Metrology
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Lecture – 28
Angle Measurement-2

I welcome you all for module 8, lecture 2, the series of lecture on metrology. In the last lecture 1, we discussed about different kinds of instruments used for measurement of taper we discussed about bevel protractor, sine bar, sign Center and sine table. In this lecture number 2, we will continue with a discussion on the other instrument used for measurement of taper, angle and tilt.

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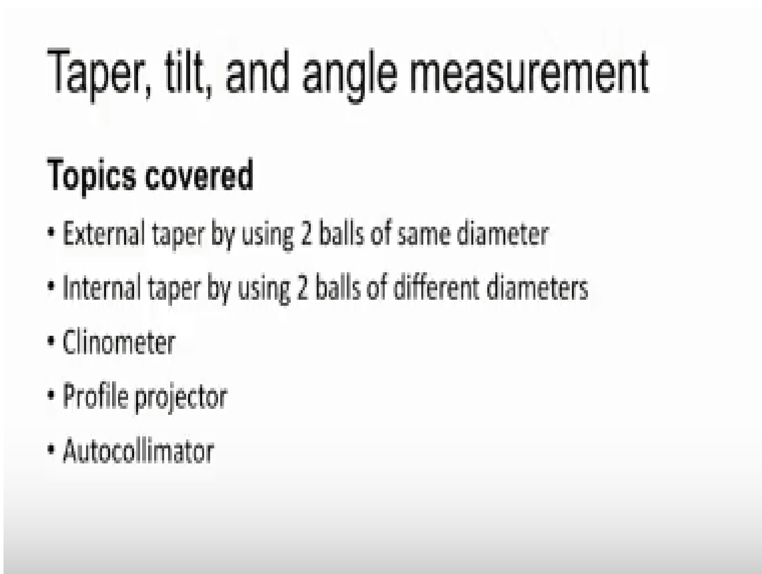

In this lecture, we will be covering the following topics external taper measurement by using 2 balls of same diameter then we will discuss about internal taper measurement by using 2 balls of different diameters and then we will learn about the clinometers, profile projector and autocollimator.

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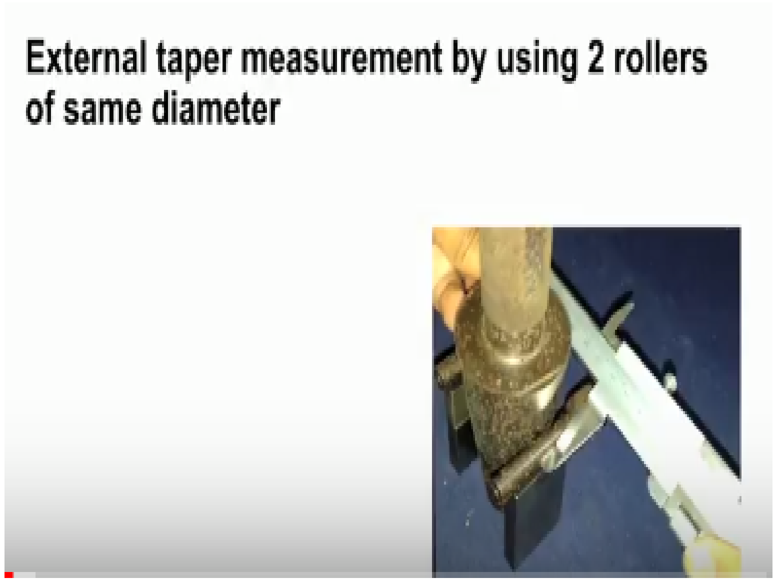

Now let us start to the discussion on external taper measurement by using the 2 rollers of same diameter in this sketch in the photograph we can see the tapered component with a taper component taper plug gauge the taper angle of this is to be determined the arrangement you can see here we have kept 2 slip gauges of same height over that we have kept 2 rollers of the same diameter and then these rollers are in contact with the surface of the taper plug gauge then over the rollers.

We have to take the measurement using the appropriate instrument for example vernier caliper so the schematic arrangement schematic diagram will be like this. We have the surface plate on which we have to keep the tapered component and then we have to keep slip gauge of equal height say this is the height h1 over which we have to keep the rollers 2 roller of same diameter the roller should contact the tapered component and then we have to take the measurement over roller.

So this is the say m1 and then we have to change the height and again we have to keep 2 slip gauges of different height h2 and then over these slip gauges again we have to keep the roller these 2 roller should be in contact with 2 taper component and the over roller where to take the width m2 using vernier caliper or any other appropriate instrument then using the relationships we can find the angle theta.

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Now we will conduct an experiment on paper measurement external taper measurement by roller by using rollers of same diameter, so now we can see the tapered component the taper angle of this component is to be determined. Now we have to take 2 rollers of same diameter we should note down what is the diameter of the roller so in this case you can see the diameter of roller is 10 Millimeter.

So we have two rollers of same diameter, now we have a slip gauge of 30 millimeter height we are taking 2 slip gauge of 20 millimeter and 10 millimeter thickness we have to bring them together to build a height of 30 millimeter and then we have to keep the to slip gauges over dislocation we have to place the 2 rollers such that they contact the taper surface of the plug gauge.

