Inspection and Quality Control In Manufacturing
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Lecture – 18
Screw Thread Metrology

Hello my friends today we are going to discuss about the new chapter that is screw thread metrology. So, before going to start just let us know that what is screw thread and why it is having so a high importance. So, generally screw thread when we are talking about generally we are talking about some kind of mechanical fastener right.

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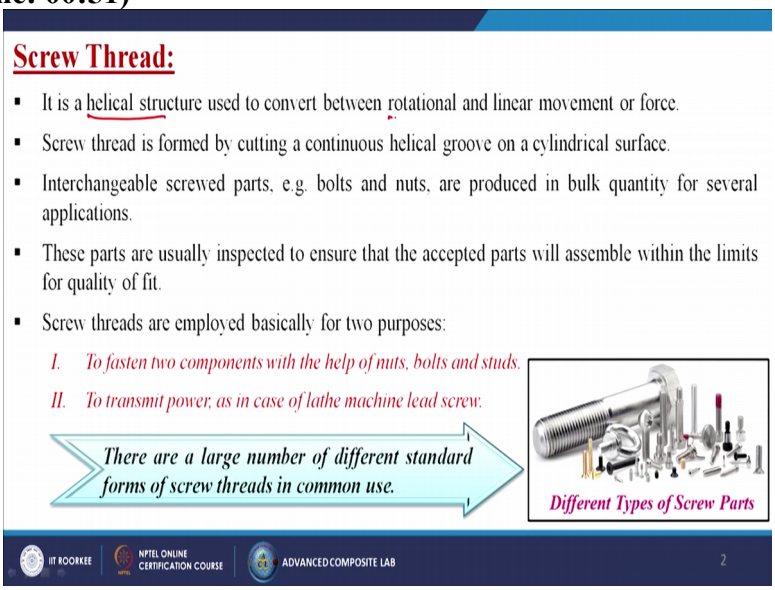

So, it is a one kind of helical structure used to convert between the rotational and linear movement or force. Screw thread is formed by cutting a continuous helical groove on a cylindrical surface. So, now from that particular thing you can understand that generally we are using the screw or maybe the nut and bolt arrangements for some kind of temporary joining process. So, now interchangeable screw parts like bolts and nuts are produced in bulk quantity for several applications, yes.

Because it is not that every bolt and nuts can tie together. So, every bolt according to that bolt internal diameter specifications or maybe that according to the bolt outer thread specifications and not the internal thread specifications so it should be compatible right. So, it does not means that every size can fit with the any size of nut and bolt. So, these parts are usually inspected to ensure that the excepted parts will assemble within the limits of quality of fit.

Screw threads are employed basically for the two purposes what are those as I told already so first one is that to fasten two components with the help of nuts bolts and the studs and the

second is that to transmit power as in case of lathe machine lead screw. So, sometimes it is trying to help to join or maybe sometimes it is helping the whole systems. So, these are the large number of different standard form of screw threads in the common use you can see.

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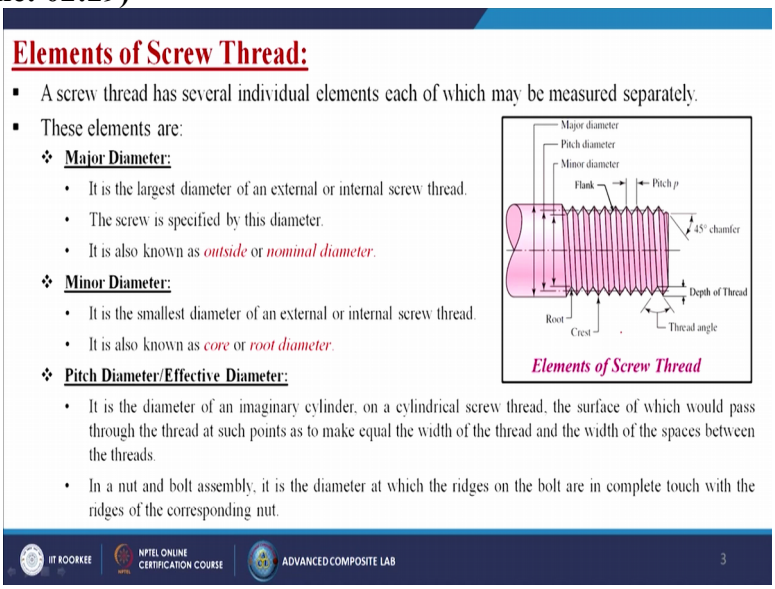

Now what are the elements of the screw thread? So, is screw thread has several individual elements each of which may be measured separately okay. So, now when we are designing that screw so we have to keep in mind all these things or maybe sometimes when we are preparing the screw so after manufacturing so how we can measure that whether the thread is proper or not or whether the design is proper or not or maybe whether that a screw thread is within the tolerance limit or not that these kind of things we should know.

So, first let us know what are those element? So, first one is the major diameter so it is the largest diameter of an external or internal screw thread. So, whatever I am talking about from this particular image you can understand everything. So, this is the major diameter over there the screw is specified by this diameter only it is also known as outside or maybe the nominal diameter. Next come to the minor diameter it is the smallest diameter of an external or internal screw thread it is also known as core or maybe the root diameter.

So, when we are talking about this is the; our minor diameter okay so from here these two this. Next come to the pitch diameter or maybe the effective diameter it is the diameter of an imaginary cylinder on a cylindrical screw thread the surface of which would pass through the thread at such points as to make equal the width of the thread and the width of the spaces between the threads. So, this is the pitch diameter. In a nut and bolt assembly it is the diameter at which the ridges on the bolts are in complete touch with the ridges of the corresponding nut.

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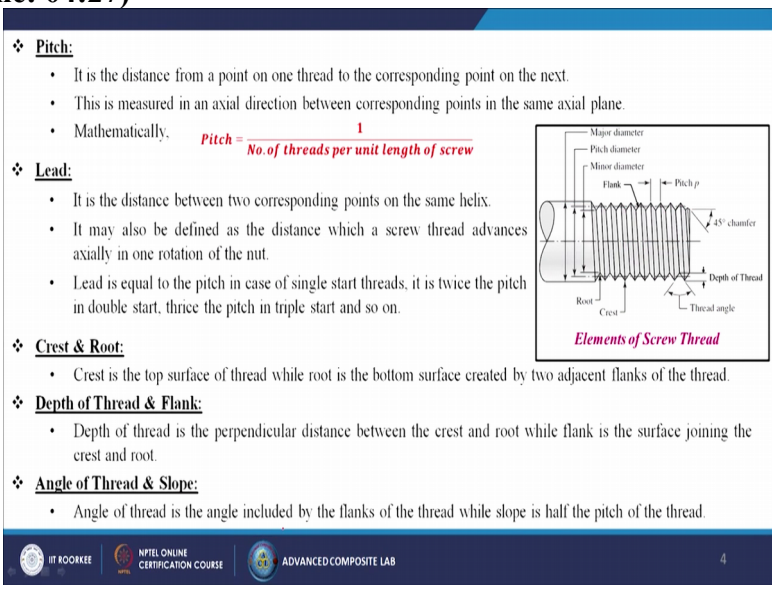

Now come to the pitch so the pitch is a very vital parameter for the screw thread so it is the distance from a point on one thread to the corresponding point on the next so this is the pitch. This is measured in an axial direction between corresponding points in the same axial plane so same axial plane it is situated mathematically pitch = 1by number of threads per unit length of screw. Now come to the lead so it is the distance between two corresponding points on the same helix.

