Metrology

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Module-5
Lecture-3
Stylus type surface measuring instruments

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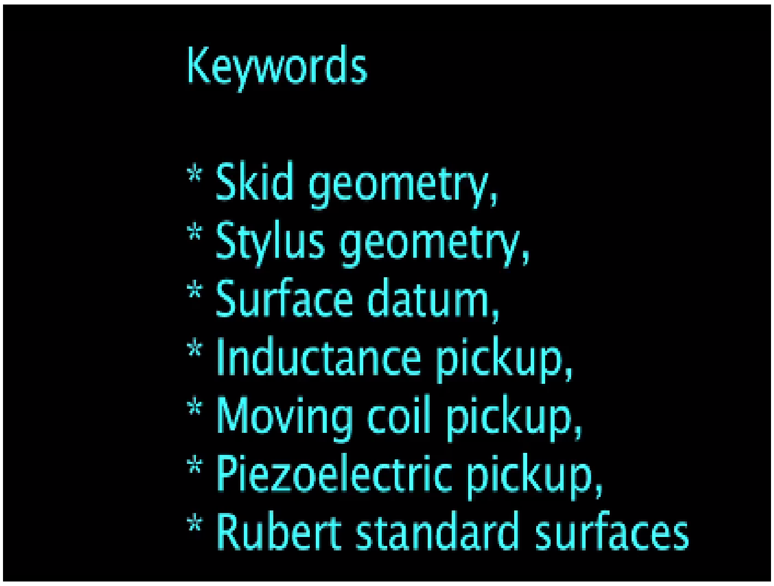

I welcome you all for the series of lecture on metrology. Now we will start module 5 lecture 3, in a previous session we discussed about the various aspects of stylus type surface machine finish measuring instruments. Now we will continue the discussion.

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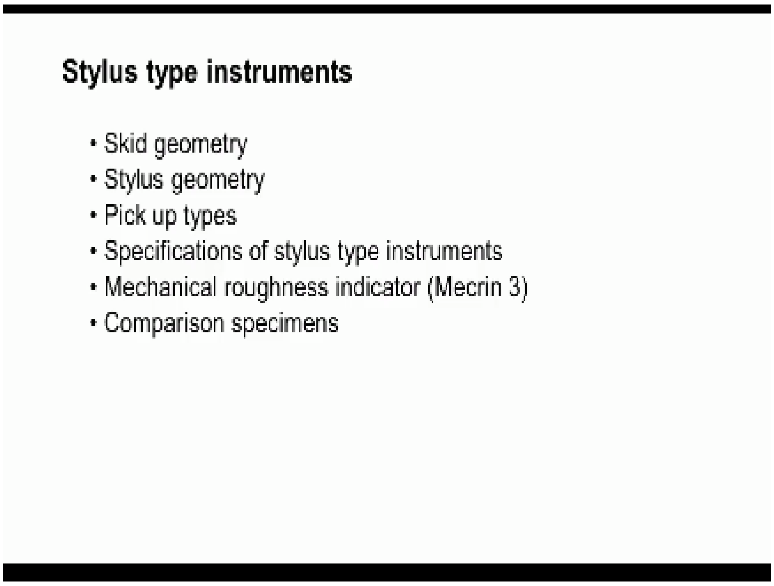

So in this lecture we will study about the skid geometry and then a stylus geometry and what are the various types of pickups used in the surface finish measuring instruments and then what are the various specifications of a stylist type instruments and then we will move to the mechanical roughness indicator other device used for measurement of surface and finally we will discuss about the comparison specimens.

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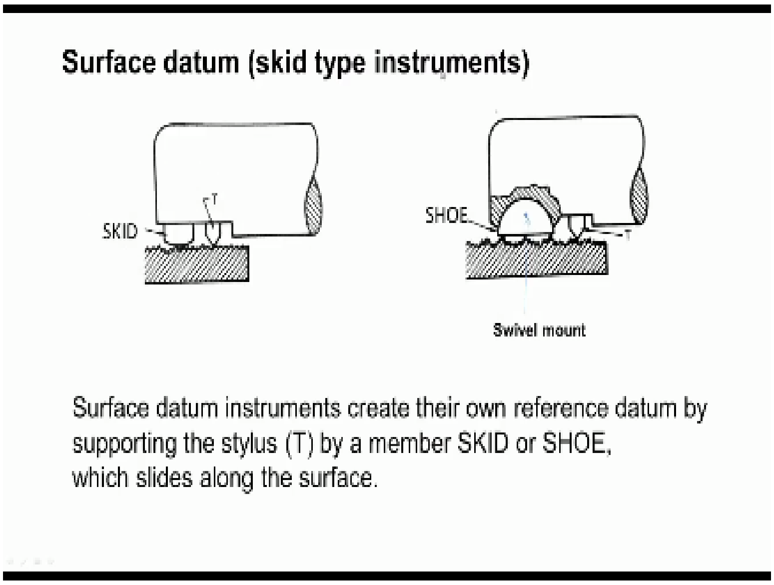

Now you can see here the previous session we discussed about skid less instrument that is the reference surface is provided external to the surface centre question where as in the skid type instruments the datum is provided by using skid which rests on the surface which is to be measured, TE is the stylus with moves up and down depending upon their asperities on the surface.

And it has pointed end where as if you see that this skid has is having a large radius so that it will simply slide on the surface so another arrangement is use of shoe you can see here in this skid we have an external convex shape shaped surface. In the case of shoe we have a flat surface which is mounted to the body of they pick up you can see here it is swivel mounted. So whenever there is a inclination of the surface because of this swivel mountains shoe will also get incline and then it slides the surface.

