edges so when we look from this side the parallels will look like this so they have a rounded edge.

So this curved surface will come in contact with the screw thread like this again other wedges used to a pair of wedges are used again this is the rounded edge and this is the screw thread now the distance between the outer edges of the parallels can be changed by moving them in this fashion so using this arrangement internal diameter of the screw threads of different sizes can be measured.

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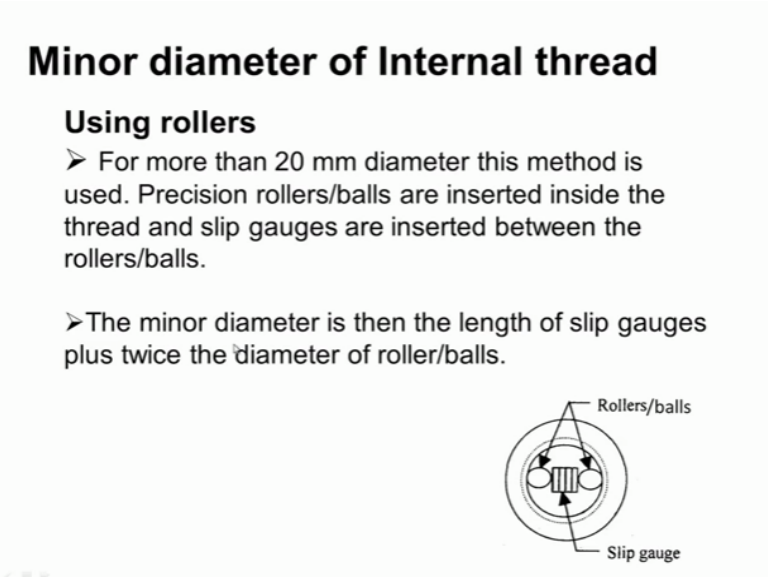

Now using the micrometer the distance between the outer edge rounded edge is measured, so that gives the minor diameter of internal thread. Now using the rollers or balls we can measure the internal threads, minor diameter of internal thread so this is used when the to thread the diameter is more than 20 millimeter precision rollers or balls are inserted inside, inside the thread as shown in this schematic diagram and the slip the edges are inserted between the rollers or balls so these are the roller or balls of same diameter.

They are in contact with the internal thread and the gap between the rollers or balls is filled with the slippage and then the minor diameter is calculated by adding the diameter of these 2 rollers + slip gauges width now let us conduct an experiment to show the measurement of minor diameter of internal thread.

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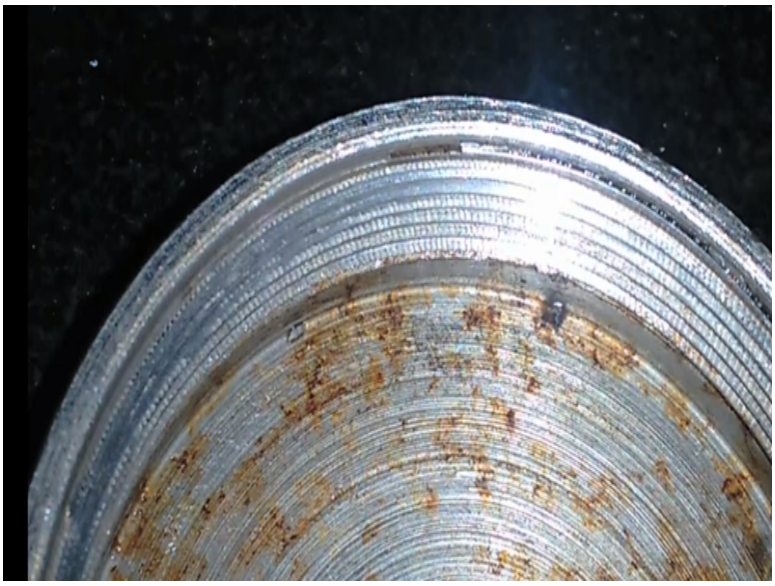

We can see a component having internal threads you can see here these are the internal thread now we are required to measure the minor diameter of a internal thread. So for this I am using 2 steel balls and slip gauge box, initially we should measure the approximate minor diameter using a vernier caliper.

So the approximate minor diameter as measured using a vernier calliper is 55,56,58 millimeter and then we have to add the vernier scale reading so it is 20th reading 20th line is coinciding with a bend scalar mark so the vernier reading is 20 into point 0 2. Now we have to keep the 2 steel balls inside where to measure what is the diameter of steel ball we can see steel ball diameter is 12 millimeter and then we are to note down the vernier reading.

The second steel ball diameter also should be mentioned to ensure that both are having same diameter again you can see the measure the diameter is 12 millimeter and then we have to note down the vernier reading. Now the we should measure the approximate distance between the 2 steel balls, so that they can easily build the slip gauge assembly.

You can see the approximate distance between steel balls is 43 millimeters and then we should see the coinciding the division. Now I am building the slip gauge assembly and slip gauge should be filled between the steel balls I am taking 20 millimeter slip gauge 9 millimeter slip gauge and

1.006 1.005 millimeter slip gauge 2 millimeters slip gauge I am ringing and then 1.23 millimeter slip gauge and finally 1.006 millimeter slip gauge.

Now the assembly and trying to insult between the 2 steel ball, so it is not entering this gap so the width of assembly is greater the gap between steel ball so we have to again reduce the width, now I am taking the 1.001 millimeter slip gauge I removed 1.001 millimeter slip gauge. Now you can see it is entering the assembly is entering in the gap between the 2 steel balls, so now this is the width of the slip gauge assembly that is 33.231 millimeter the total width is 33.231 millimeter.

Then we have to add diameter of this steel ball and diameter of this steel ball to get the minor diameter of internal thread. Now in the experiment we observed that ball diameter is 12.56 millimeter and gap between balls she is 33.231 millimeter so the minor diameter is 2x the ball diameter + the gap between the balls. So finally, we get 58.351 millimeter, so this is the minor diameter of internal thread let us summarize this lecture in this lecture.

We discussed about the different methods of making the screw thread and how they are classified and what are the various types of screw threads first normally used we also discussed about the 2 thread terminology and then we studied about the measurement of major diameter and minor diameter of external screw thread and internal screw thread with this we will conclude this session. Thank you.