Now we have to take the measurement over rollers this is the m1 I can see the reading is 60,62 millimeter reading 62 millimeters. Now we have to take another set of slip gauges now we have we are ringing the 2 slip gauges 30 millimeter and 20 millimeter thickness so total height is 50 millimeter another slip gauge 50 millimeter height. Now we have to keep the 2 rollers on the slip gauges of height 50 millimeter and over the roller we have to take the measurement over roller.

Now the reading is 65, 66, 67 and we have to see the coinciding division so the vernier reading is 67.8 millimeter.

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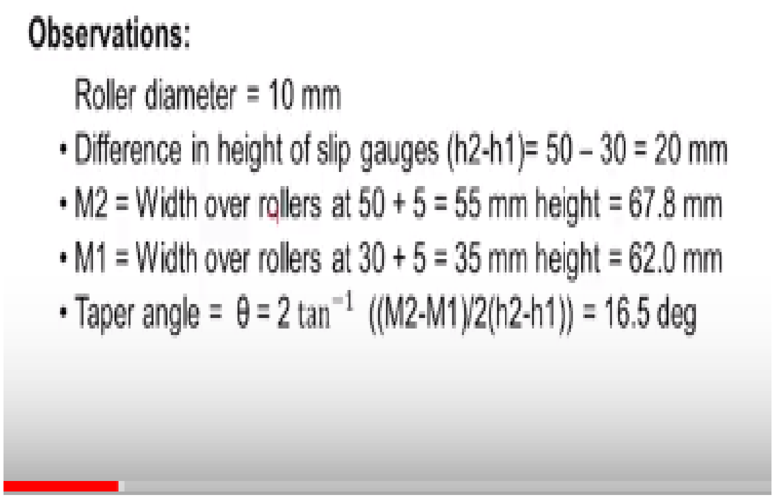

Now the we have recorded the observation the roller diameter is 10 millimeter and difference in height of the slip gauges=50-30=20 millimeter and width over rollers at a height of 55 millimeter so 50 millimeter is the height of slip gauge+5millimeter is a roller at so total height is 55 millimeter, so at a height of 55 millimeter the measurement over roller is 67.8 millimeter.

Similarly width over rollers at a height of 30 millimeters 30+5 millimeter, 35 millimeter height is 62 millimeter, so the taper angle is 16.5 degrees that is 16 degree and 30 minutes is the taper angle of the component.

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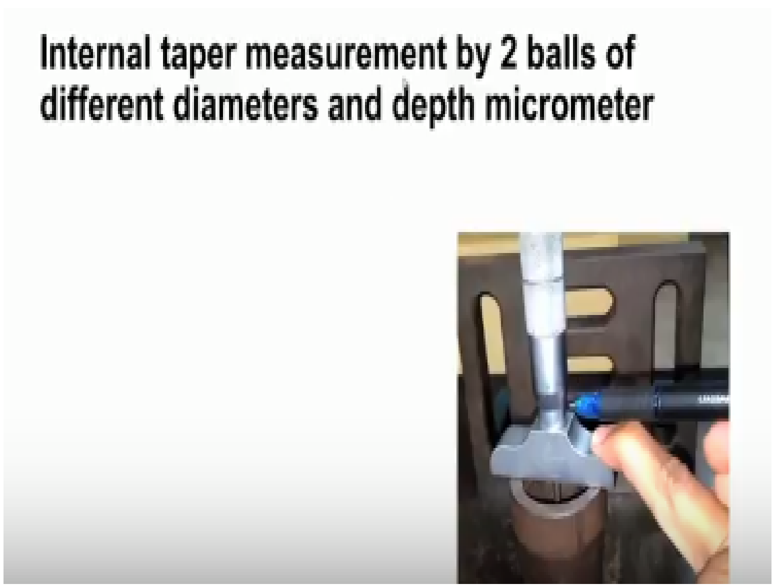

Now we will learn internal paper measurement by 2 balls of different diameters and by using a depth micrometer you can see the photograph here this is a tapered component having the internal taper and then we are using a depth micrometer and then we have to use the 2 balls of different diameter.

Now this schematic geometrically we can show like this this is a surface plate and this is the tapered component, now we have to keep a ball of some diameter we are to note that what is the diameter of the ball and then using the depth micrometer we have to measure what will be depth so we are to note down the what is the reading the spindle of the depth micrometer should just touch the top point on the ball and then we have to note down the reading.

We have to note down this reading say h1 and then we have to remove this ball and then we have to insert another ball of bigger diameter and then again we have to take the measurement say this is h2 from this top perfect reference so this will be h2 and then by knowing the diameter of 2 balls and these values h1 and h2 we can calculate the taper of taper angle of this component.

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Now we will conduct an experiment to learn the measurement of measurement of internal taper of a component we can see the arrangement measurement arrangement we have 2 balls of different diameter and we have a tapered component internal tapered component and then we have a depth micrometer with different spindles of different size and then we have a vernier caliper for measurement of diameter of ball.

Now I am measuring the diameter of ball can see the diameter is the 25 millimeter and then we have to see coinciding division the diameter of second ball you can see a tapered component we have the internal taper and measuring the total height of the component so it is 79 millimeter and the main scale and then they have to see the coinciding division by 5,10,15,25 25th division is coinciding so 25x0.02 that is 0.5 that is the diameter the total the height of the component is 79.5 millimeter.

Now have to keep the ball in the internal tapered component and then we have to measure the height of the top of point from this reference surface and then we have to record what is a reading you can see the swindle is just touching the top point on the ball then we have to note down the reading.