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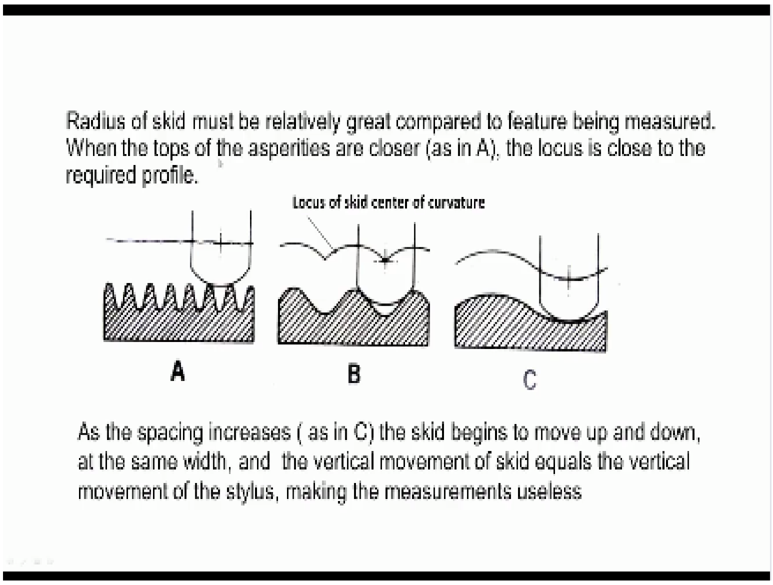

Now of the radius of skid must be relativity large completely featured being measured when the tops of the asperities are very close as we can see here the peaks are very close and when we move the skid, so this is the locus of the centre point of the curvature of this skid. So this is almost an error to be required to find and as the spacing the increases as shown in the figure see here.

The skid begins to move up and down at the same bit and the vertical moment of this skid becomes equal to the vertical movement of the stylus making the measurements useless. That means the no longer it will provide a datum surface. So always it is necessary that the skid radius should be too big compared to the roughness. Now keep spacing.

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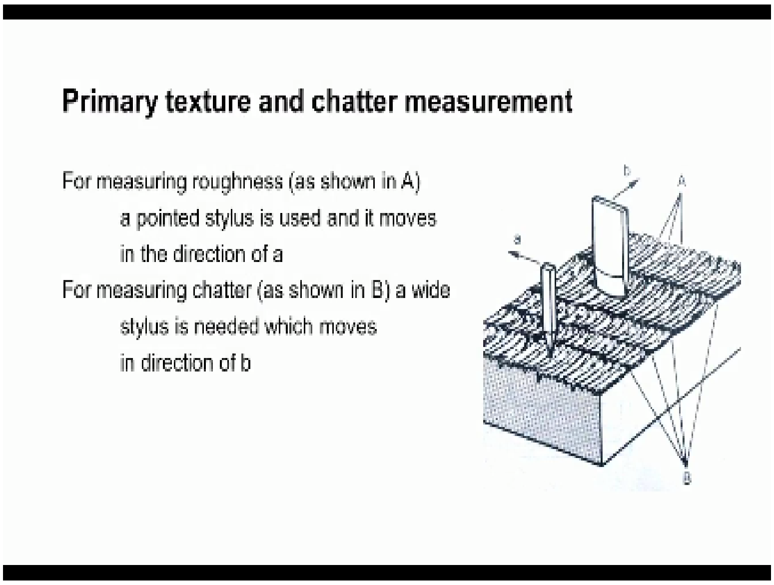

Now sometimes we need to measure the primary texture and sometimes we need to measure the chart. So in such cases what type of style one should used for measuring the roughness as shown here is a roughness of the surface and we need to measure the roughness of the surface then we should use a very pointed stylus and stylus should move in this particular direction. So that we get the surface roughness profile.

When we need to measure the chatter mark then necessary to measure the very wider stylus and you should moved in the direction B as shown in the picture. So physically selecting the different types of stylus it is very difficult and commercially available for measuring instruments only one stylus is provided. So in order to segregate separate the chatter characteristics from roughness and to separate the way winners and to separate the form of a work piece we need to use appropriate electronic filters.

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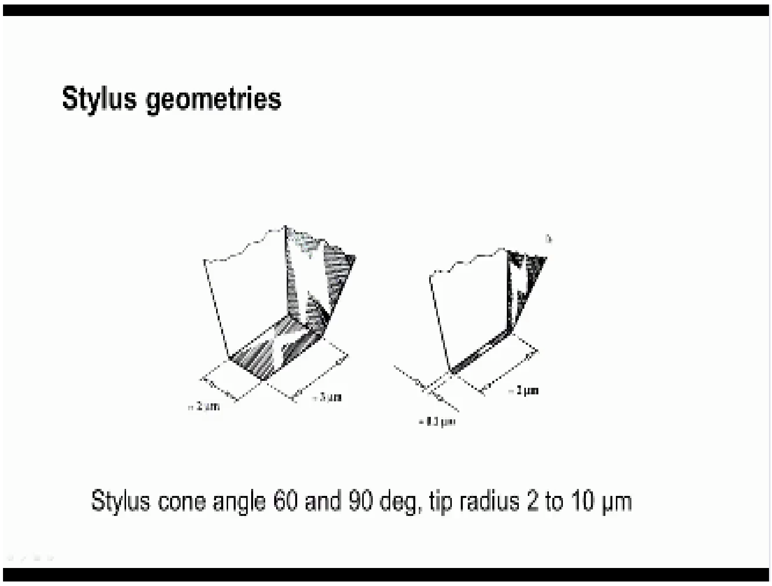

I know this shows the stylus geometry normally a cone angle of 60 or 90 degrees used in the stylus that means the stylus will have an angle of 60 or 90 degrees and the end will have the radius of 2 microns or 5 microns or 10 microns. So which will move on the work piece surface and see here the size of the style which is 2 micron, 3 micron, or we can have a very narrow stylus with 0.1 micron wide and 2 micron longer. So such geometries are necessary whenever we need to measure very narrow the surface roughness narrow places.

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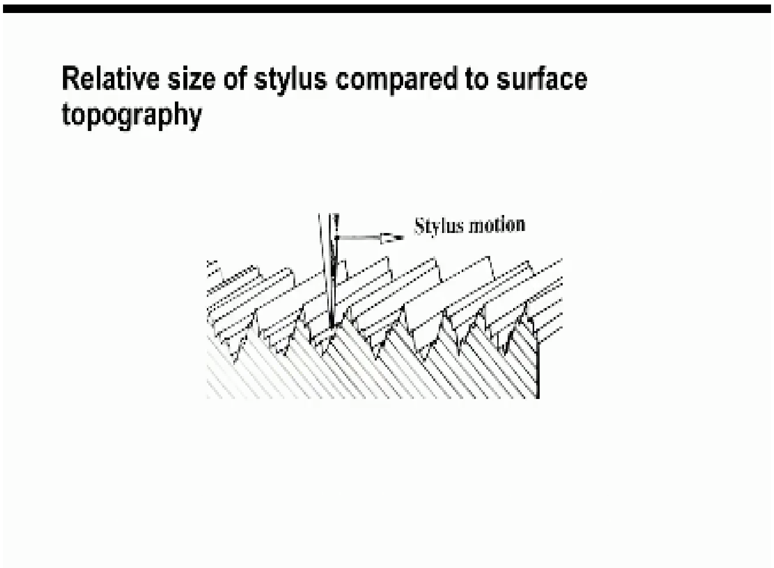

And then relative to the surface topography we should use a very thing stylish, so that it can enter into the valleys. If the stylus is too big like this and then with radius of 5 micron or 10 micron, then it cannot enter into the valley because of this size cannot enter into the valley. So it is necessary that we should use a very shallow a very think stylish. So that it will enter into the values and they get a proper sufficient reading.

