Computer Integrated Manufacturing
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Lecture 37
Laboratory Demonstration
Co-ordinate Measuring Machine

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Good morning. Welcome back to the course. In this lecture, I will discuss 3D measurement and co-ordinate measuring machine. 3D measurement, specifically I will discuss 3D scanning and co-ordinate measuring machine will have a lab demonstration on the co-ordinate measuring machine.

The co-ordinate measuring machine that we have here in IIT, Kanpur in machining science lab in mechanical engineering department is one that will work on.

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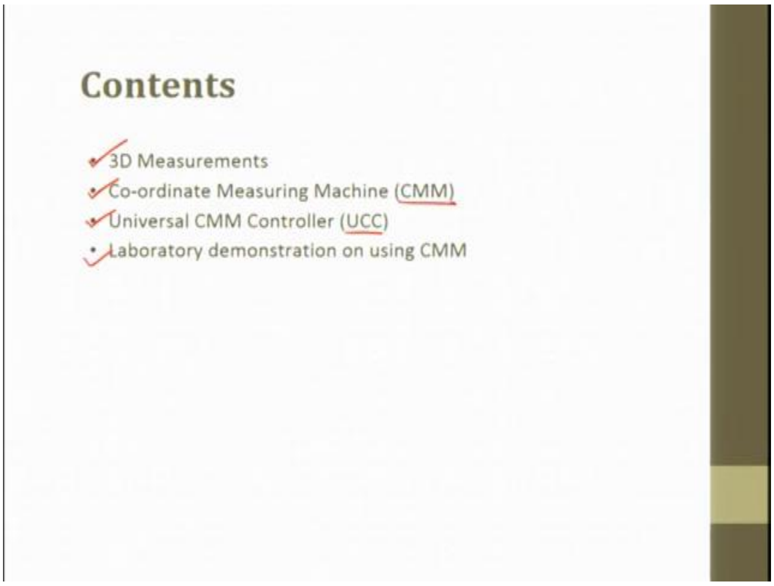

Before the start of the lecture, I will just tell you what is 3D measurements, will just recall those then what is co-ordinate measuring machine and specification of this machine, the particular machine that we have in our lab.

Then we have UCCs Universal CMM Controller. If I think of the whole CMM machine, the controller that controls the machine is known as UCC. So laboratory demonstration on using CMM there we will show you the parts, the various heads all the axis and we will see that what are the degrees of freedom all those things we will see and also we will try to measure one component that would be kind of standard component.

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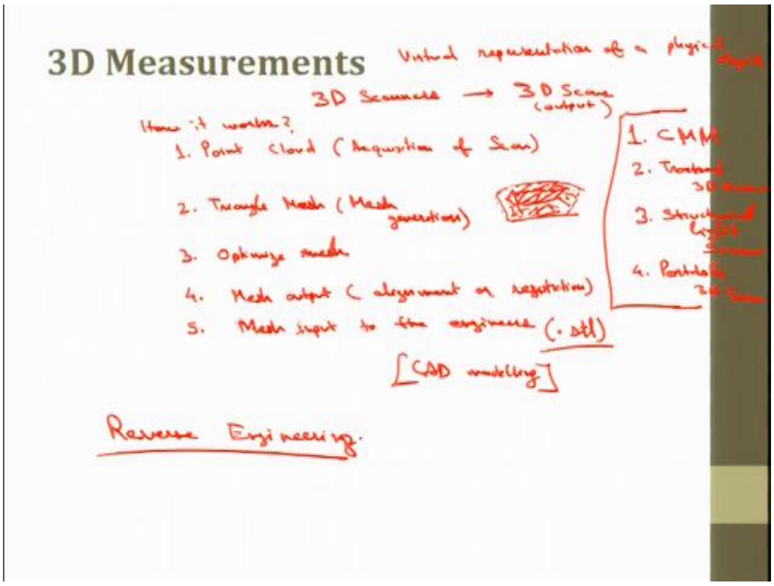

3D measurements, what are 3D measurements? 3D measurement is a process of creating measurement or virtual 3D representation of a physical object. This is virtual representation of a physical object. Now 3D scanners are optical devices used to create 3D measurements or 3D scanners. We have 3D scanners. 3D scanners if I say 3D scanners the outputs are known as 3D scans, 3D scans is the output.

There are certain kinds of 3D scanners we have measuring arm 3D scanners, track 3D scanners, area-based 3D scanners, portable 3D scanners, portable 3D scanners could be held in hand and, for instance, I like to just scan this object, I can scan it for one view, third view, second view, and third view, okay, that is front view, side view, top view any view I can think just need to see make sure that the angle on which I am scanning is also recorded in the software as well.

So I am putting the same input in the software. So that kinds of scanners here. So the outputs are known as CD scans, so while the mainstream manufacturing continues its session with 3D printing, 3D scanning is act of capturing data from objects in the real world and bringing them into the digital pipeline.

Recent study has reported that there would be an about 15 percent increase in the production using 3D scanners annually. So this is high rate, 15 percent. So portable 3D scanning is actually feeling the moment from the laboratory to front lines factory and feel driven and followed by key factors and because they are low cost so better accuracy is there.

Simplicity is there. Convenience and flexibility is there, so 3D scanners can scan the real object and produce a virtual image of that. It can produce this object how what are the steps for that I will just give you a brief introduction to them as well. So before that, there are 3 or 4 types of 3D scanners, number 1 that I am going to discuss here is CMM. This, I will discuss in detail.

Co-ordinate Measuring Machine, so in this arm scan, we equip with either fixed probe or touched trigger probe heads. It is also possible to mount a 3D scanning head on the CMM. So we will discuss as many advantages, that many different tools can be mounted on a portable CMMs and making it possible to easily enter great scanning and probing, so limitations are also there.

Portable CMMs you know needs to be fixed on the surface, so use of physical link. So we do not have the portable machine, we have a full-fledged CDD scanner, not a very big industrial size but for research, it is quite capable of producing the output that is required, so also we are doing some industrial consultancy here as well.