So, now it may also be defined as the distance which a screw thread advances axially in one rotations of the nut. So, now I am having this one and I am tithing it so particular single rotations how much it is going forward. So, lead is equal to the pitch in case of single start threads it is twice the pitch in double start and thrice the pitch in triple start and so on. Next Crest and root, so Crest is the top surface of the thread Y so this is this point so this point nt is known as the crest.

So, crest is the top surface of thread while root is the bottom surface created by two adjacent flanks on the thread itself. So, now this is root depth of thread and flank depth of thread is the perpendicular distance between the crest and root while the flank is the surface joining the crest and the root. So, this is the depth of thread and this is known as the flank. Next come to the angle of thread and slope. Angle of thread is the angle included by the flanks of the thread while slope is half of the pitch of the thread.

So, now you can see that here we are giving certain kind of thread angle over there we are giving certain chamfer like 45 degree chamfer over there so these all are the extra things.

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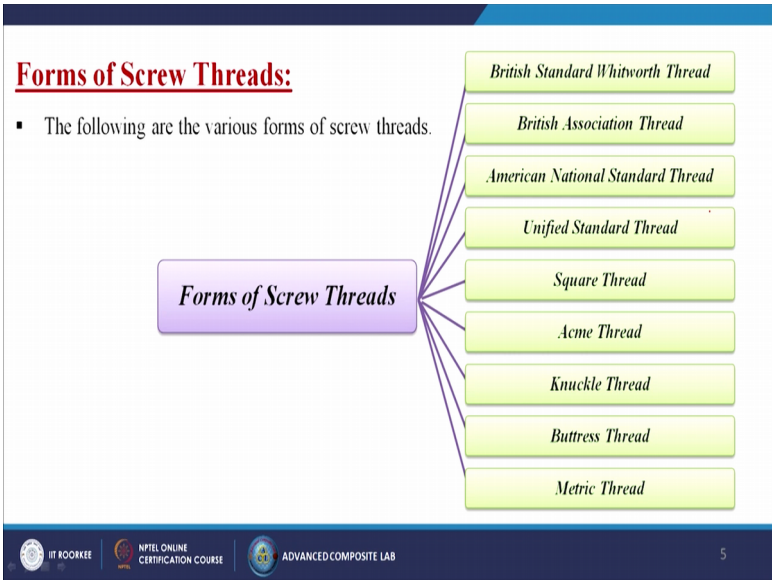

So, now forms of screw threads the following are the various forms of screw threads what are those first one is called the British standard Whitworth thread then British Association thread then American national standard thread then unified standard thread then square thread, Acme thread, Knuckle thread, buttress thread and the metric thread.

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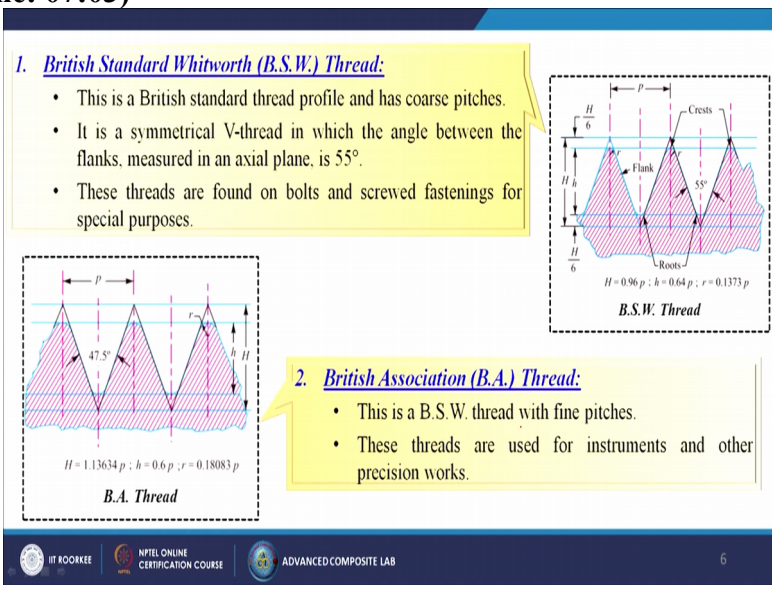

Now we will discuss one by one so first it is coming the British Standard Whitworth thread or in short generally we are calling it as a BSW. So, this is a British Standard thread profile and has coarse pitches. It is a symmetrical v thread in which the angle between the flanks measure in an axial plane is 55 degree. These threads are found on bolts and screwed fastenings for special purposes.

So, here this angle it is the 55 degree angle now when you are talking about the British Association thread so this is a BSW thread with the fine pitches. These threads are used for

instruments and other precision work so this is the example of the BA thread. So now you can see that angle is 47.5 degree.

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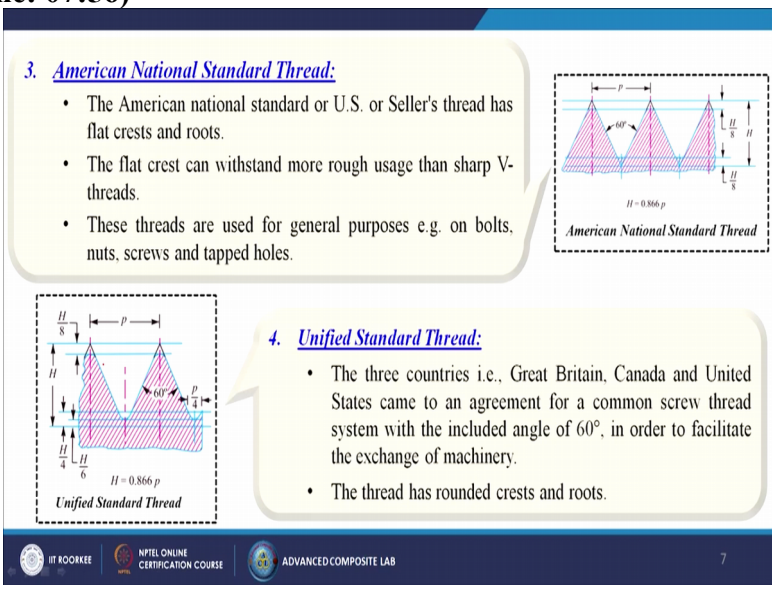

Next come to the American national standard thread. So, the American national standard or US or Seller's thread has flat crest and roots the flat crest can withstand more rough usage than sharp V threads. These threads are used for general purpose like on bolts nuts cruise and tapped holes. So, in this particular case you can see the angle is larger than the BSW that is 60 degree. Now we can talk about the unified standard thread.

The three countries like Great Britain, Canada and USA came to an agreement for a common screw thread system with the included angle of 60 degree in order to facilitate the exchange of machinery so that means what one country is preparing some kind of equipments then when they are exporting that equipments to some other country and maybe some problem creates so that they are keeping their instruments in such a manner that that country also can produce this kind of thread and they can easily replace that one.