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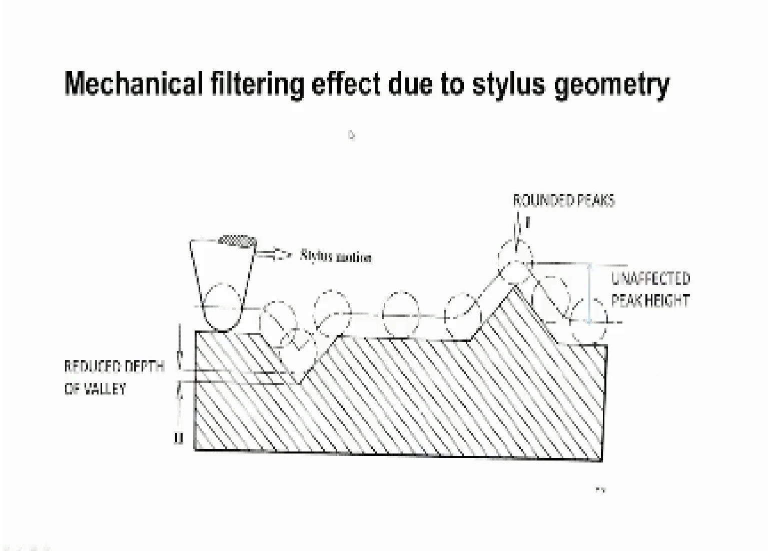

And then there is mechanical fitting effect due to a stylus geometry normally a radius of 5 to 10 microns is provided under tip of this stylus and the when it is made to move on the surface you can see this stylus at the centre point locus we can see, whenever there is a peak the we get it becomes very smooth, so because of this will definitely affect the surface finish reading, height is unaffected.

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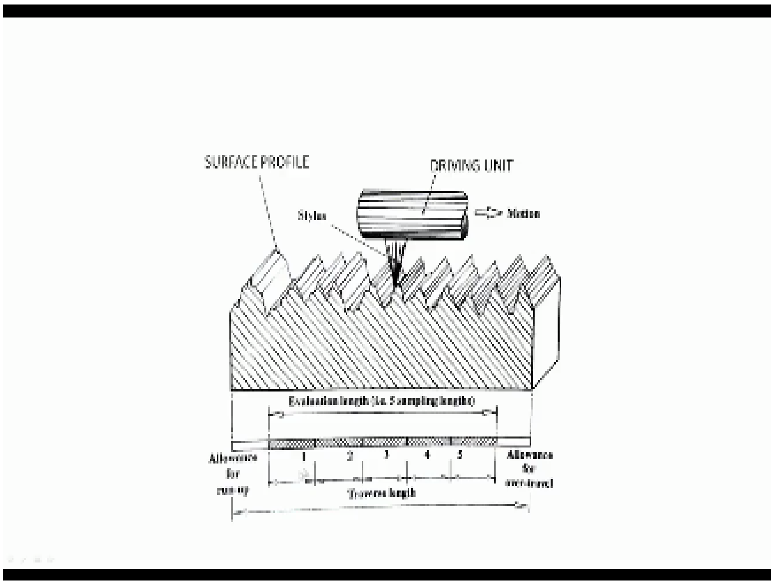

But we do not get fix it gets grounded, also the death gets reduced because of this shape of tip and here we can see date travishing length through which stylus will move there is some allowance for run up and some allowance over travel and these two are not considered for the evaluation. So the remaining length which is known as evaluation length is divided normal into 5 and each length and each sampling length is analysed for various parameters etc.

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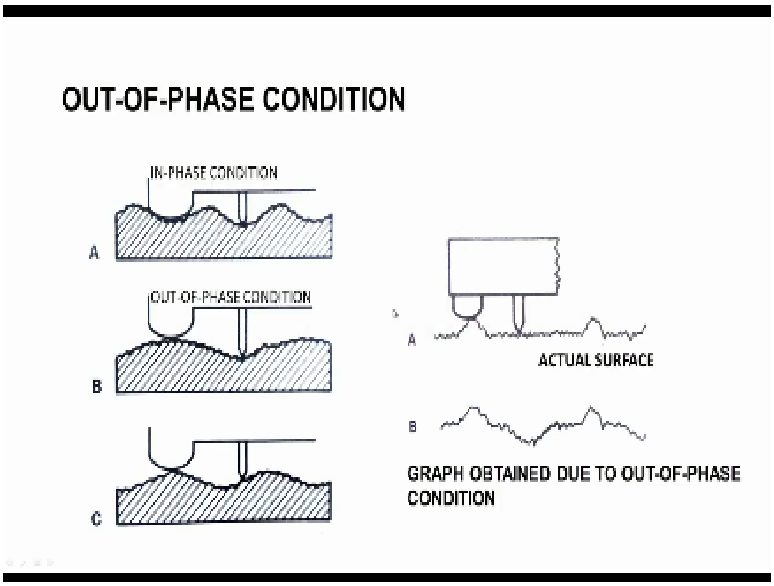

The average values are calculated and then the average RA or RP, results. Now sometimes what happens we have skid and then we have some distance we have a stylus. So if they are in phase that means the stylus is also in valley and then skid is also in valley, if this is the case we say skid and stylus are in phase condition. And if the stylus is inside the valley and the skid is on the tip of the peak then we say it is out of phase condition.

And this is in between condition, so what is the effect of this out of phase on the surface. Now we can see here we have the surface the actual surface and the skid and the stylus. Now you can see there in out of phase condition. So because of this we get a graph like this ok, so which is actually distorted the actual surface is like this whereas because of out of this condition the profile is distorted it looks as if there is some bigness.