So second type of 3D scanner is track 3D scanner. Track 3D scanner, a track 3D scanner here optical tracking devices can track various types of measurement tools including positioning of a 3D scanner. So positioning could be external optical tracking device, these scanners use an external optical tracking device to establish positioning.

So, they usually use markers such as passive or active targets that optically bind the tracking device to the scanner. So another kind of a scanner is structured light scanner. So by structured light I mean these scanners project a pattern of light on to a part or a process when it is happening and how the pattern is distorted when the light hits the object.

Even an LCD projector or scanned or deflective laser beams projects the light pattern. One or two or sometimes more sensors record the projective patterns. So it just put the light and the structured lights scanner, the patterns in a change of a light tells us the various profiles or curves of the object. So this is another way.

So one more type of scanner is portable 3D scanner. Portable 3D scanner can be either CMM or they meant as a portable 3D scanner, anything that can be held in hand and taken to the machine or the component where definitely like to measure is would be called as portable. So these are the major kinds of scanners.

I am just introducing. I am getting into details, for details we will share you the notes and you can read them. So how does 3D scanning works? What happens when it scans, when it try to scan, when we use CMM machine, it will try to touch the point. Okay, the first step it produce is the point cloud. Okay, I will write it. How it works?

The first step is the point cloud. So point cloud I can even better put as it is actually acquisition of the data. The data or the shape whatever we like to, we are trying to just, this is the first input I am getting from my surface. So this is I can say acquisition of scan. So if I need to produce this surface the points would be produced first. This kind of curve, the points would be produced first.

So these kinds of points would be produced. The curve, let me say this is one surface. The points are produced, these are the points. This is point cloud. So the scanning results are representing using free form. This is free form or unstructured form. Sometimes structured components are like we have a circle, a quant, a plane a rectangle when these things are known, the known shapes are there those are known as structured forms. This is a kind of a free form.

Okay, however, if we know about the curves, Bezier curves, the supplying curves, those are also there but nowadays those are also not very significant even the free forms. Any curvature that we need is quite possible to be scanned using the 3D scanners. So, first point is the point cloud. Using the point cloud, we create a triangle mesh. What is the triangle mesh? This is the point cloud, we will make triangle out of this.

Joining a point with other point we are trying to make the triangles. Similarly, the whole surface would be in the form of the triangles. This is known as triangle mesh. So this is actually I would just call it mesh generation. The third step could be when the mesh is generated we need to optimize the mesh.

Optimize mesh means there are number of triangles you know when we conduct the analysis or when we conduct the strength analysis or heat analysis, this is the mesh, the more the number of triangles are more with the computational part.

So it depends upon what type of competition we need to do. So optimization of mesh to reduce the time of computation and to get the optimum shape as well that is also important. For instance, if they are steep angles here, the steep angles here, the triangle mesh can be the smaller triangles here it is kind of a plane surface.

If it is a kind of plane surface here, so here the triangles are of bigger size. So we need to optimize the mesh to obtain the near possible shape here okay. So optimisation of mesh is required then. After that, fourth point here could be the output of the mesh. So images and scans are brought in to common reference system where data is merged in to a complete model.

Complete model data is merged and, a complete model is formed, this process is called alignment or registration or we can call as mesh output. This is alignment or registration. So we have scanned from different views when we are aligning those surfaces to get this specific shape, the solid shape this is known as complete mesh output.

So after it, so mesh is input to the engineers. Mesh input to the engineer workflow, so this output goes, I will put mesh input to the engineers. So this mesh input goes to the engineers, they can create a surface if they like out of that. So they can create a solid model if they like, so these things can be created using these. So this is the next step.

So this mesh input goes to the engineers, how does it go to them? It is generally produced in the STL format, dot STL format, okay. So the computer softwares can be used to clean up the scanned data, filling holes, correcting errors, then improving data quality, so the resulting triangle mesh is typically exported in this format, STL format, and we can buy it into the known form.

Like, we can convert it into the bee supply or a Bezier curve if it is possible. If not, then also the things can go. So CAD modelling can be produced out of this. So this was the brief introduction about 3D scanning. Next, where does 3D scanning apply? The major application is in reverse engineering. So what happens in reverse engineering?

In mechanical engineering, this process reverse engineering aims to create virtual 3D model from an existing physical object in order to duplicate or into enhance it. So the procedure is again very similar in reverse engineering. We create 3D scan mesh, so then we extract the information, then CAD modeling, then verifying the data, then analyzing feedback, then exporting to the model.

So what is reverse engineering actually, what is general engineering? We have an idea. From the idea we have certain plans, certain plans, or certain models we have, finally, we get the final product after getting through various analyses, technical, financial, availability of material, manufacturability, all those things. We get a final product.

Reverse engineering is if I have got this final product, I like to scan this product, okay, then move reverse, move reverse, I will create a model out of that and just trying to create a replicate of this product. This is reverse engineering. Okay.