So, if the machine will be break down then no need to wait for a longer time that the material will come from different country so in this way they are doing. So, the thread has rounded crest and roots. So, here you can see it is not sharp so it is having some roundness.

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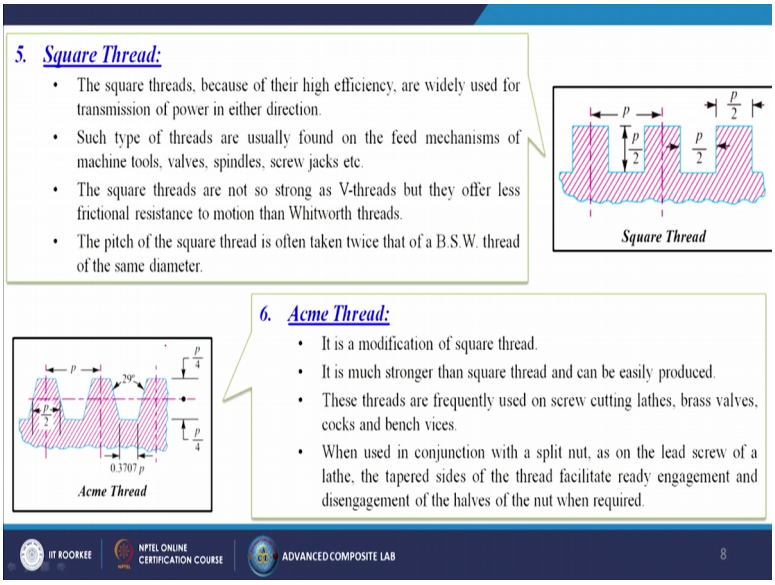

Next come to the square thread the square threads because of their high efficiency are widely used for transmission of power in either direction such type of threads are usually found on the feed mechanisms of machine tools, valves, spindles, screw jacks. The square threads are not so strong as with threads but they offer less frictional resistance to motion than Whitworth threads.

The pitch of the square thread is often taken twice that of a BSW thread of the same diameter. So, now here P and this is the P / 2 so this is the square thread so where we need the maximum mechanical strength generally that time we are using this kind of square thread. Now come to the ACMA thread it is a modification of square thread it is a much stronger than square thread and can be easily produced these threads are frequently used on screw cutting lathes, brass valves, Cocks and the bench vices.

When used in conjunction with a split nut as on the lead screw of a lid the tapered sides of the thread facilitates ready engagement and disengagement of the halves of the nut when required so from this particular case you can understand that how we are making. So, in the screw thread case this was the total perpendicular normal now we are giving a certain angle that is the 29 degree over there.

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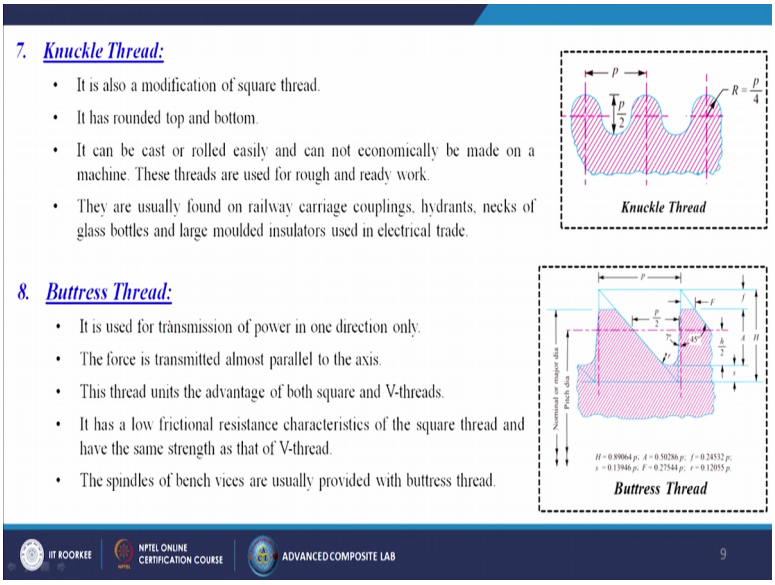

Next come to the knuckle thread so it is also a modification of square threat it has a rounded top and bottom. So, you see this is the image it can be cast or rolled easily and cannot economically be made on a machine these threads are used for rough and ready work. They are usually found on railway carriage couplings, hydrants, mix of glass bottles and large molded insulators used in electrical train.

Now come to the buttressed thread it is used for transmission of power in one direction on only okay the force is transmitted almost parallel to the axis. These thread units the advantage of both Square and V threads. It has low frictional resistance characteristics of the square thread and have the same length as that of V threaded. The spindles of bench vices are usually provided with buttress thread so this is the image.

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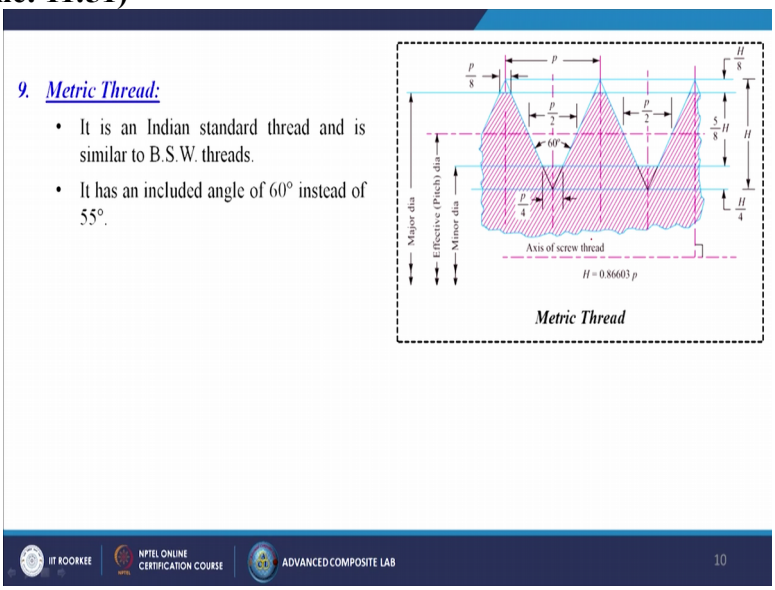

Now come to the metric thread it is an Indian standard thread and it is similar to BSW thread it has an included angle of 60 degree instead of 55 degrees. So, if you remember that when I

talked about the BSW threads that time this angle was 55 degree now it became the 60 degree that is that difference over there from the BSW thread and the Metric thread. Now we have discussed about the different types of threats but how to measure this diameter how to measure the maximum diameter minimum diameter pitch, angle, radius everything.

So, now what kind of techniques generally we should adopt so there are some kind of techniques to measure the quality of the threaded element.