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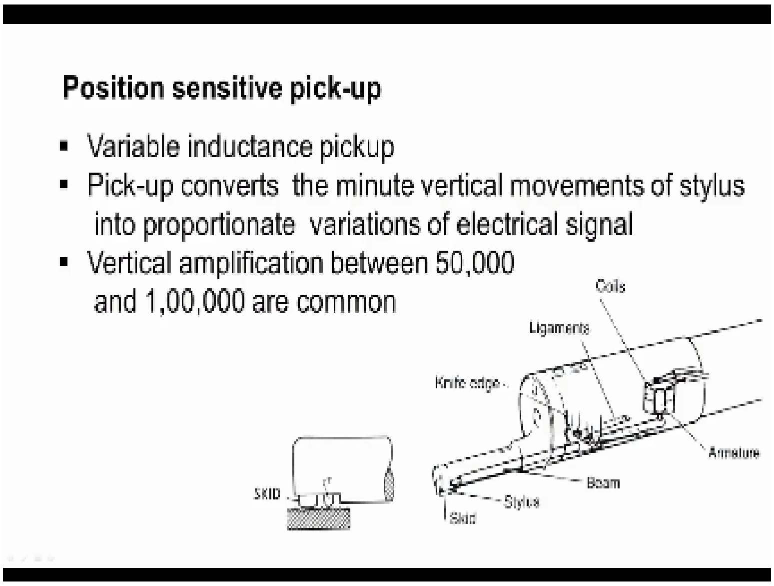

So we have to use appropriate software correction we should make to eliminate this out of phase condition and then let us study about the different types of pick up used. So this picture shows a position sensitive pick up ok this is a variable inductance pick up you can see this skid and they pointed stylus here at the style of his mounted on a be ok and then there is an knife and then the other end of the beam is connected to the armature which moves inside the coils ok.

And there is a knife edge so it will act as a pivot and the skid is mounted to the body of the pickup. Now the because of the variation of roughness this stylus will move up and down and these moments are converted into a very stylus skid moves in and out the armature also will move in and out and an inductor current characteristic will change, so the change in the current characteristics is amplified in amplification of 50000 to 100000 are commonly used depending upon the surface roughness.

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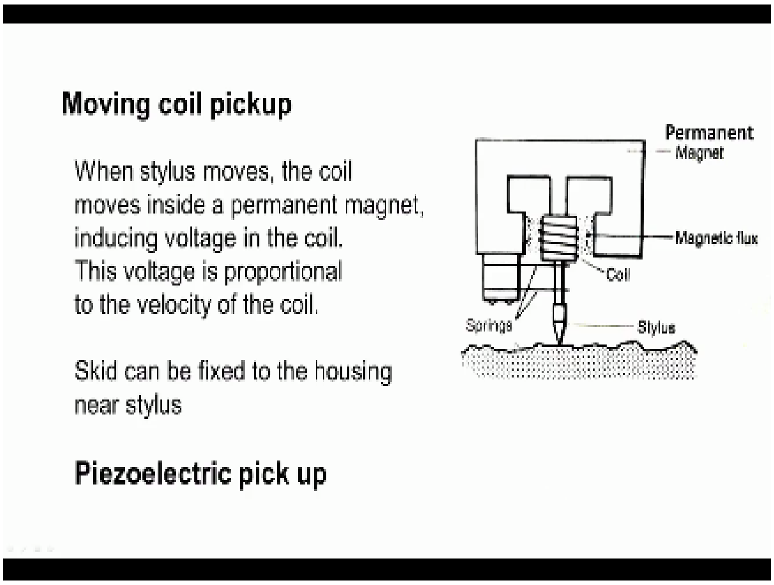

So the amplifier signals are sent to the software for analysis purpose to calculate have a different parameters like rdp etc. etc. We can see here another kind of this is moving coil pickup, now we can see here we have the stylus which moves on the surface and when the stylus moves the coil connected to the stylus will move inside a permanent magnet and using voltage of the coil. So the voltage that is induced depends upon the velocity of the coil.

If the roughness is more or if the surface is something like this so this up and down movement of the stylus is repeated if there is a higher velocity of moment of stylus and the higher voltage is generated .If the asperities peaks and valleys are very small then the velocity is well and the voltage that is used also less. So they voltage output is process to get the various parameters. Now the skid can be fixed to the housing like this is a housing in which moving coil pick up is present or mounted.

Now we can always there is the surface roughness, we can mountain the skid on the mountain housing of the pickup, there are piezoelectric pickup, now when the stylus moves up and down because of geometry variations, so we have a piezoelectric crystal. So because of this moment the crystal gets compressed the geometry of this pick up will also change hence the voltage output.

So depending upon the movement of the stylus so the voltage output will also vary which is connected to the computer or calculating the surface parameters.

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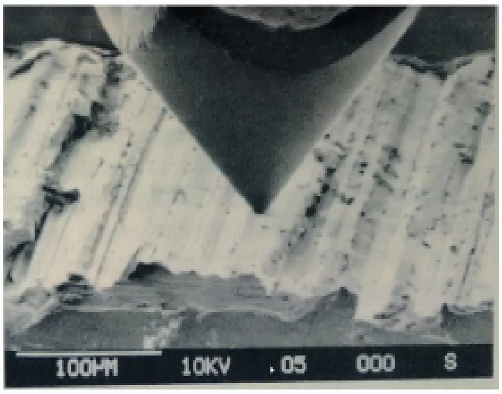
90 deg conical stylus tip (X200)



Now here we can see a tip a conical stylus if angle is 90 degree and there is a radius of about 2-3 microns, so this is magnified view of stylus.

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Specifications of surface tester

Parameter	Value
Measuring range - drive unit	16mm, 5.6 mm, 25 mm, 50mm
Detector range/resolution (μm/μm)	360/0.02, 100/0.006, 25/0.002
Measuring speed, mm/s	0.25, 0.5, 0.75
Retracting speed, mm/s	1
Measuring force/stylus tip	0.75mN/60 deg, 4 mN/90 deg
Skid force	400 mN or less
Roughness Parameter	Ra, Ry, Rz, Rq, Rt, Rmax, Rp, Rv, …

Now let us move to the specifications of surface tester, so the various parameters and the corresponding values we can see here. The instrument surface tests available with measuring rangers like measuring ranges that means moment with unit graduate 16 mm, 5.6 mm and 25 mm, 50 mm. So like this different ranges are available and the detector range 2 resolution, so detected range is 260 micrometre with resolution 0.02 are available or 100 micron detected range with resolution 0.006 micrometer are also available.