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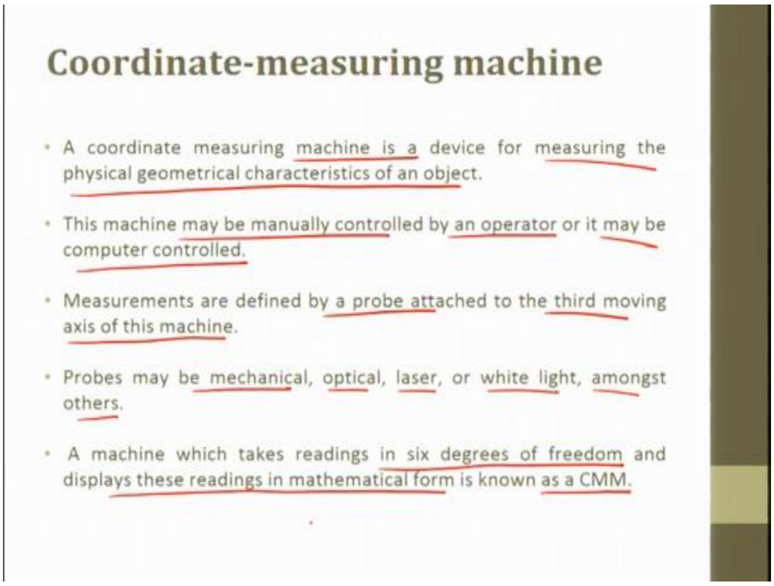

Now I like to move to the co-ordinate measuring machine. A co-ordinate measuring machine is a device for measuring the physical geometrical characteristics of an object. This I have just explained. So this machine maybe manually controlled by an operator or it may be computer-controlled, so we will show you the both operations, the manual control using a joystick and CNC mode as well.

CNC mode is computer numerical control. We just give the initial point over this is a starting point. Now after each mm or after each 2 mm, we can just give the distance, it will just recording the points, on a specific plane or specific curve or we can then change the direction of our probe, those things can happen, this is CNC control.

Manually also we are just using a joystick, we can keep touching the probe to control the data. So measurements are defined by a probe attached to the third moving axis of this machine. The 3 axes, x-axis, y-axis, and z-axis. In z-axis, z-axis third moving probe is attached, so that helps us to record the data. So probes maybe mechanical, optical, laser, white light, and many such.

Mechanical optical is light you know laser, white light all these are what, probe we have here in our machine is the mechanical probe. Okay, it will physically touch the component that we are trying to measure, it will touch and it will produce a beep sound, and also an indicator would blink, so whenever it touches here, so this probe will use here.

The machine which take readings in 6 degrees of freedom and displays these readings in mathematical form, is known as co-ordinate measuring machine. The 6 degrees of freedom that is all the dimensions, all are taken in to account and displays the reading in the mathematical form, the mathematical form readings can be obtained like the distance between the two objects and the shape of the objects, if it is a free form it will create a free form.

If we know that there is a structured form, we can select it beforehand only that okay this is a circle that we are going to measure, for circle wants some minimum to require, to measure for a plane 3 points are required to define a plane for a cylinder 8 points are required, for a cone 8 points are required, so I will come to them.

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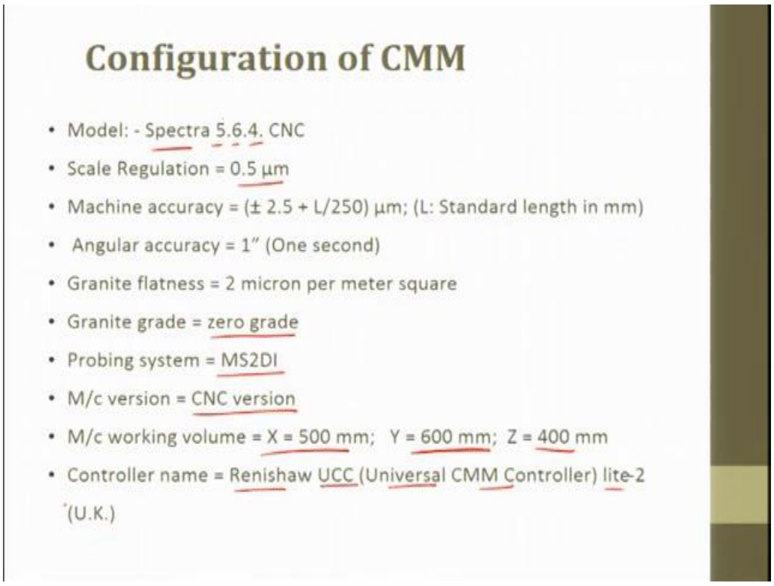

So the CMM machine that we have here, the configuration of that is it is Spectra 5.6.4. What is 5, 6, 4? 5 is 500 and 600 and 400 is the work area or workspace that is available in the 3 axes. 500 mm, 600 mm, and 400mm, okay. Then scale regulation is 0.5 micrometer machine, accuracy is (±2.5 + L/250) micrometers, so this L is the standard length in mm, so angular accuracy is by one second of the angle.

So granite flatness, granite is the worktable that we have. It is the flatness, it is a zero grade granite, so 2 microns per meter square is the flatness. So it is quite smooth to keep our measuring instruments over it, so it is zero grade that is Thermal expansion is also zero. So probing system, this is the name of the probing system. We have machine version is CNC version.

Machine volume is as I said 5. 6.4. It is x in x-axis we can move 500 mm and y-direction we can 600 mm, in z-direction we can move 400 mm. So controller name is Renishaw UCC universal CMM controller lite-2, okay, from the U.K. Now we will take you to the machining science laboratory in mechanical engineering department and we will see what is co-ordinate measuring machine.

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So this is co-ordinate measuring machine in our machining science lab, spectra co-ordinate measuring machine. This is a vertical bar, this is a bridge-type co-ordinate measuring machine. We have 18 pneumatic bearings, so one barring is on this side, okay, one on this column, 11 in this column, so may I removing the bellow from here.

When we remove the bellow, we can see that there is a bearing inside, so there are 11 bearings on this side, one on this side and 6 on this side. 11 plus 1 plus 6 is 18, so this is pneumatic bearings, okay, that helps to move the columns and various other moments, okay. So bellow helps us to save it from the dust to keep it secure from dust, so this can move, (you know) this can move freely here.

So it can compress and produce spring motion due to air blow like there is air blow between the two surfaces, it can compress and produce the spring motion, so that can move from one side to another side so they are 6 bearings on this side. So the side to side movement is possible and microfilm flows due to complete dry air, so this is a controller. This is the controller that is used to switch on and off the compressor.

So this is a controller knob. So we have a Renishaw server power amplifier. Okay, Renishaw is the company, it is the make.