Now we are removed the bigger ball and now the keeping the smaller ball into the hole taper hole and then again we have to measure the depth I am changing the spindle and I am putting the spindle of longer length. Now we can see I have inserted a spindle of longer length into the micrometer, now I am measuring the depth we are note down what is the reading.

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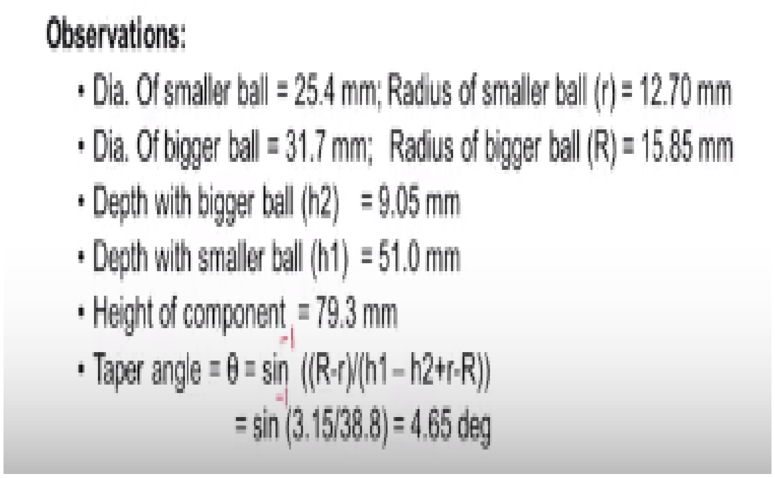

Now these are the observation after conducting this experiment the diameter of smaller ball is 25.4 millimeter, so the radius of this smaller ball smaller is 12.7 millimeter diameter the bigger ball is 31.7 millimeter so the radius would be bigger the ball is 15.85 millimeter, depth with the bigger ball =9.05 millimeter, depth with the smaller ball =51 millimeter, so height of the component is 29.3 millimeter.

So now we can calculate the taper angle using the base relationship, so we get the taper angle of 4.65 degrees.

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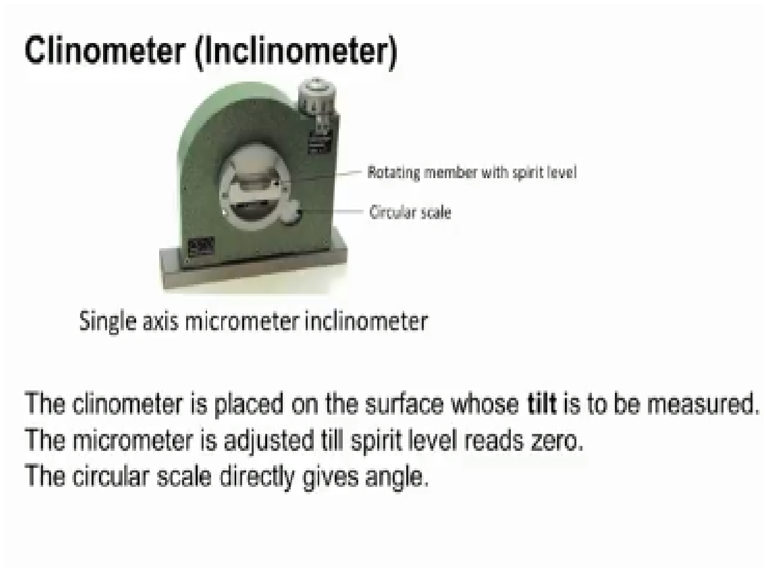

Now let us move to another instrument known as the clinometer which is also called in inclinometer which measures the surface tilt the arrangement of for the instrument is like this we have a base precisely finished the base and then we have a micrometer. So when we operate this micrometer is screw inside there is a screw.

When they operate is micrometer spirit level the round part containing this spirit level will rotate and then this circular scale which is housed inside the body will directly give what is a tilt of the surface initially we have to keep this instrument on a leveled surface that is surface plate and let us keep the clinometer like this and then we should the check the weather spirit level is reading 0 or not whether the scale is reading 0 or not.

Then they have to keep this instrument on the surface which is inclined like this and then we have to operate the micrometer till the spirit level again reads 0 so this circular scale will directly give what is the tilt of the surface.

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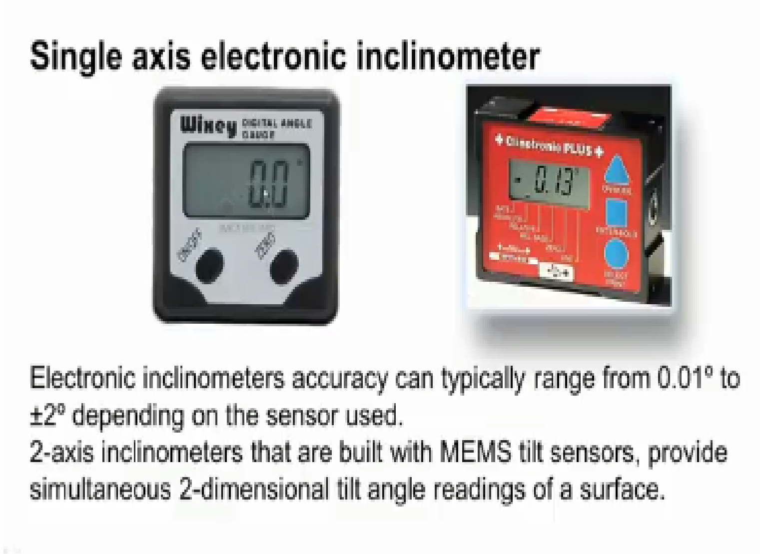

Now we can see the commercially available single axis electronic in kilometer this is the base this base should be placed on the circuit whose tilt to be measured so this electronic in kilometer will directly give what is the tilt angle.