And very fine resolutions of not to micrometre also available and the measuring speed it varies from instrument, the instrument with 0.25 millimetre per second and 0.5 millimeter per second 0.75 metre per second measuring seats are available and retracting speed say when they stylus moves during measurement it moves very slowly with specified speed up0 0.25 millimetre per second or 0.5 millimetre per second.

Whereas while retracting to go to initial position it moves at a speed of 1 millimetre per second. Now what is the force that is applied from the stylus on to the surface, so small 4.75 millinewton with 60 degree angle for 90 degree stylus and skid force is about 400 millinewton and various roughness parameters can be obtained by these roughness or value or by Ra, Ry, Rmax etc. etc.

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Specifications of surface tester

Parameter	Value
Number of sampling lengths	X1, X2.... X20
Storage With memory card	10000 measured profiles, 500 display images, 500 statistical data.
Maximum power consummation	50W
Measurable hole diameters, mm	4.5, 2.8
Special accessory	Gear tooth surface detector, deep groove detector (2mm x 9mm) Support feet set, attachment for deep bore surface measurement (135mm)

And then we can always select the number of lens or it is fixed in the instrument like 1 sampling length or 2 sampling length of a lens are used and normally 5 something are used and storage with memory card up to 10000 measured profiles can be stored and 500 display images can be stored and 500 statistical data can be stored. So whenever you can retrieve these data and profiles and maximum power consumption is about 50 bands.

We can be operated using the batteries and then the measurable hole diameter normally very thin ropes are provided with skid and stylus and these can enter into holes ok. So this diameter is a 4.5 millimeter and very thin probes are also available and they can enter into holes with 2.8 min diameter, so with special request we can obtain the very thin probes and special accessories are always available or probes are available to measure the surface on gear tooth.

And deep groove detector like we have a groove like this, so the probes can enter into such a narrow grooves and they can measure the surface, surface finish at the bottom of a narrow groove. So they can enter into the hole at the narrows slot up to 9 millimeter down and width is 2 millimetre, such a special accessories and support feet test for adjusting a height support fits are available and attachment for deep both surface measurement.

If we have a hole of depth 135 millimetre, so probe can enter into that and it can measure their surface finish.

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Now let me show an instrument stylus type instrument, you can see the display of the instrument, we can see the various button to start the instrument switch on the instrument and there is red button to start or stop the instrument and this display will show what is the cutoff length that is selected and it will also so what is the parameter that is selected.

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Now you can see the movement of the stylus pickup is what is the moving it is now it is retracting now cutoff length selected is a 0.8 millimetre and it is showing RA value is 0.05 micrometre.

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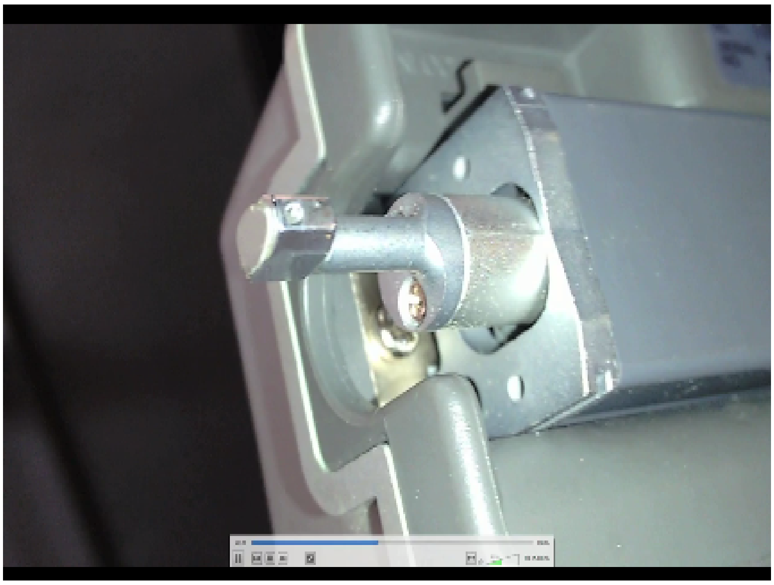

Now you can see another instrument you can see the various parts of the instrument pickup inductive pickup, yeah this is inductive pick up we can see the stylus here with this is the stylus. Now we see how to use this instrument to measure the roughness of the given surface.

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You can see the surface is kept here this B block is used only to support the work piece.

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Now for the pickup is not moving and then now it is retracting, it is going to initial position, it is showing the array value, array values 1.89 micrometre and cut of land that is select this 0.8 and also we can see how many sampling lens are used 0.8x5 something else. Now other parameters as I can see or y parameter is 11.42 micrometre to get the different values we have to operate this button parameter button for Rz 11.42 micrometre and RZ is 11.42 micrometre and Rq is 2.45 micrometer.

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Now we can see another work piece is being inspected, it is moving on the yeah it is going back to initial position after tracing.

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Now you can see display it is showing Rq is 0.55 micrometre, you can see the various buttons here this is start and stop button, parameter button and then cut off length selection and the feeling better we can select the air filter and then you can use this to 2 modes mm mode and inch mode, so Ra value of this particular surface is a 0.45 micrometre, so these are ground surfaces.

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Now Ry is 2.62 micrometre and Rz is 2.62 micrometre and Rq is 0.55 micrometre.

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Now you can see one more work piece it is placed in position and now style pickup is moving it is sensing the surface and it is going back to its initial position, now immediately reading a Ra value is 1.98 micrometre or y value is 10.37 micrometre, RZ distance. 37 micrometre and Rq is 2.38 micrometre. Now while storing it is very essential that we should retract the pickup and then now you can see the inductive pickup is being retracted it is moving inside the body.

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And then it moves up into the proper position, now we will see another surface finish your instrument stylist type instrument, you can see the stage of x y a table for mounting get a flat surfaces, we have good sex micrometre and then Y direction also there is a micrometre for positioning of the work piece and there is a rest a blade is provided to support the word piece and this is the work table with ball joint.