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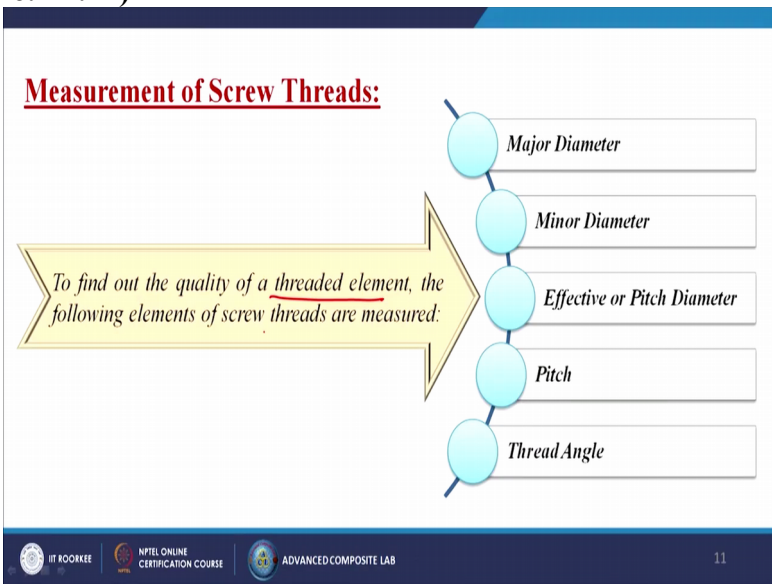

The following elements of screw threads are measured like major diameter, minor diameter effective or piece diameter, pitch, thread angle so, these all are the parameters. Now first let us start with that how we can measure the major diameter.

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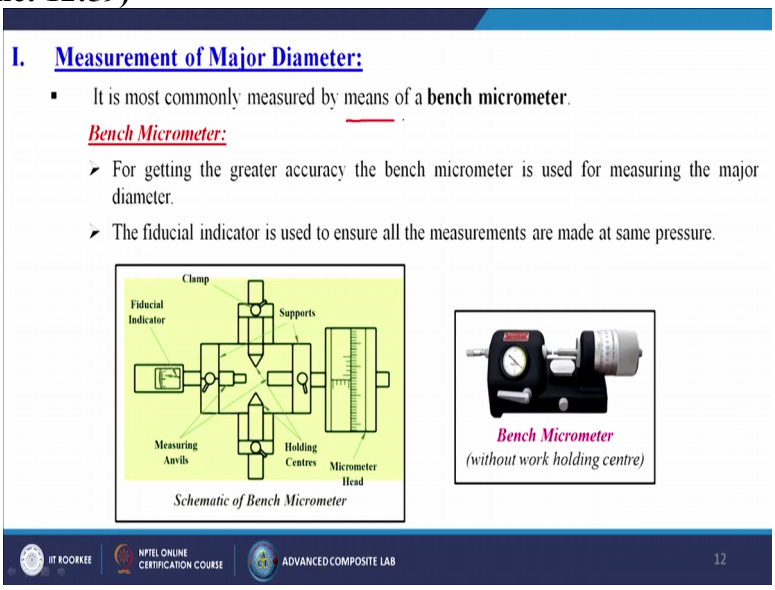

It is most commonly measured by means of a bench micrometer. What is bench micrometer? For getting the greater accuracy the bench micrometer is used for measuring the major diameter. The fiducial indicator is used to ensure that all the measurements are made at same

pressure. So, in this particular case this is the schematic of the bench micrometer so this is the micrometer head we are having these all are the holding centers these two points and these are the measuring anvils and these two plates are the supporters. So, now this is the overall image of that bench micrometer without work holding center.

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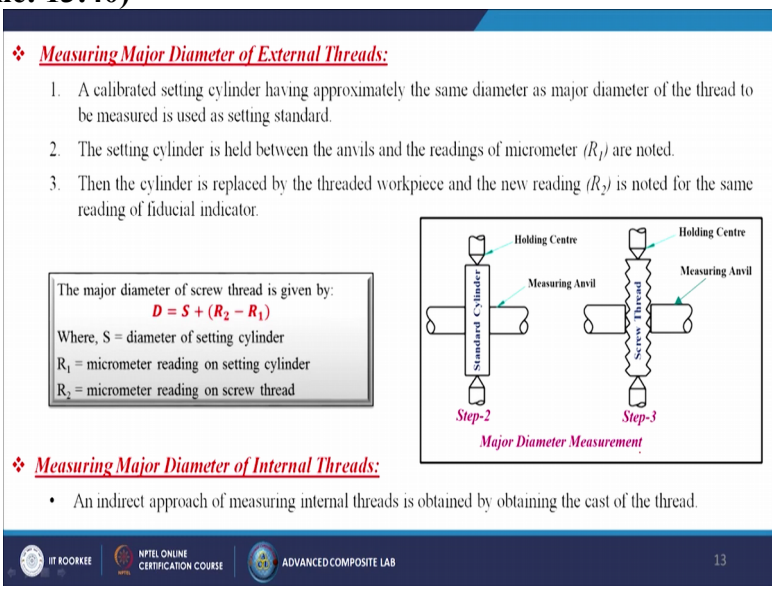

Now how we are using measuring major diameter of external threads a calibrated setting cylinder having approximately the same diameter as major diameter of the thread to be measured is used as setting standard. The setting cylinder is held between the anvils and the readings of micrometers are noted then the cylinder is replaced by the threaded workpiece and the new reading is noted for the same reading of fiducial indicator.

So, the major diameter of the screw thread is given by d = S + R2 - R1 what is S that is the diameter of setting cylinder then R1 micrometer reading on setting cylinder R2 micrometer reading on screw thread so simple what just we are doing one shadow kind of things. So, we are having the same external diameter cylinder we are measuring it and then we are putting our screw in between that and we are measuring the outer diameter. So, first we on the basis of some reference we are measuring the, our product.

Now measuring major diameter of internal threads and indirect approach of measuring internal threads is obtained by obtaining the cost of the thread.

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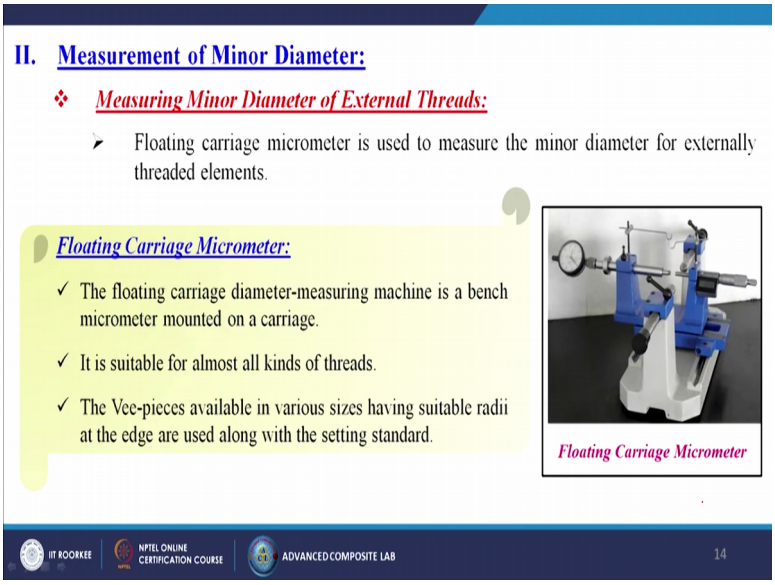

Now measurement of minor diameter how we can measure the minor diameter? So, floating carriage micrometer is used to measure the minor diameter for externally threaded elements so this is the equipments. So, how we are doing the floating carriage diameter measuring machine is a bench micrometer mounted on a carriage it is suitable for almost all kinds of threads. The V pieces are available in various sizes having suitable ready at the age are used along the setting standard.