This is another instrument with a better accuracy these were electronic inclinometers accuracy can typically range from point 0.01 degree to +/-2 degrees depending upon the sensor that is used to accessing kilometer that are built with MEMS tilt sensors provide simultaneous 2-dimensional tilt angle readings of the surface.

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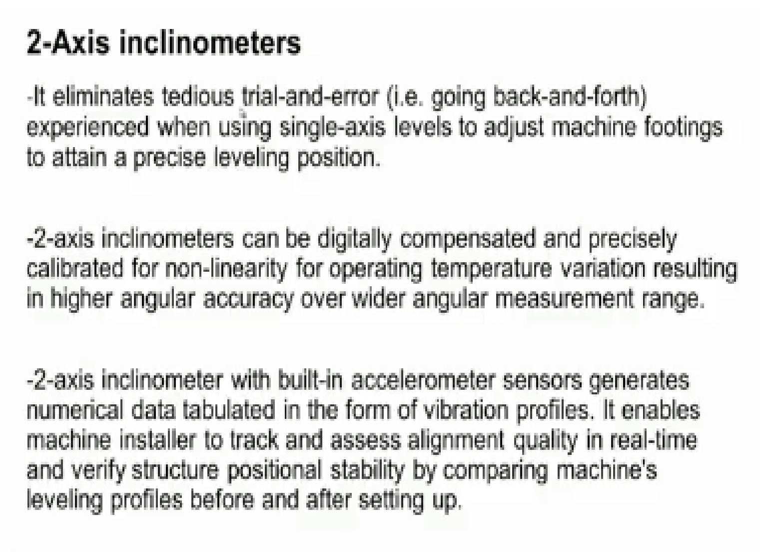

So these 2 accessing inclinometers it eliminate the tedious trial and error experience when using single axis levels to adjust a machine footing to attain a precise leveling position. 2 axis inclinometers can be digitally compensated and precisely calibrated for non-linearity for operating temperature variation resulting in higher angular accuracy a wider angular measurement range.

These 2 axis inclinometer with built-in accelerometer sensor generates numerical data tabulated in the form of vibration profiles it enables machine installer to track and assess alignment quality in real time and verify structure positional stability by comparing machines leveling profiles before and after getting up.

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Now what are the specific functions of these inclinometer they measure the slope angle during distance measurement and measuring the height of a building tree or other feature using a vertical angle and a distance determine by taping or pacing using trigonometry, the alert an equipment operator that it may tip over so this photograph shows a 2 axis in inclinometer.

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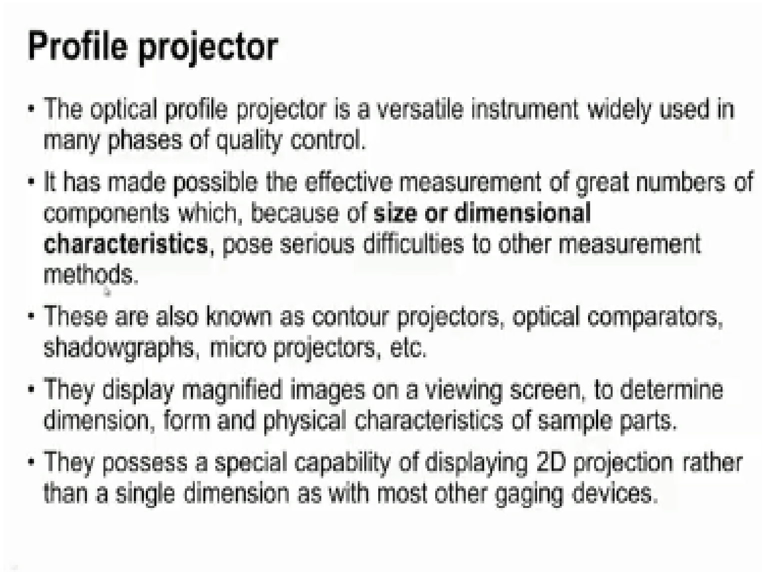

Now let us move to another very important instrument used for measurement of angles that is the profile projector this profile projector optical profile projector it is a versatile instrument widely used in the many phases of quality control. It has made possible the effective measurement of great numbers of components which because of size or dimensional characteristic pose serious difficulties to other measurement methods.

For example if the work piece is very fragile, very thin and other instruments are it is not possible to use other types of instruments for measurement of such a fragile or thin component in such cases this profile projector will be very, very useful. So these are also known as the contour projector, optical comparators, shadowgraph, micro projectors etc they display magnified images on a viewing screen.

This is very important that they display magnified images on a reading screen that means we can always select what is the magnification that is desired whether it is a 10X 0or 20X or 50X or 100X so depending upon the magnification that is needed we can amplify the image and then we can make the measurement and then we can find the dimensions form and physical characteristic of the parts that also can be checked.