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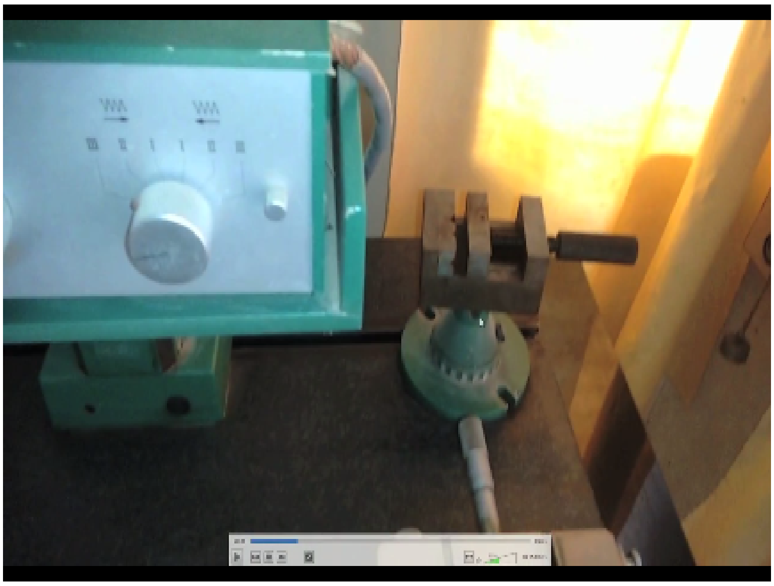

This can be used to oriented prepared work pieces and now this is the drive unit pick up drive unit and you can see there is a knob for adjusting the orientation or the inclination of the pickup dry unit, fine adjustment of the inclination we can do here and we can select required cutoff length and now you can see the pickup inductive pick up, so this pick up can be moved up and down and made up on work piece height

Try a table for mounting the flat earth surface we have got 6 micrometre and then my direction of opposition and the rest is provided to support the work and this is the work table with ball joint this can be used to orient paper and now this is the drive and pick up drive unit and you can see there is a knob for adjusting the orientation or the inclination of the pickup dry unit, fine adjustment of the inclination we can do here.

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And we can select required cutoff length and now you can see the pickup inductive pickup this pickup can be moved up and down depend upon the work piece height. So this is for fine adjustment and you can see we have a keyboard here, so that these keys up and down the keys this whole drive you down and this is the column top guide the up and down movement of the drive unit.

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So depending upon the work piece height we can move the drive unit up and down, now you can see the pickup this is a guard, guard for the pickup, now you can see the dedicated computer, it depends on the mechanical unit, we can see various buttons.

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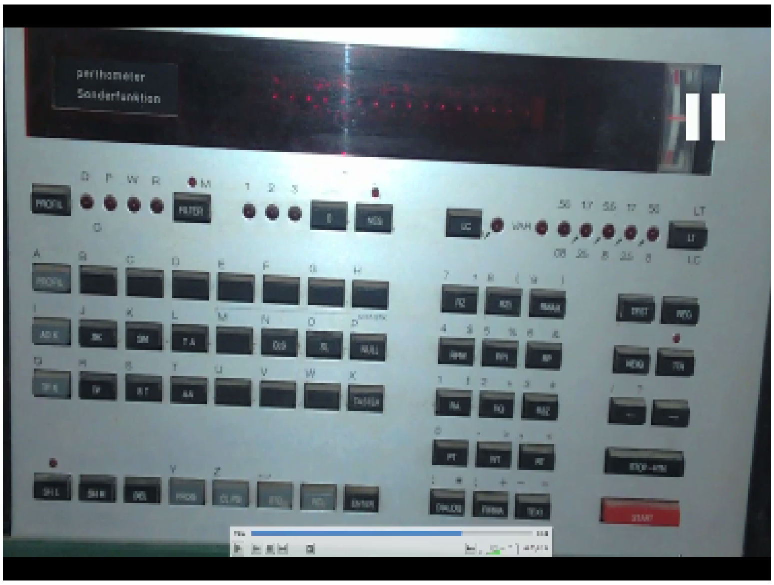

Now we have the start button here and stop and return button you can select various parameters like Rj, Ra, Rmax, RPM, RPI, RP1, Ra value, Rq value, Rz value and then various parameters like WT, WT parameter, Rt parameter, Pt parameter and then the cut off also we can select cutoff length we can select 0.08 millimeter or 0.25, 0.8, 2.5, and 8 millimetre, depending upon the process machining process we can select appropriate cut off length.

And we can make we can create our own program what are the various parameters we require or we can enter everything until the parameters required and then you can create our own program and we can also select the filter different filter and what type of a profile be required that also you can select whether we want roughness profile, so that we can select.

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And this is the printing unit, so it will give us the various it will print the various parameters also it will get a profile. So this is the printing unique and also select the magnification how much magnification is required, how much horizontal magnification is required those things we can select.

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Now let us move to another contact type instrument which is known as the Mecrin, it is the short form of mechanical roughness indicator, so commercial it is known as Mecrin-3 and is used for practical shop work inspection, see all the measuring instruments to finish measuring instruments if it is possible also available which can be carried to the machine shop may be surface finish for the components can be checked.

And for the final inspection have to move the work piece to the metrology lab very sophisticated metrological surface finish instruments will be available and surface roughness of the work piece can be checked there. So for very critical components verify instruments used to check the surface finish. Now we will learn about this Mecrin-3, which can be used in a machine shop see the advantage of this instrument is measurement is possible without deburring and without unloading the work piece.

You can see this picture a work piece is good condition it is placed between check and the dead centre and it is not removed from the set up, the machine conditioner machine is stopped and then we can take this device Mecrin-3 and then we can measure the surface roughness, we can see the picture here photograph here we have this black thing is the body. So this is the body of the instrument, so which has a dial ok.

So this dial inside we have a scale round the scale which shows the reference values and symptoms of grade scale and N1, N2, N3 and etc and also the Ra value symptoms of micrometers like 0.25, 0.06, 0.100 etc. etc. and this indicator can be rotated inside this housing can be rotated and it can be fixed to the body at any particular orientation for that a screw is provided.

We can rotate it as required and then we can fix it to the body is in this fixing screw and now we can see there is a trigger here, the instrument is like this so this is the dial, so inside there is a scale and then there is a pointer and then there is a screw to fix the dial in the required orientation and then there is a trigger. So we have to pull the trigger so I can see here with one finger we can pull the trigger.

So when we pull the trigger here there is a very thin stainless steel blade, the thickness is about 50 microns. So at the end of the thin blade there is a tip with a sharp corner ok, it is screwed it is screwed to the thin blade, so the thin blade of stainless steel with above 50 micron thickness and when you pull that trigger this blade will move out, so when you pull when we keep all pulling the trigger this will move in and move out.