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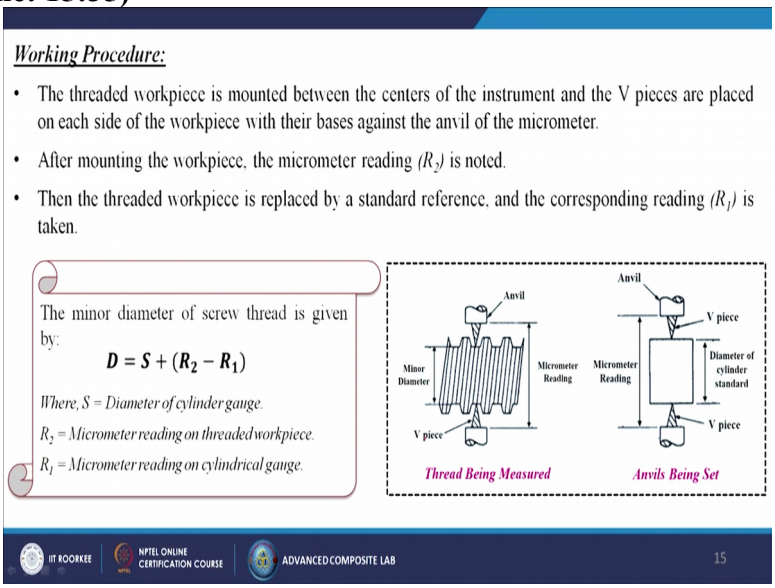

Now working procedure so the threaded workpiece is mounted between the Centers of the instrument like this way and the V pieces are placed on each side of the workpiece with their basis against the anvil of the micrometer. Now this is the V spaces over there after mounting the workpiece the micrometer reading is noted R2 then the threaded workpiece is replaced by a standard reference and the corresponding reading R1 is taken.

So, the minor diameter of screw thread is given by D = S + R2 - R1 where S is the diameter of the cylinder gauge R2 is the micrometer reading on threaded workpiece R1 is a micrometer reading on cylindrical gauge so same thing we are doing the shadowing kind of things.

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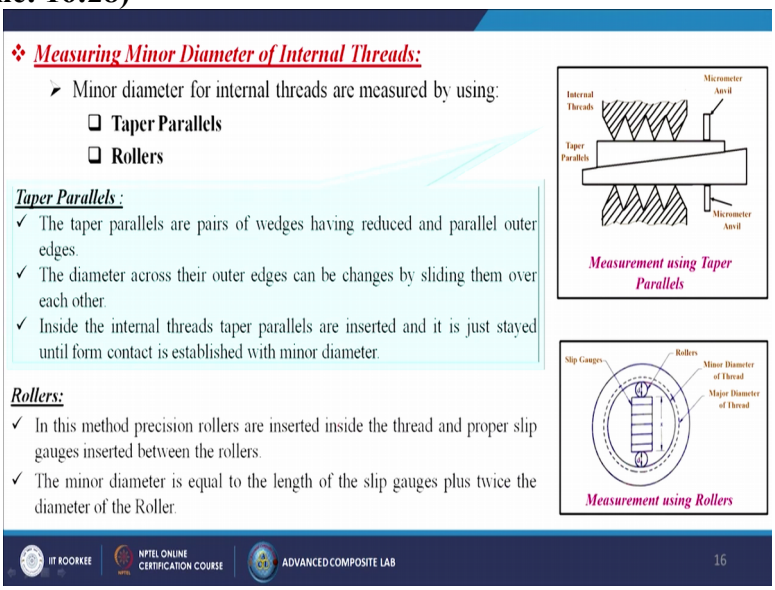

Now measuring minor diameter of internal threads till now we are discussing about the external threads now if I am having the internal threads so minor diameter for internal threads are measured by using taper parallels and the rollers. So, what is taper parallels? The taper parallels are pairs of wages having reduced and parallel outer edges the diameter across their outer edges can be changes by sliding them over each other.

Inside the internal thread taper parallels are inserted and it is stayed until from contact is established with minor diameter so this case so here this is the micrometer and below over there okay. And then this is known as the taper parallels so now I am having the internal threads over there so it should touch the points over there. Now if I want to use the rollers then how we can do it? In these standard precision rollers are inserted inside the thread and proper slip gauges inserted between the rollers.

So this is all are the slip gauges this depends it is not the fixed quantity it depends upon the diameter over there okay but the roller diameter that is fixed then depending upon your internal one then how many gauges are required that it is in your hand. So, the minor diameter is equal to the length of the slip gauges plus twice the diameter of the roller because this one side is the d and this one side is the d so, it should be d + d.

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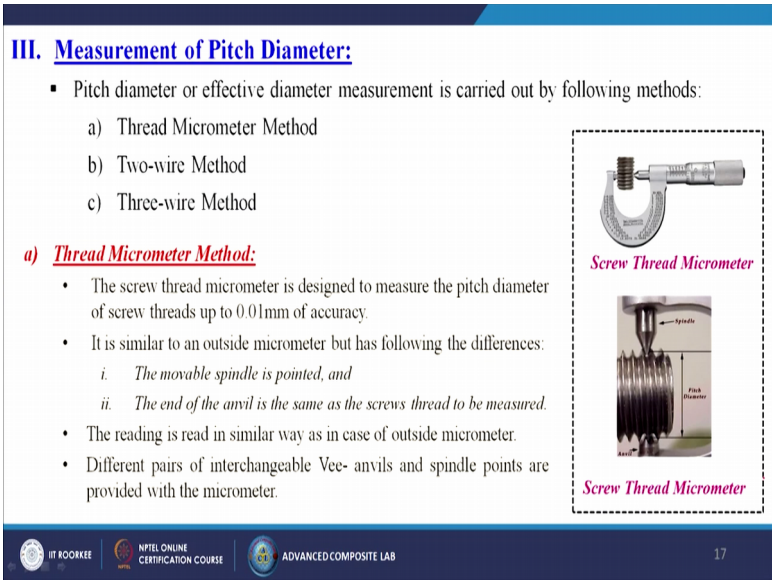

Now we are going to discuss about the third one that is the measurement of pitch diameter. So, pitch diameter or effective diameter measurement is carried out by following methods what is that thread micrometer method, two wire methods and the three wire method. So, first is called the thread micrometer method. So, the screw thread micrometer is designed to measure the pitch diameter of screw threads up to 0.01 millimeter of accuracy. It is similar to an outside micrometer but has following the differences what are those?

First one is the movable spindle is pointed and the end of the anvil is the same as the screw thread to be measured. So, the reading is read in similar ways as in case of outside micrometer, different pairs of interchangeable Vee and anvils and spindle points are provided with the micrometer itself. So, here in this particular case you can see so that is known as the supporter anvil okay.

This is the pitch diameter over there and this is the spindle and if you see carefully that spindle is having a very sharp point over there so it can go up to that pitch diameter.