The process is special capability of displaying 2D projection the other instruments like micrometer or vernier they measure only one dimension at a time these the profile projector at a time they can display 2D projection rather than a single dimension as with most of the gauging devices.

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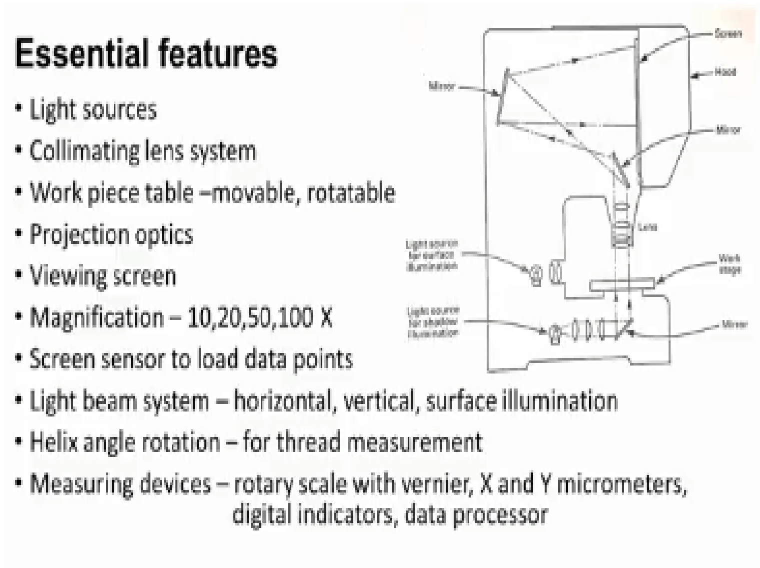

Now what are the essential features of this profile projector you can see a schematic diagram of a profile projector, you can see the various optical elements like lenses, light sources, mirrors for deflecting the light, collimating lenses to have a parallel beam of light, light sources normally they are made out of tungsten filament and they have the collimating lens system to get a parallel beam of light, work piece the table this is very important work piece.

That can be placed on the table you can see the work table here normally these are work stages are what tables they have a glass plate on which we have to keep the a work piece so light will pass through the glass plate and they will pass through work piece and then we get the projected image amplify the image you can see we have lens system and then we have mirror and then we have another mirror and finally we get the a magnified view of the shadow of the component on the screen

Now for the these tables in some case of their stationery in some models they are movable they can move in the X direction or Y direction that is we can move the table parallel to the column or perpendicular to the column sometimes they can be rotated so this rotatable the table is very useful when they use the optical projector for measurement of angles for example screw thread measurement and sometimes they work pieces the tables can be moved up and down.

For the proper focusing and then we have projection optical system and then we have a weaving screen which is made out of glass on which we get the amplified image and different magnifications are possible so commercially 10X, 20X, 50X, 100X for magnifying lenses are available and with special requests even 500X and 1000X magnifying lenses are also available.

Screen sensor to load data points so they can always mount a screen sensor on the screen a sensor can be mounted here so which will sense the data points and then which it could be fed to a microprocessor unit for a processing of the data and then they have light beam or system horizontal lighting system vertical lighting system and surface elimination.

So the surface elimination will be a very useful to study the surface characteristic of for the work pieces and then we have a fixture called Helix angle rotation for thread measurement so we have we can rotate the thread, so that the thread becomes parallel to delight diamond then they can take the measurement.

Then there are measuring the devices were incorporated into the profile projector like rotary scale with vernier and XY micrometer for measurement of movement of table and then digital the indicators to indicate what is the movement of the table and then the data process also incorporated to process the data.

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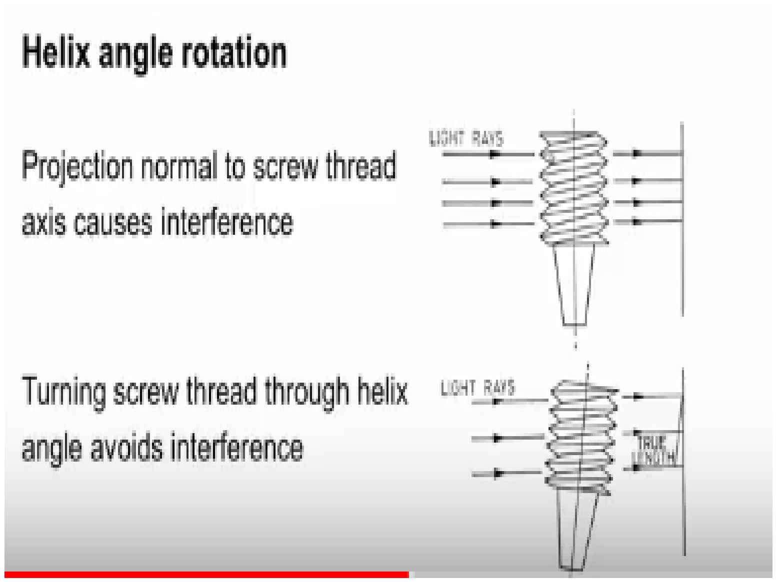

Now you can see here a Helix angle rotation a facility, so this is the light way so and this is the helix angle so now because of this Helix angle projection normal to the screw thread axis projection is normal to the screw thread axis which in this case will be interference and we do not get a proper clear image so what we have to do is we have to rotate this screw thread by helix angle so that the light rays will move parallel to the helix threads so that we get a very clear picture.