Now how to use this Mecrin for measurement of surface roughness. So initially we have to calibrate this instrument using the standard services provided with the instrument, so two surfaces between 3 and 5 if that is provided using the specimen we can celebrate this instrument those details will see when they conduct the experiment. Now after calibration so we have to hold the instrument on the work piece surface which is to be inspected and initially we should use a very small angle should be almost like this with the trigger.

And then we can see here the tip is in contact with the surface to be tested, so in this condition we have to pull the trigger, now if the tip slice smoothly then we have to increase the angle you are slightly increase the angle may be by 2-5 degrees, again you pull the trigger again the tip is made to move on the surface, say it is lights again, so again you increase the angle maybe by 5 degree see you keep on doing this till the tip does not slide.

So in that case this blade will bend like this, so the blade is available here that is placed here, it bends like this. So that we can observe here through this window, so that we can that bending of the blade, so that angle is called critical angle. So at that angle so what is the value indicated by this pointer that we should note down. So that indicated value is rough surfaces. So now it is showing their value between 0.8 and 1.2.

So the surface roughness is roughly about 0.9 micrometre or 1 micrometre Ra, so we can get a very fine finish of about 0.9 micrometre Ra, or 1 micrometre Ra adjusting the machining parameters. That means if the surface is very find the critical angle will be removed and if the a surface is very rough then the critical angle will be less. So the advantage of this is without deburring the work piece we can use we can measure the surface roughness and without unloading we can measure thickness.

Just we have to stop the machine, we had to stop for the rotation the work piece, we have to earn maybe where to clean the surface with a brush and then we can take the instrument and then we can measure the roughness, so this is if it is roughness is not up to the requirement we can adjust the final setting the feed rate and speed risk adjusted against that can be given and again that the surface can be tested.

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So like this to control the machining operation we can use this instrument. Now let me show how we can use Micren-3 instrument for the measurement of surface finish is a very handy and very light instrument which does not require any electrical power and there is no battery inside. So inside we have a pendulum which way is operated by gravity and point is connected to the pendulum.

Now along with the Mecrine-3 instrument a reference calibration standard, so standard specimens are provided. Now we can see the calibration standard which has 2 standard specimens with N3 grade and N5 grade, the surface finish off this surface is 0.1 micrometre and finish of this surface is a 0.4 micrometre.

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So this is N5 grade surface and this N3 grade surface using this calibrate standard we have to calibrate this instrument, now we can see the various parts of the Micren-3 instrument.

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This is the real you can see the yeah this is a screw, so we have to unscrew this and then we have to rotate this dial for calibration purpose, now you can see the scale it starts from N1 and it goes up to N8 and in terms of micrometre or it start from 0 25 and it goes up to 4.8 micrometre, this is the range of this instrument, I can see the body and can see the trigger we have to operate the trigger.

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Now when we operate the trigger you can see we have a stainless steel think stainless steel blade and at the end of the blade we have a tip with a sharp corner. So we can see when we operate the trigger the blade is along with the tip blade is moving and at the back side of the instrument I can see here we have another screw, so before using this instrument we have to unscrew it so that pendulum is released.

So now pendulum can move I am showing how to calibrate the instrument, now we can see we have to hold the instrument on the surface and then we have to operate the trigger, so that blade move the stylus moves on the surface vacancy stylus is moving in the surface. Now when it slides we have to increase this angle, so at a particular angle you can see the blade starts to bend so that angle at which date start stop band called a critical angle.

Now you can see how we have used N5 surface and so we have to rotate the dial so that point reads N5 and then we have to lock it, we have to lock this indicator. So now they similarly we have to calibrate using this entire surface entry and now the instrument is ready for measurement. Now I have taken a ground surface you can see a moving the tip on the surface which is to be inspected and operating the trigger.

So the tip is sliding over now again I have to slightly increase the angle when the blade starts to bend we have to read the dial, I am taking another surface we should start from a smaller angle I can see the blade is moving sliding on the surface, so slightly increase the angle again operate the trigger. So now you can see it just starts to bend, so reading is between N5 and N6 or between 0.6 and 0.8.

So we can take it to the 0.7 micrometre Ra, the surface finish of the surfaces 0.7 micrometre Ra, so this is another ground surface, again vacancy how to use this instrument. So we have to keep a smaller angle and then that operate the trigger now that if now it has started to bed now the reading is between 0.25, 1.05.

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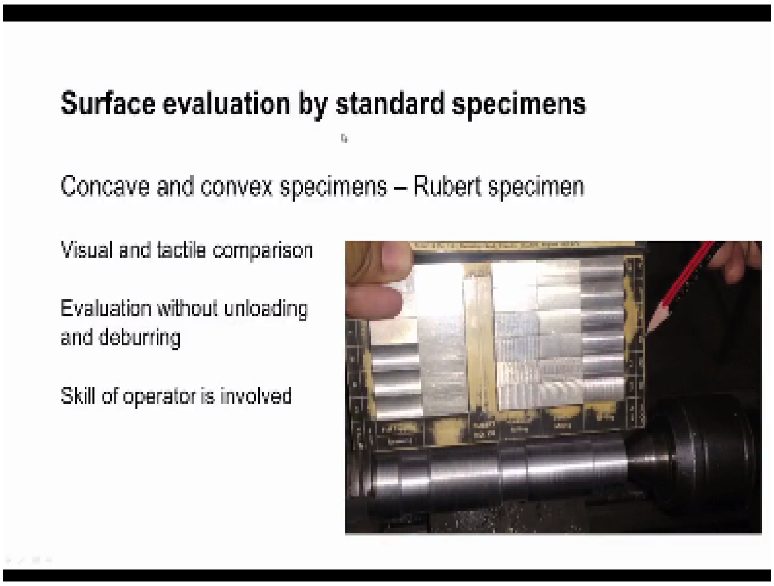

Now we will move to the measurement of surface evaluation by standard specimen, so I can see that of standard specimen. So I can see the set of standard specimens so we can see the some surface, some specimens of convex and some surfaces of concave, now concave surfaces can be used to compare the surface roughness of drilled and hold holes and these convex surfaces can be used to compare the roughness with torrent surface or single ground surface and skilled surface.

Now these this set and dispatch and despatch that flat surfaces that means so these are the 6 surface. Now these set and this set there flat surfaces that means so these are B6 surfaces, so these surfaces they are produced by grinding process and again we have 3 flat surfaces produced by flat lapping process and these three concave surfaces are produced by reaming process.