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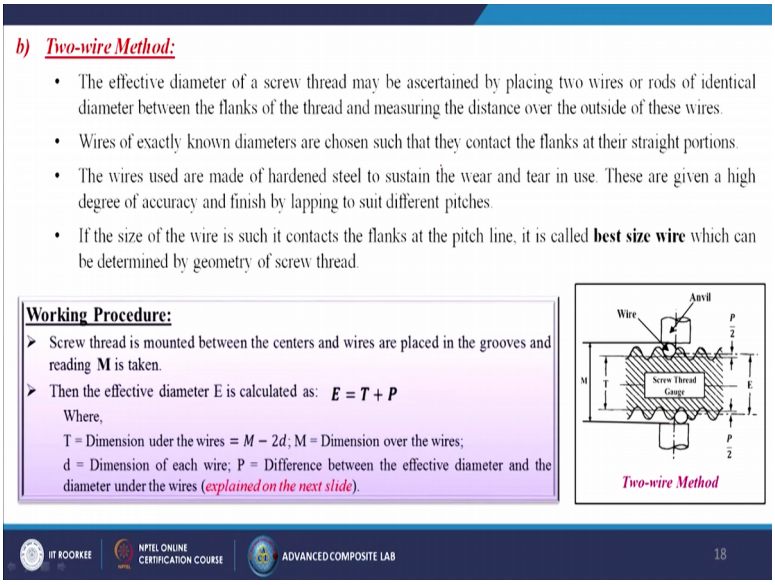

Next second one is that to wire method so the effective diameter of a screw thread may be ascertain by placing two wires or rods of identical diameter between the flanks of the thread and measuring the distance over the outside of these wires. Wires are exactly known diameters are chosen such that they contact the flanks at their straight portions. The wires used are made of hardened steel to sustain the wire and tear in use.

These are given a high degree of accuracy and finish by lapping to switch different pitches. If the size of the wire is such that it contacts the flanks at the pitch line it is called the best size wire. So, simple you can see that we are inserting the wire over there. So, that wire diameter should be like that it should be touched the maximum points over there which can be determined by geometry of screw thread so working procedure screw thread is mounted between the Centers and wires are placed in the groups and reading aim is taken as I told.

Then the effective diameter E is calculated as E = T+ P, so this is the things what is T that is a dimension under the wires that is M – 2d, M is the dimension over the wires, d dimension of each wire P difference between the effective diameter and the diameter under the wires I will do the explain of this one in the next slides.

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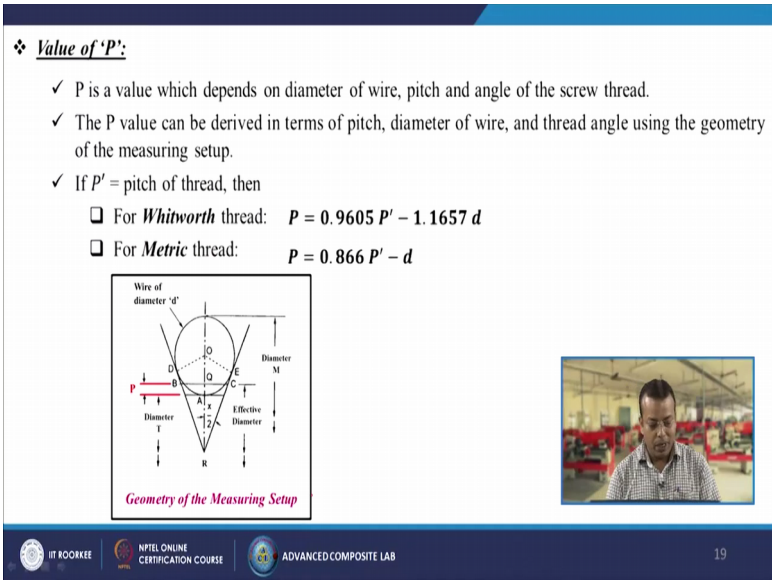

So, what is value of P so generally the P is a value which depends on diameter of wire pitch and angle of the screw threads so, this is the wire actually. So, the wire diameter is d over there the P value can be derived in terms of pitch diameter of wire and thread angle using the geometry of the measuring setup if P prime is the pitch of the thread then for Whitworth thread P = 0.9605 P prime – 1.1657 d. For metric that capital P =0.866 P prime -d so like this we can measure.

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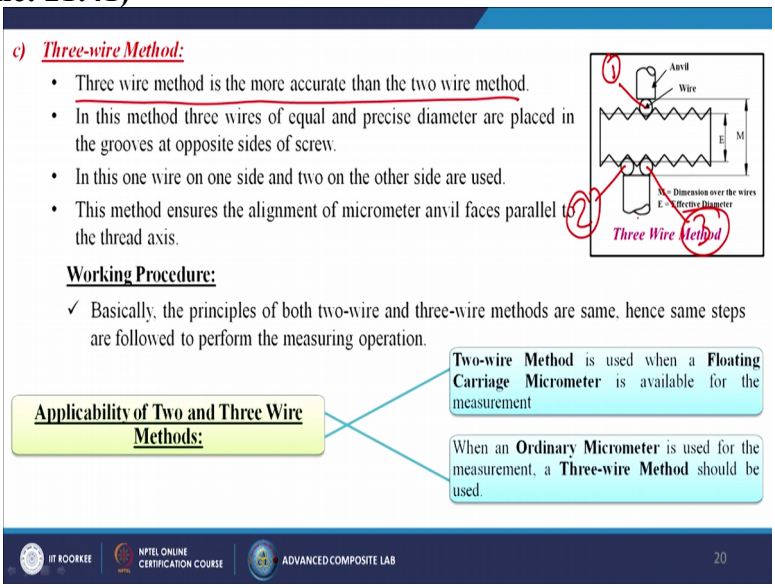

Next come to the third one that is the 3 wire method so in the 3 wire method is the more accurate than the 2 wire method now it is 1 this is 2 and this is the 3. So, that is why it is called the 3 wire method. In this method 3 wires of equal and precise diameter are placed in the groups at opposite sides of screw in this one wire on the on one side and 2 on the other sides are used. Now you can see this method ensures the alignment of micrometer and will faces parallel to the thread axis.

Now what is the working procedure basically the principles are both 2 wire and 3 wire methods are same. Hence same steps are followed to perform the measuring operations. So, what is the applicability of 2 and 3 wire methods, 2 wire methods is used when a floating carriage micrometer is available for the measurement when an ordinary micrometer is used for the measurement a 3 wire method should be used. So, these are the applications.

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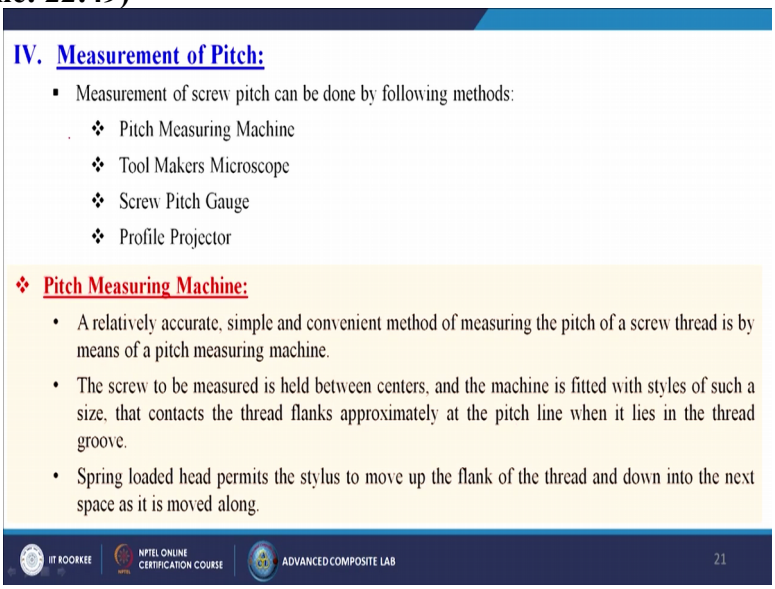

Next measurement of pitch so measurement of screw pitch can be done by following methods one is called the pitch measuring machines second is called the tool makers microscope third is the screw pitch gauge and the 4rth is the profile projector. So, what is pitch measuring machines a relatively accurate simple and convenient method of measuring the pitch of a screw thread is by means of a pitch measuring machine.