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I can see the photograph of a profile projector this is the viewing screen you can also see the rotary scale protractor rings are provided on the viewing screen and then there is a vernier attached to the screen and then we have magnifying lens there is a turret here on this turret we can mount the 3 magnifying lenses at a time that is 10X, 20X, 50X like that we can magnifier can be fixed manually we can rotate this turret and we can select the appropriate magnifying lens.

This is the work stage a work table you can see 2 micrometers are attached so this is 1 micrometer this is another micrometer by operating these wheels the table can be moved perpendicular to the column or parallel to the column and we can see there is a helix angle rotation fixture is there and 2 centers are there using these 2 centers we can mount the thread screw thread.

Then we can rotate through helix angle to get a clear imaginary screen and then we have this is a main switch and we have 2 types of eliminations 1 is the surface elimination and another one is erroneous flow elimination the surface elimination by using this surface elimination we can study the surface characteristic of the work piece and by using throw elimination the light rays will pass through the work piece.

We get the contour image on the screen giving screen and then by using the reference cross line by moving the cross line on the screen we can make the measurement and this is the data processor unit you can see the enlarged view a various functional keys are there by selecting appropriate key we can make the measurement for example if you want to measure the diameter of a rounder part we have to keep the round part under a glass plate.

Then we should get the contour on the screen and then we have to move the cross line reference lines and then we can take the measurement so in when we want to measure the diameter of a work piece, so we have to select 3 points on the contour so this image will be there on this screen which shadow will be on the screen we have to select one point go to select another point and then we have to select the 3 point.

So like that we are to select where we should input the 3 points and then the after loading all the 3 points with the data processor will process and finally we will give what is the diameter of the work piece.

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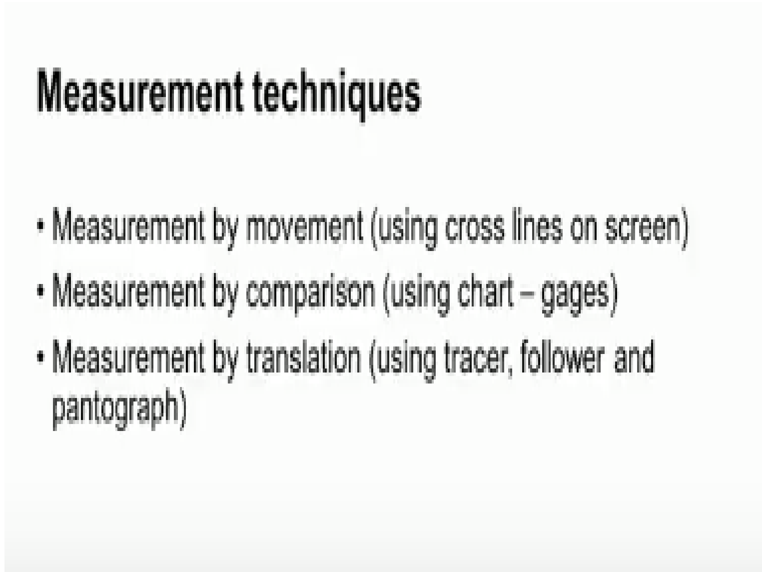

So there are the different techniques by which we can make the measurement using the profile the projector there is measurement by a movement that is using cross lines on the screen we can move the cross line from them for example say we want to measure the diameter of a work piece and this contour is obtained on the viewing screen.

Now we have this cross line so we should move the cross line order to just adjust the one point on the periphery say this is the reading is 0 and then we should the move it and then we should make it to touch the other point and then we should note down the reading say 10 so the diameter is 10 millimeter so like this by moving by moving the cross lines which can make the measurement also by rotating the cross link.

We can make the measurements where we have a third profile on the screen like this and we want to measure what is a thread angle so 1 cross lines so they should make it to align with this particular flank say reading is 0 degree and then we should rotate the cross line so that it aligns with another flank say this is the reading a 60 degree so this thread angle is 60 degree so like this by movement we can make the measurement.

Similarly we can measure the depth where we have a step here we want to know we want to measure what is the depth so the cross line should be aligned with this was say the reading is 0 and then it should move down and then should be should make it to align with this particular surface say the reading is 10 is non-degree it is 0mm and it is the 10mm, so the depth is 10 millimeter like this by move measurement by movement.

We can make a measurement another technique is measurement by comparison that means on the screen we have we have to paste a chart which is known as the chart gauge say for example we want to measure the screw thread. So we have to mount the chart gauge of appropriate magnification with the 2 contour lines.

So 1 for the maximum size another for this is the tolerance band and then we have to get the shadow of the thread which is to be inspected. Now it falls if it falls like this between the 2 contour lines then the work piece is accepted to the image falls outside then it is not accepted like this by comparison we can make a measurement and other technique is measurement by transformation using tracer, follower and pantograph.

The pins there will be a pantograph mechanism and then we have to keep the work piece with the profile on the table and there will be a tracer a ball tracer which will trace the surface of the work piece and on the other side of the pantograph there is a follower so follower it will be moving now this follower is projected onto the viewing screen so the projected image of the follower will be like this.