And then we have a 6 ok totally 12 standard payments are available here ok, these 6 surfaces are produced by vertical milling you can see it told mark and these 6 specimens are produced by horizontal milling process, can see the charter mark ok. So now you can also see we have a component whose surface is to be evaluated and this is turned surface silicon surface.

So we have to compare this with these convex specimens. Now the skin of the operator is involved here personal factories in one, very skilled operator I will be able to compare the surface of the world peace with the scanner specimens and he will be able to evaluate the roughness of the surface.

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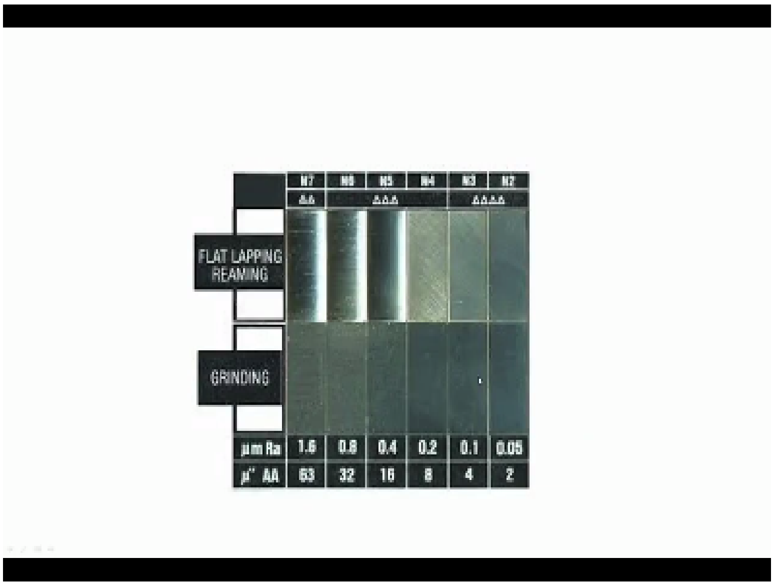

Now this shows an enlarged view of these three surfaces, so these three surface flat lapped surfaces and these 3 concave surfaces are reamed surface, we can also see the roughness grades, so here we have 4 triangles that means very fine surface finish is there on the surface, the value is also mentioned here. So this is 0.05 micrometre Ra and then they have 0.1 micrometre Ra and then 0.2 micrometre Ra.

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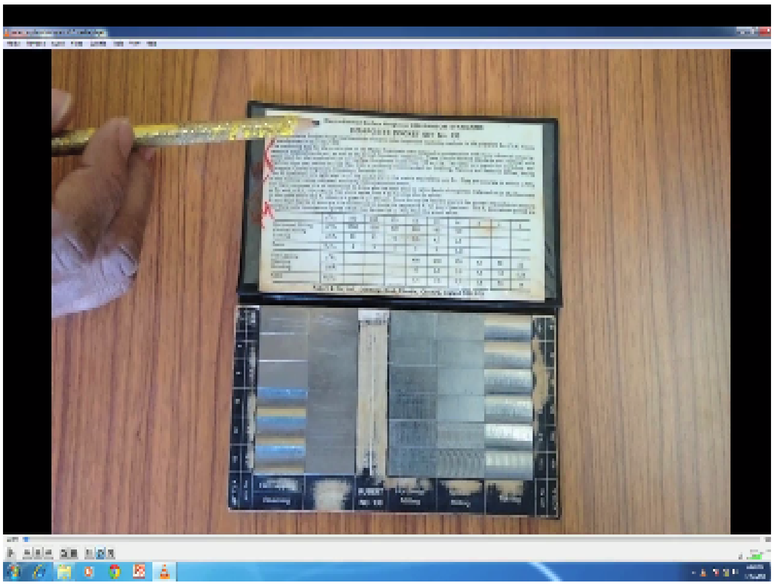

And then these 6 surfaces their ground surfaces with these Ra values, now I am showing a standard specimen set, this is a composite pocket set number 130 made by Robert company, the standard specimens for the horizontal milling process vertical milling process, turning process and then flat lapping, reaming, grinding, so those specimens are available in this set. Now you can see the standard specimen for flat, lapping as well as for rimming.

You can see the top three specimens are made by there for comparing the flat lapped specimens and bottom three surfaces they are for reaming for comparing the specimens other pieces produced by reaming, now can see that this set it contains both flat surface as well as convex surfaces produced by turning operation and it also contains concave surfaces produced by reaming operation.

So the work pieces produced by reaming can be compared with these standard specimens, now you can see there are 6 pieces for comparing the ground specimens. So we have another 6 surfaces for comparing with horizontal milled work pieces, we can see the lay and waviness and those things we can see and D6 specimens or for comparing with vertically milled surfaces.

Another set of 6 pieces for comparing turned work pieces, so we can see if these are produced by large feed rate and here these pieces near feed rate. Now we can see the value for this specimen, so this the specimen for this particular row they have roughness of 12.5 micrometre and discuss specimen has a roughness for 6.3 micrometre Ra and next month is having this particular person is having a roughness of 3.2 micrometre Ra and then this particular specimen it has roughness of 0.4 micrometre Ra.

Also the readings are available in CLA micro inch, now you can see this side also the roughness values are mentioned for the specimens both in micrometre Ra as well as CLA micro inch, this particular surface is having particular is having value of roughness values of 0.2 micrometre Ra and this particular piece is having a roughness value of 0.1 Ra micrometre and this last piece is having a roughness value of 0.05 micrometre Ra.

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And again we can see the surfaces produced by different manufacturing processes, so these specimens can be used to compare or for visual inspection to find out the value of work pieces produced by can compare the roughness of the work piece with these on surfaces having known Ra value, so the visual inspection we can find roughness of work piece, also these work pieces can be used for scratch test.

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Now let me explain the scratch test, now we have to take the specimen of which we have to inspect and then we have to move our nail on the standard specimen also.

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So what is the seal on the surface to be tested the same feel we should get on the selected standard specimen and accordingly we have to note down the reading, so here the personal factories is now skill operator is very important. The same specimen inspected by different inspectors may give different results. Now let us conclude discussion in this session we discussed about the different types of hiccups used in the stylus type instruments.

And the design of skids and design of stylus and then also we studied about the use of Mecrin mechanical of indicating instrument which is the contact type measuring instrument and then we also studied about the use of standard specimen for comparison purpose you can compare the surface of the component with the standard specimens whose values are known and then we can assess the roughness of the surface of unknown surfaces. So with this will conclude this section.