The screw to be measured is held between centers and the machine is fitted with styles of such a size that contacts the thread flanks approximately at the pitch line when it lies in the thread group 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.

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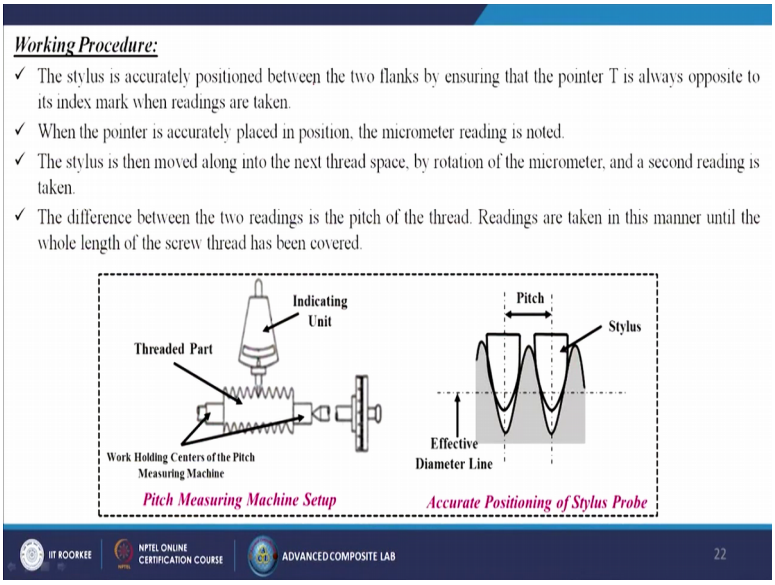

Now working procedure the stylus is accurately positioned between the two flanks by ensuring that the point at T is always opposite to its index mark when readings are taken. So, in this case this is the indicating unit okay this is my thread part over there and these two are the work holding centers of the pitch measuring machines so I am going to measure like this. So, when the pointer is accurately placed in positions the micrometer reading is noted.

So, you see the stylus it is touching at the pitch it is okay. Now the stylus is then moved along into the next thread space by rotations of the micrometer and a second reading is taken the difference between the two readings is the pitch of the thread readings are taken in this manner until the whole length of the screw thread has been covered so total pitch I can measure.

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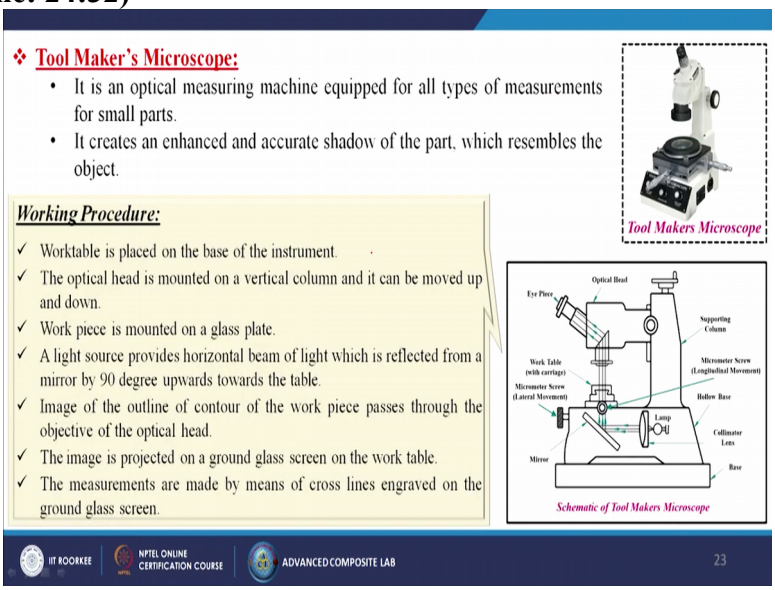

Next toolmakers microscope it is an optical measuring machines equipped for all types of measurements for small parts it creates an enhanced and accurate shadow of the part which

resembles the object simple I am having the screw thread I am seeing it through some micrometer and course that micrometer is having some scales or maybe some readings by which I can measure easily.

So, now what is the working procedure what table is placed on the base of the instrument so I am having that work table at this particular case ok so this is the base and this is known as the work table. The optical head is mounted on a vertical column and it can be moved up and down so this one this can be adjustable workpiece is mounted on glass plate a light source provides horizontal beam of light which is reflected from a mirror by 90 degree upwards towards the table so simple here my eye and I can see it so light source is coming and it is falling onto your screw threads just exactly the 90 degree.

Image of the outline of contour of the workpiece passes through the objective of the optical head the image is projected on a ground glass screen on the work table the measurements are made by means of cross lines engraved on the ground glass screen.

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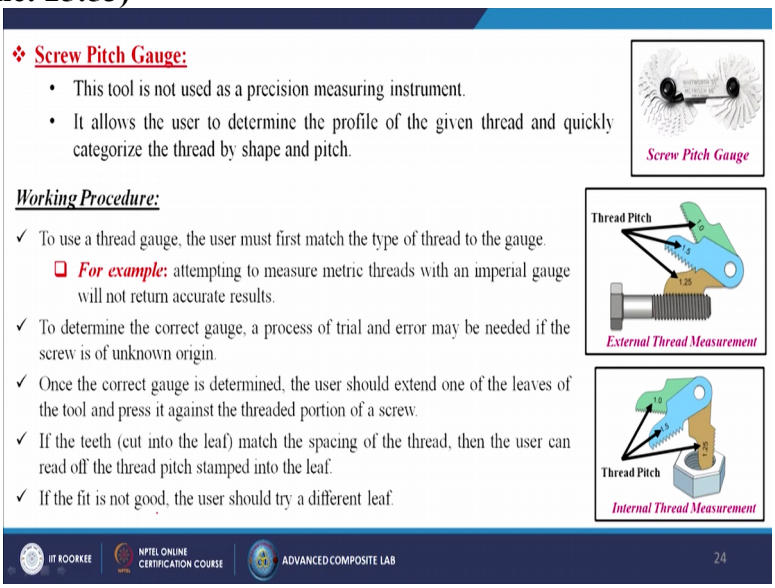

Next screw pitch gauge this tool is not used as a precision measuring instruments it allows the user to determine the profile of the given thread and quickly categorize a thread by shape and pitch. So, working procedures see before going to tell you the working procedure by this seeing this image you can easily understand that we are having the different value that pitch gauge having so simple one by one I am matching with my thread itself and if it will be fully matching so simple from this value I can get the exact pitch of my parts.