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So this is a tube pipe from which compressed air is coming from the compressor, so this is the Kaeser compressor, it is refrigeration type air compressor, it is 100 percent moisture-free that is a not going to harm the machine. So the compressor that we have to use here, it has to be moisture-free.

You know we are trying to save the machine using these bellows from the dust and other impurities so that the dust particles just come in between the moving components and does it act as a breezy weight. It may deteriorate the machine in the long run, so to save that and also to save the machine from being corroded, this kind of refrigeration, air compressor, and moisture free air compressor is used.

This is the control valve, so the front view of the compressor looks like this. It is Kaeser air compressor. So this is our co-ordinate measuring machine as I said, this is used to measure the parameter of 3D objects. The 3D objects maybe complex geometry or maybe some specimen, so we can measure with the help of this CMM. So it has 3 axis, okay. X, Y, and Z.

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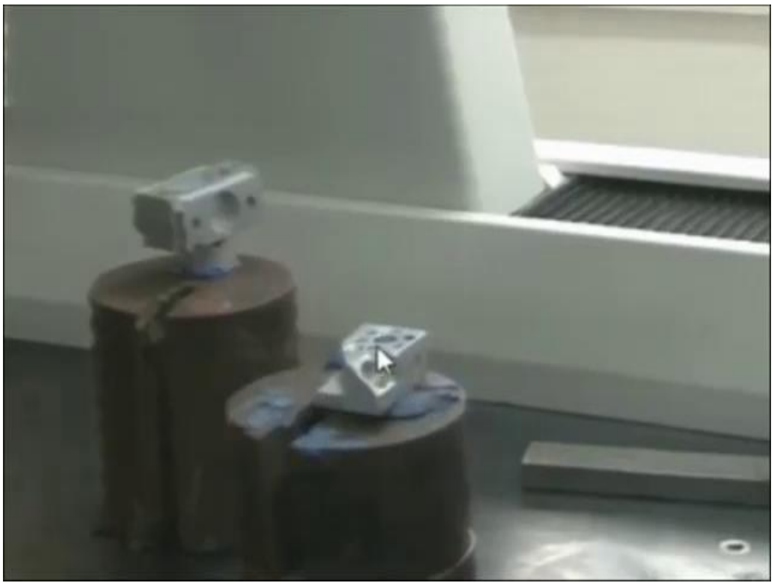

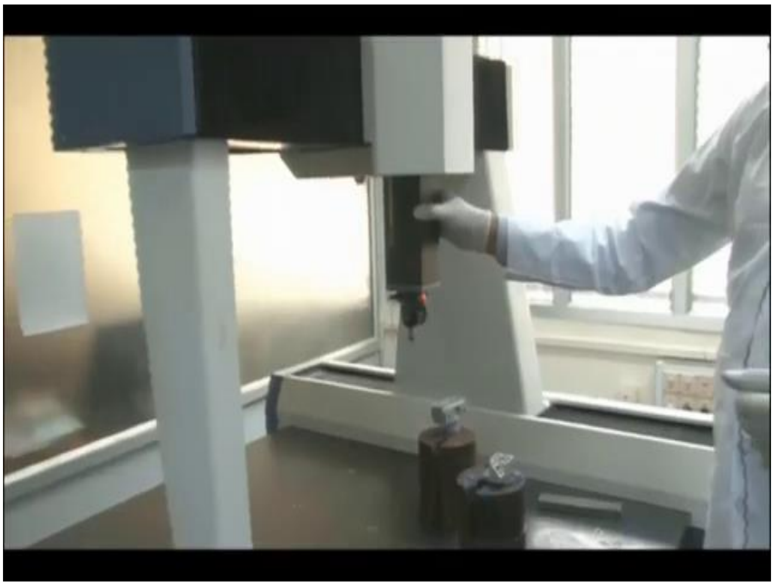

This is 3D object that we will measure using this co-ordinate measuring machine, okay. We will try to measure the features of the job, of this component. So you can see there are number of circles here. Okay, there center circle, center cylinder here, okay, we have circles here. Then we have 6 cylinders around the center cylinder. Okay, I will just measure this full cylinder. Then I will this 6, 1, 2, 3, 4, 5, and 6. I will measure try to locate these 6 circles, not the cylinders.

So also we have a cone in the other direction. We have this cone here, we have this surface at an angle, this surface, this plane, and this plane is at 90 degree, so let me first talk about the axis. There are the 3 axis when I switch on you can see that the indicator is on. So this is our Y-axis when I move in this direction, this is our Y-axis. This is our Z-axis. This is Z-axis.

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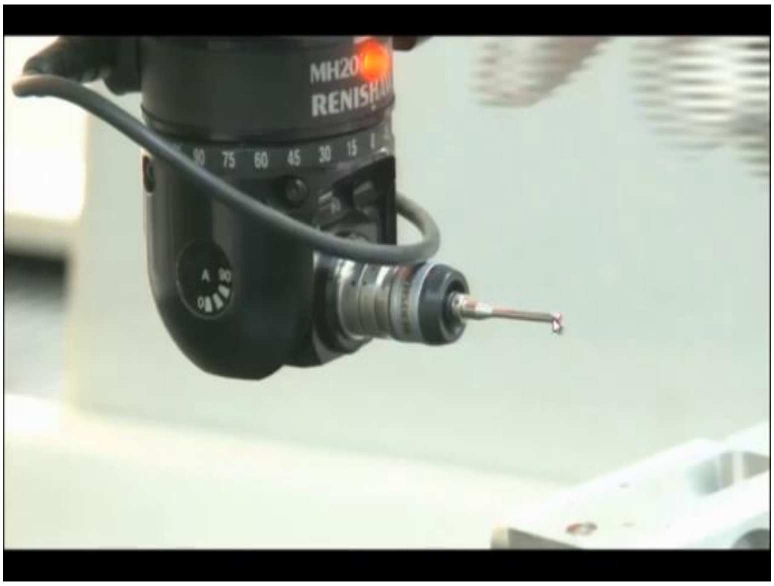

We have actually this is LVDT, this is LVDT. We have 3LVDTs, each axis has an LVDT. These LVDTs for Z-axis, so for inside the column above, we have for Y-axis, here we have for Y-axis and also we have for X-axis as well here. This is a probe, we can rotate it to (90) 180 degree. This is 180 degrees.