Again there will be a chart with 2 contour a line 1 maximum size and 1 minimum size like that so when we move the tracer onto the work piece the follower will also be moving if the image of the follower moves within these 2 limits then the work piece is accepted so this is the measurement by translation.

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Now we will see a profile projector I can see a profile the projector this is a viewing screen with protractor ring now this is the magnifying lens 20X and then yes we can see another magnifying lens of 10X and you can see the, the light source for surface elimination purpose we have to keep the work piece on this glass a table glass plate this is the table work table and this is the glass plate on which we have to keep the work piece.

There we have to we want to study the surface characteristics and then we should use surface elimination which means light beam follow a move like this and here it will be tilted and then again it gets the reflected and then the image you will get on the viewing screen this is the turret in this is the turret we can mount 3 magnifying lens so this turret can be manually rotated to bring a magnifying lens of appropriate magnification of in line in the work piece.

Yeah now we can see a fixture this is a fixture to mount the screw thread we have the 2 center these centers can be moved in and out the clamps are provided to fix the center at a desired location and then you can see there is a pivot here this is the pivot we can tilt the screw thread by helix angle so that we get a clear image and that angle also we can see here what will be helix angle or rotation we can see by using the scale.

Now we can see the helix angle the rotation facility it is a reference on one side they have up to 10 degrees and other side we have another 10 degrees, now you can see the projected image of the screw thread and you can also see the protractor ring here this is the 0 and in the anti-clockwise direction it is 5 degree,10 drgree,15 ,20, 30, 40it goes upto 355,360 complete 360 degree in rotation it can measure and then they have.

So each degree is divided into 60 parts so the least count of arrangement is 1 minute so 1 degree is divided into 60 parts so least count is 1 minute now it can see it is the main switch and this is the switch to activate to the surface elimination and then this by operating this switch. We can have the vertical elimination system to get the shadow of the work piece and again we can select high intensity light or low intensity light depending upon the requirement.

You know this is the pivot of the helix angle rotation arrangement and this is the work piece we can see the light it is passing through the work piece yeah I can clearly see this screw thread and this is the glass plate.20X magnifier. Now you can see the data processor microprocessors attachment we have to load the data points into this microprocessor.

Then by selecting appropriate keys we can get the radius, diameter, angle, major diameter, minor diameter, etc etc I can see the various function keys here to find the included angle you can select this K and to get the diameter of a component we have to collect O and to find the radius we have to select a L like this and then what is the if you want to find the distance between a point from a line which is passing through 2 points to 3 then we have to select this key J.

Now if you select this L 5 measurement points are required I can see the display unit so this is X micrometer and Y micrometer now they are set to 0 by operating the micrometer so we want to measure the pitch so we should move with a vertical cross line and then M Now measure the pitch so we should move the vertical cross line and then we can measure the pitch so we have to make vertical cross line to pass through the point.

We should note down the reading and we should move the vertical cross line to this particular point and then again we should note the reading the distance gives the pitch so like this we can make the measurement and finally the data processor will process and it will give what is now you can see they, they have measured the thread angle it is 56 degree 54 minutes.

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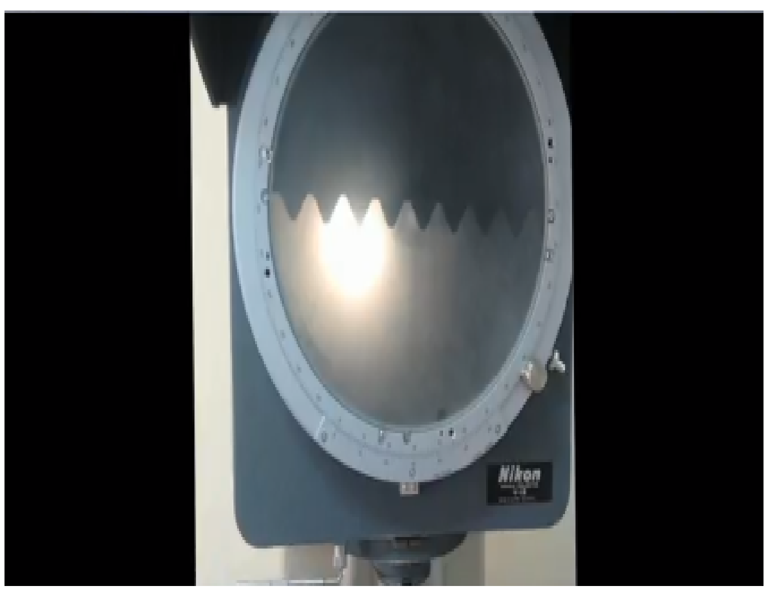

Now we can see triangle measurement using the data processor we should select appropriate processing function keys thread angle measurement is like this way we have we have a profile like this so we should load totally 4 point 4 points are needed they have to select the key and then we have to input the four points so first point second point third point four points we have to select on the flanks and then we have to input these four points under the data processor will process.

These4 data points and finally indicate to you think what is the intersection angle, Similarly in order to find the diameter of a component we have to feed 3 data points so first data point second data point and third data point like this they should give 3 points, so in that case we should select the key, similarly we can find the distance of point one from a straight line passing through 2 points say this is 2 and say this is a 3.