So, now what is the working procedure to use a thread gauge the user must first match the type of thread of the gauge for example attempting to measure metric threads with an imperial gauge will not return accurate results to determine the correct gauge a process of

trial and error may be needed if the screw is of unknown origin. If I am having certain kind of assumptions so directly I can put that exact value over there but if it is not known to me then that time I have to the matching over there and which will value which particular value will match properly then only I can say.

Once the correct gauge is determined that user should extend one of the leaves of the tool and press it against the threaded portions of his screw. If the teeth cut into the leaf match the spacing of the thread then the user can read off the thread pitch stamped into the leaf so this is the value. If the fit is not good the user should try a different leaf. So, that is why I told you because that maybe there is due to some human error due to some other problem may be it varies from person to person.

I am thinking that 1.5 is matching particularly very good but somebody can get that maybe 1.25 is matching properly so that is why this is one kind of techniques which we cannot use for the high precision purpose.

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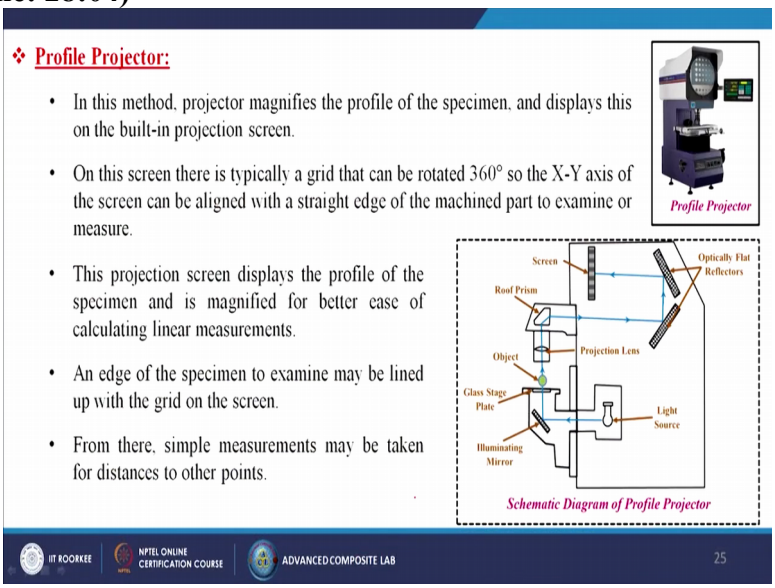

Next is called the profile projector so in this method projector magnifies the profile of the specimen and displaced on the built-in projection screen on this screen there is typically a grid that can be rotate 360 degrees so the XY axis of the screen can be aligned with a straight edge of the machine part to examine or measure. This projection screen displays the profile of the specimen and is magnified for better easy of calculating the linear measurements.

So, now we are having that light source illuminating mirror then glass stage plate and then we are having that object right then we are having the roof prism and this one is the reflectors and then it is coming to the screen which we are seeing. And age of the specimen to examine

may be lined up with the grid on the screen from there simple measurements may be taken for distances to other points.

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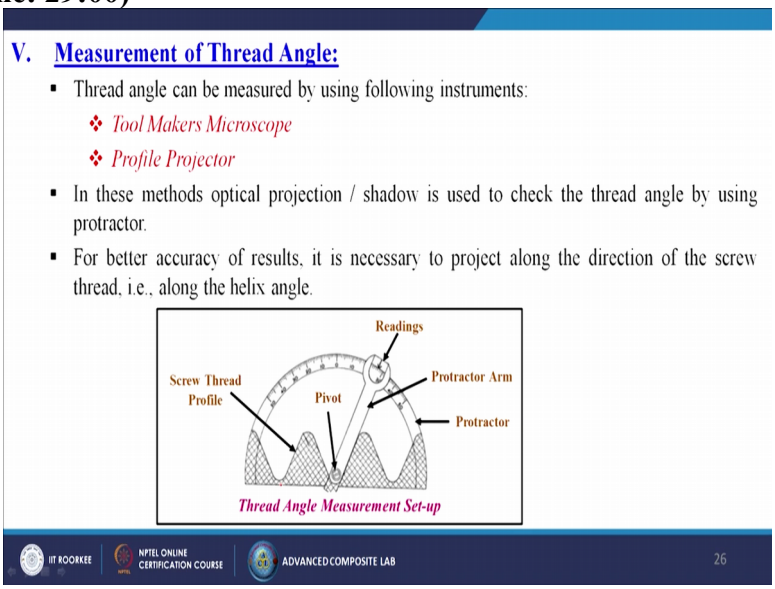

Now come to the 5th part that is the measurement of thread angle. So, generally the thread angle can be measured by using the following instruments one is called a toolmakers microscope and the second one is called the profile projector. In these methods optical projections shadow is used to check the thread angle by using protector. So, simple I am measuring what is the angle over there for better accuracy of results it is necessary to object along the direction of the screw thread along the helix angle so simple by projector I can measure this kind of angle over there.

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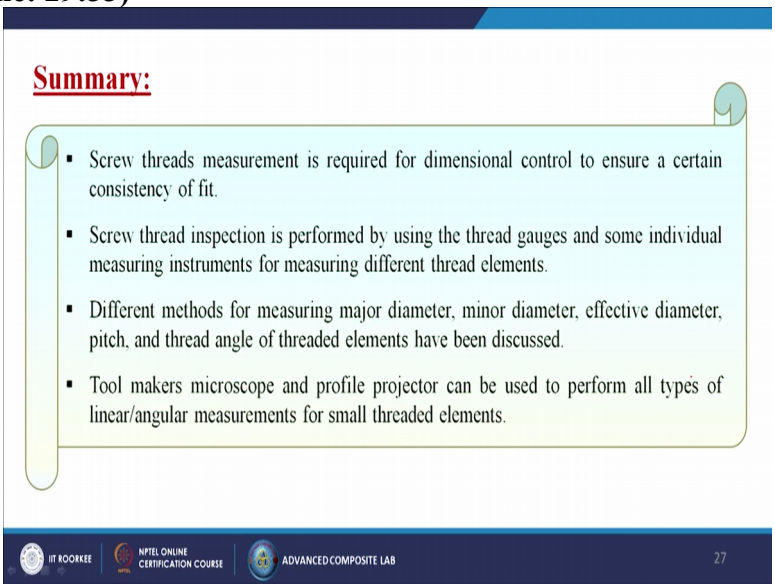

Now we have come to the last slide of this particular lecture so in summary we can say that screw threads measurement is required for the dimensional control to ensure a certain consistency of fit if it is not tightly packed so what will happen after certain time it will give

you some kind of vibrations and after that there will be a brick. Screw thread inspections is performed by using the thread gauges and some individual measuring instruments for measuring different thread elements already we have discussed in this particular lecture.

Different methods for measuring major diameter minor diameter then effective diameter pitch thread angle of threaded elements have already been discussed toolmakers microscope and the profile projector can be used to perform all types of linear angular measurements for small threaded elements not only that these are the high precision techniques that we can use for the better results, thank you.