It can be rotated to and this can be rotated to 90 degrees, 0 to 90. So we can index it. Index to 90 degrees here, so index the point to 180 degrees, so this is the front-most position in a stylus. So this is stylus. If we see the tip of the stylus this is sapphire ball. This is of sapphire material then the diameter is 2 mm, so this rotation, let you know, this rotation is called as A.

This rotation is called as A, and this rotation is called as B, okay. So A can rotate up to 90 degree, B can rotate up to 180 degree, okay, 90 degree on this direction, B can rotate up to 180 degree or we will try to explain it using the help of the software, the name of the software is Tangram software. So how to start here?

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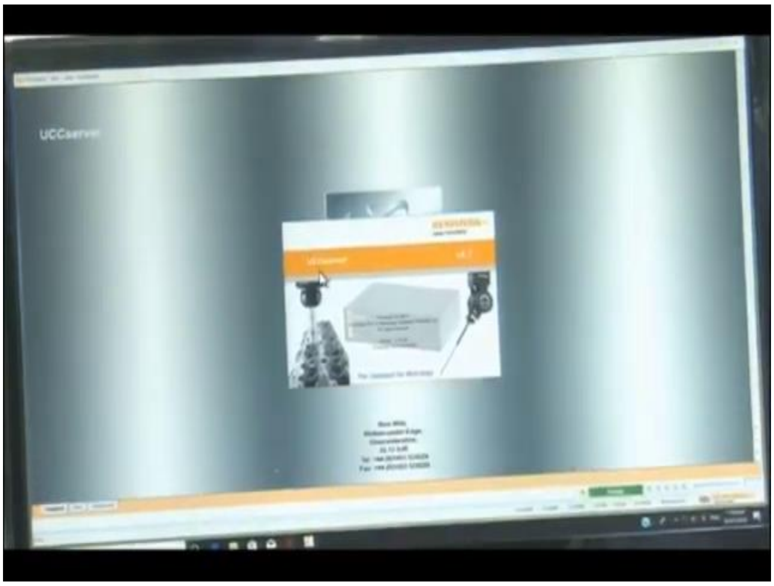

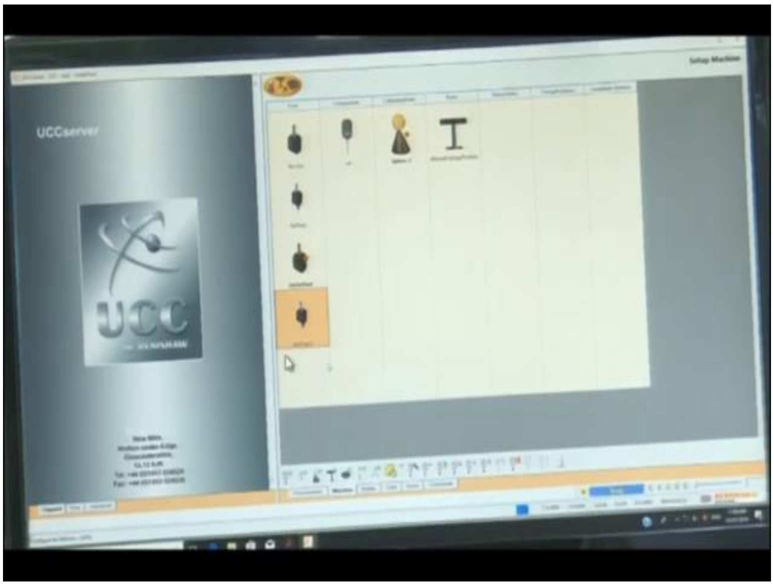

So first click on the UCC server, UCC as I said, UCC is universal CMM controller, so we have vanished our UCC controller which is designed to link the hardware of a co-ordinate measuring machine to the co-ordinate measuring machine host computer. So this is a host computer, we have the hardware machine, so read has probes, probe had controllers limits to chase, emergency stop, analog signals to subway amplifiers, joystick unit all these things are the components of the co-ordinate measuring machine.

The purpose of UCC is to permit the control of CMM from the front end software. The controller provides the control signals to CMM probe system necessary to give the required response. For example, to position the target to the given parameters, so there are certain purpose is that this UCC controller is accomplish.

For instance, data transfer and control so then communication with a controller, then especially controller features are also there. They are like CMM measuring accuracy enhancement, then measurement co-ordinate system, we can use different co-ordinate system, digitizing and scanning abilities are also there, then data filtering can also happen using this controller here only because we can produce, we can create the file in .igs format, so what is igs format?

We can, we will produce igs format would produce a lot of codes, okay, a lot of codes can be produced. One who has sign information of the codes can also use those that format when we will produce a shape. One thing is they just have a geometrical shape. Another thing is we can have the data in excel format. We can have data in IGS format. So the graphic user interface one can try to learn in-depth also.

So these things are possible. Interfacing to the other components is also possible through this UC controller. So next I am trying to generate a platform to measure the features of the object, so we click on the machine here. We right-click here and click set. When we click set here, then we can click yes, okay. The machine is going to home position now. Its reference tool is when you click machine is going to the home position.