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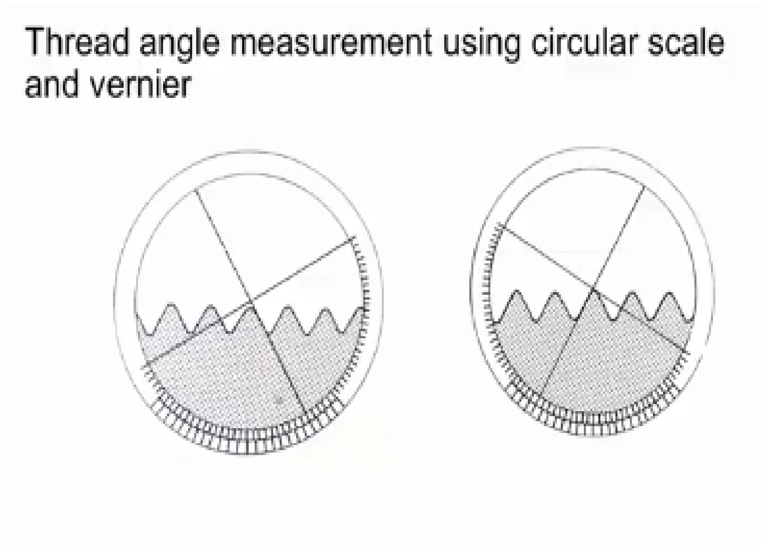

So now what is the distance between point and this strike line passing through these 2 points that we cannot find by selecting appropriate key. Now you can see here thread angle measurement using the circular scale and vernier so we have circular scale here this is circular scale curve is a protractor ring and this is the vernier, vernier scale. Now 1 cross line should the align with 1 flank and then wave what is the reading we should take and then we should rotate the cross line.

We should make it parallel to the other flank and then again we should take reading the difference will give the angle.

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Now the will conduct an experiment to show how to use profile projector to measure thread angle I can see the protractor ring to show in 30 degree, 40 degrees, 50 degree etc and then this is the vernier, so release count is the 1 minute. Now the reading is when the cross line is parallel to 1 flank the reading is 31, 32, 33 degrees and coinciding division is 25, 33 degrees ,25 minutes. Now you can see I am rotating the screen so that the cross line becomes parallel to another flank.

Now it is the parallel to remember flank and then again we have to note down what is the reading. Yeah now you can see the reading is 331, 332 degrees and 21minutes this is the reading the difference we should take to get the thread angles.

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Now you can see the observation first training is 33 degree 25 minutes and second reading is 332 degrees 20 minutes, so this we have to deduct from 360 degrees, so 360 degrees-332 degrees 20 minute=27 degree 40 minutes so the thread angle is we have to add this 27 degree 40minute with 33 degree 25 minutes so you thread the angle is 61 degrees 5 minutes so like this we can use profile projector for measurement of thread angle.

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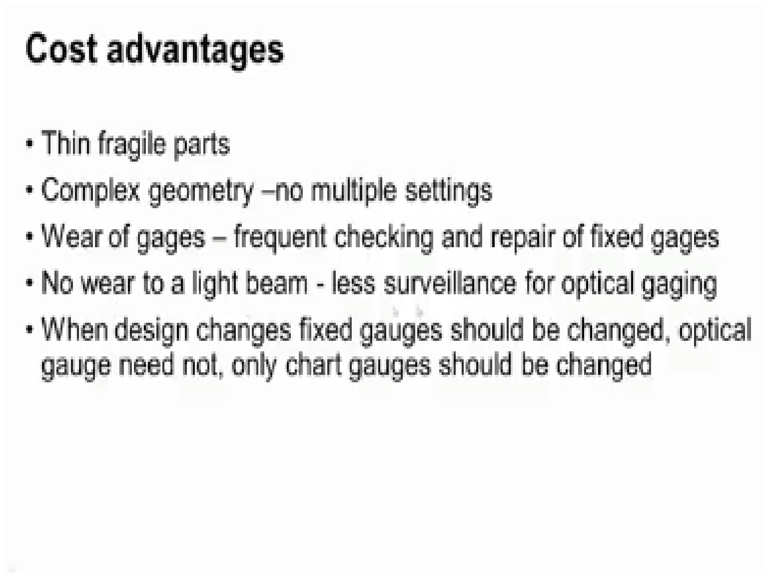

Let us see what are the cost advantages of using profile projector if the components are very fragile, very thin then other measuring instruments cannot be used so this is the only option and if the complex work piece the geometry is very complex. Then multiple settings are required if you use the other types of instruments like micrometer or vernier calliper whereas in this profile projector in a single setting.

We can measure the multiple learn dimensions the 2D measurement is also possible and in conventional instruments and the gauges there is a problem of we are frequently we have to check the gauges and we have to replace the gauges whereas in the case of optical gazing there is no wear of light beam so the optical gauge is not subjected to wear so the frequent checking and frequent, frequent replacement.

Problem will not be there when the design of the work piece changes fixed gauges should be change new set of gauges should be purchased in the case of optical gauge we need not have to purchase the new profiler same couple projector can be used even when the work piece changes only thing is where a charge gauges so I have to change like this the profile projector offers many cost advantages

So with this let us conclude this module 8, lecture 2, in this lecture we discussed about the various instruments used for measurement of angle like clinometer and then the way also discussed about profile projector what are the various measurement techniques of profile projector and what are the cost advantage profile projector those things we discussed we will conclude the next lecture in the next class we will continue the discussion. Thank you.