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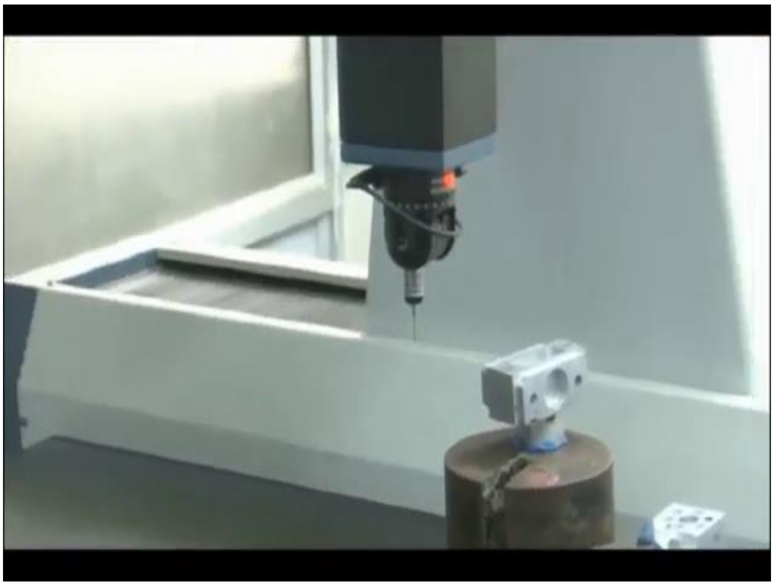

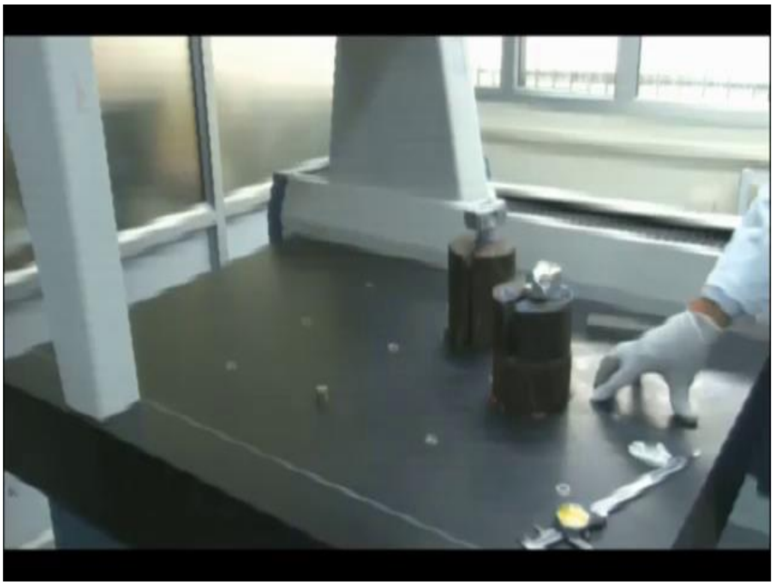

So I will come to machine, you can see the machine is going to home position by itself. So going to home position serve multipurpose. One thing is it is make sure that each and every component is working properly second thing is that machine is now free to take it to the desired position wherever the operator would like to take it to.

It will first went to Z home position and it went to Y home position and it went to X home position. I can repeat it again. So first is Z home position, then Y home position. This is Y and X is moving simultaneously, Y and X home position, so it has now went to the home position. Now machine is homed I can say. There now machine is home, now machine is homed.

Other components we have this software and we have this granite surface plate or surface table here. This is zero grade surface plate as a side the accuracy is quite high and the thermal expansion is zero. So size of the machine is 500. This distance, x distance, this distance is 500, this distance is 600 from here to here. This distance is 600 and the height is 400. So that is why it is known as 5.6.4 so this is spectra 5.6.4.

So next component is joystick. So when we rotate this joystick clockwise, it moves that direction downwards. When I rotate it anticlockwise, it moves the Z accords. So this is left X motion, X-axis motion. And similarly, I can have right axis motion, Y-axis again, back, backside, then forward side. So the simple joystick, the operator uses it to control.

Only Y and X-axis are very similar to the moments there, so only the thing is that rotation of this knob anticlockwise and clockwise makes it the Z-axis fast forward. So this is joystick X, Y, and Z. X, Y, and Z. So this is engagement of sensitive mode, engage sensitive mode if it is required. So we would not work on this.

The software here is Tangram, we have the indicator here. Indicator would blink and when this will touch and also beep voice would come. So we actually are trying to put the voice over the recorded video. So the actual laboratory conditions are quite noisy. We will also try to show you the actual laboratory conditions when we will start the measurement and like to hear the voice and the noise there as well.

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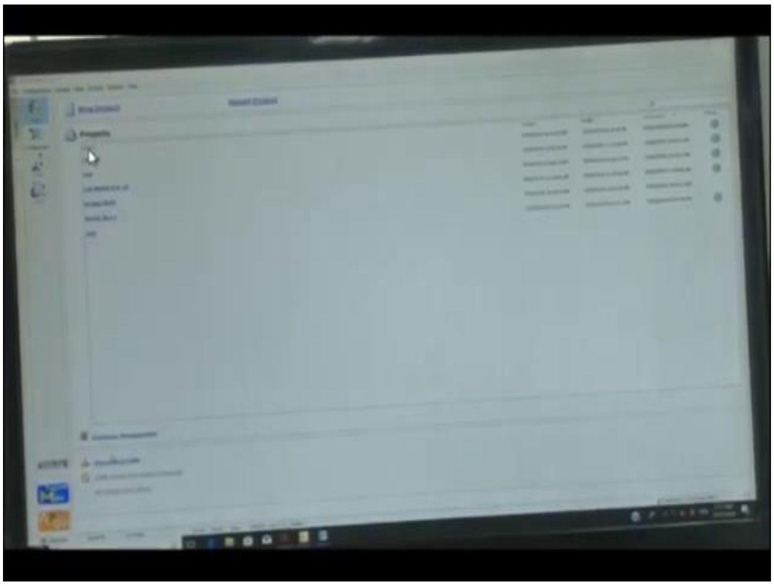

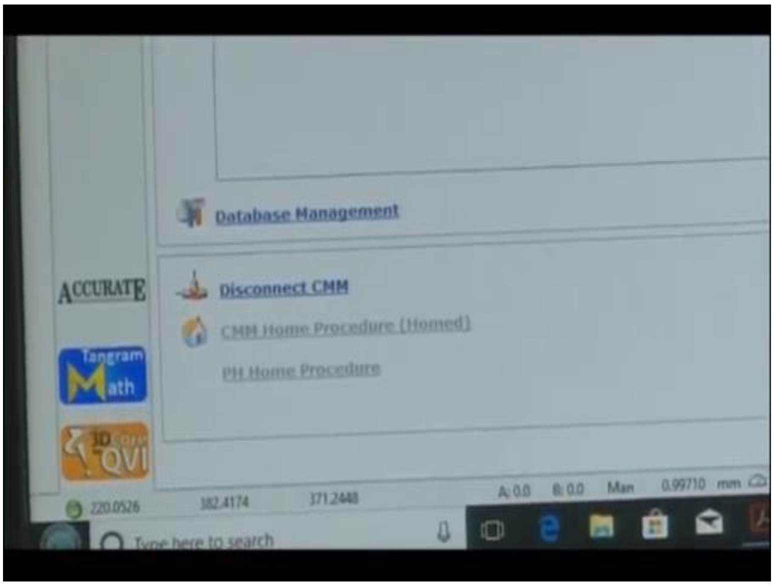

Now we open the new project, the projects we open the new projects, okay. Then screen opens, so first, we take the reference system. Then we take 3 points, top plane and 3 points are taken from the other plane and cylindrical point from a region then we select the pin and move the joystick.

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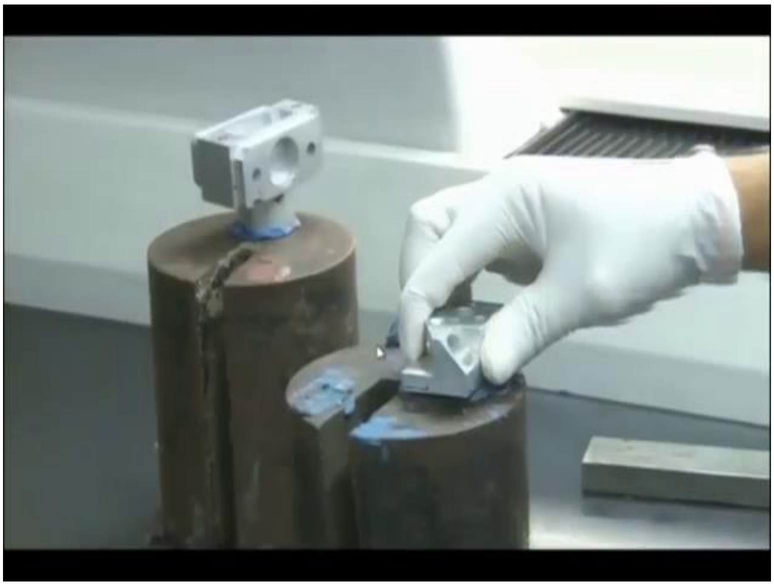

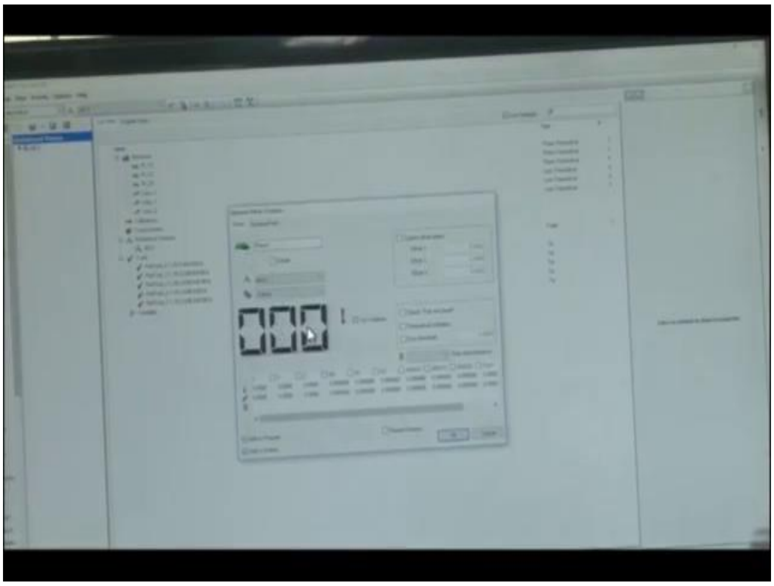

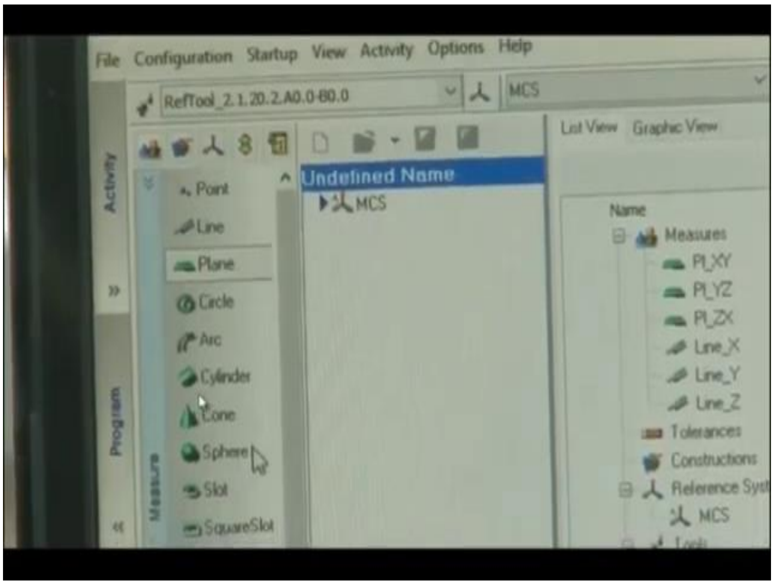
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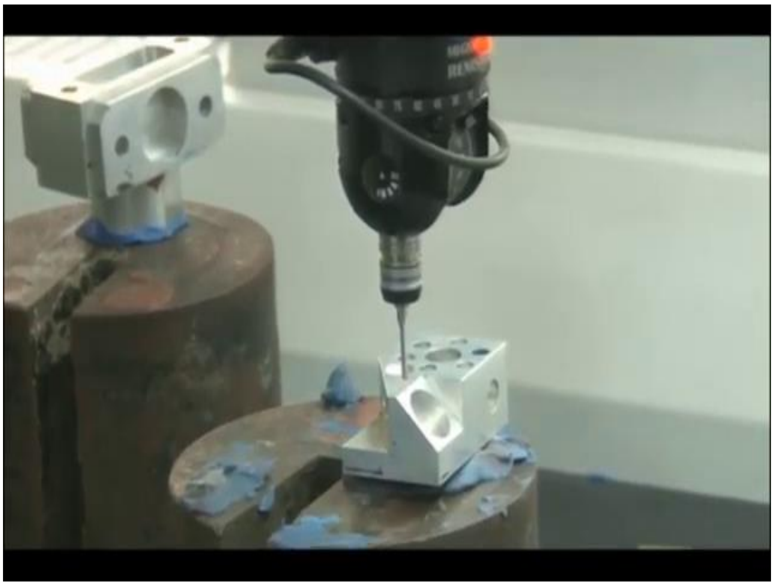

So this is our workpiece, the features of which we are going to measure. So we will take 3 points from this plane, 3 points from this plane. So this is our cylinder, this is cylinder. What is display? This is ZY plane, this is ZX plane. What is this stop plane? This is XY plane. So this we have selected plane, plane 1. It will try to record the points at least 3 points are required to define a plane.

So we will record the points using joystick, we are trying to move the probe close to the component when they will touch the tip of the probe that is the wire material, we are doing it again, we have selected the plane, plane from here. So before moving all the components we have point, line, plane circle, arc, cylinder, 8 points of cone, 8 points sphere we need multiple points for this layer.

Sphere slots, square slots, ellipse, curve, surface, torus, they are you know they are multiple objects here in this software and, this is just the general or the structured surfaces, free form surfaces are when we just imagine the free forms. Then we have distanced angled points, there are the construction measures. What do we need to measure? We measure the plane, we measure the line, so this is general measure that was construction.

Then we have various other tools like 3 dimensional other forms etc. So we are just touching it to 1, 2, and 3. 3 points are now recorded in our software.

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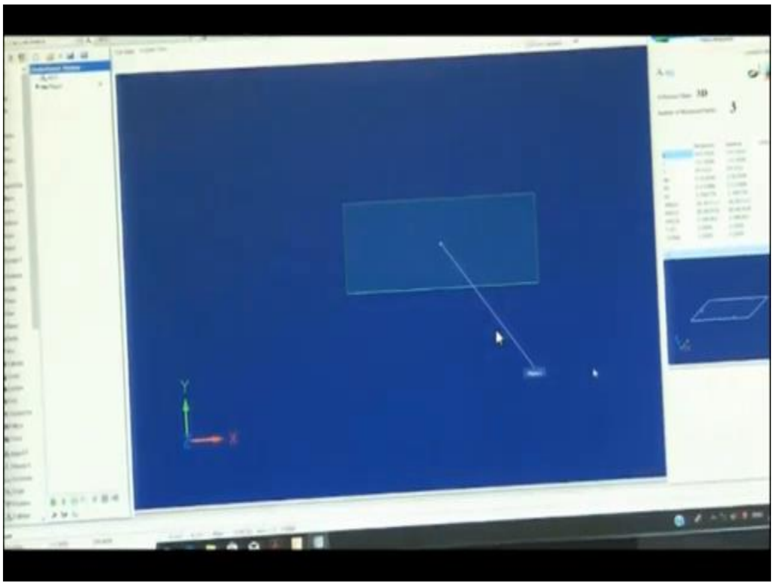

So it has shown this plane here, this plane 1 is now defined. We can name the plane as well, we can name it XY plane, we can mark it whatever name we will like to give, we can name the plane as well but it has just marked as plane 1. Because we did not change the name, the default name was plane 1.

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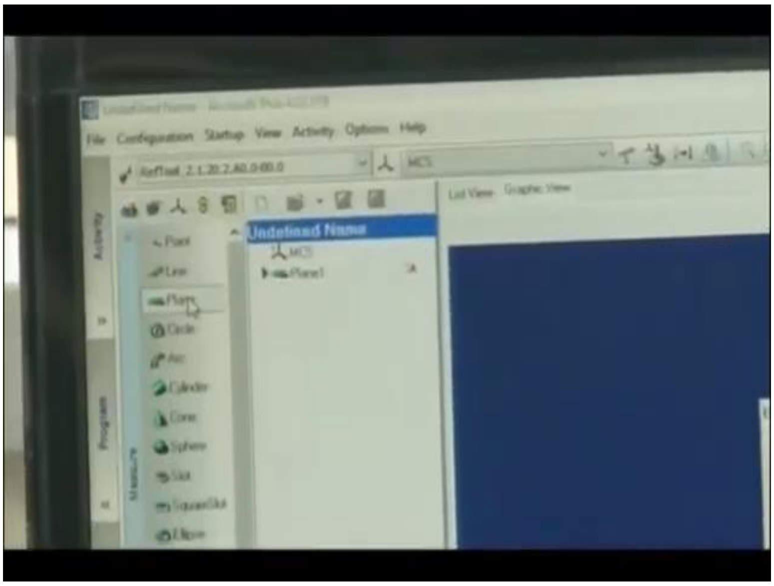

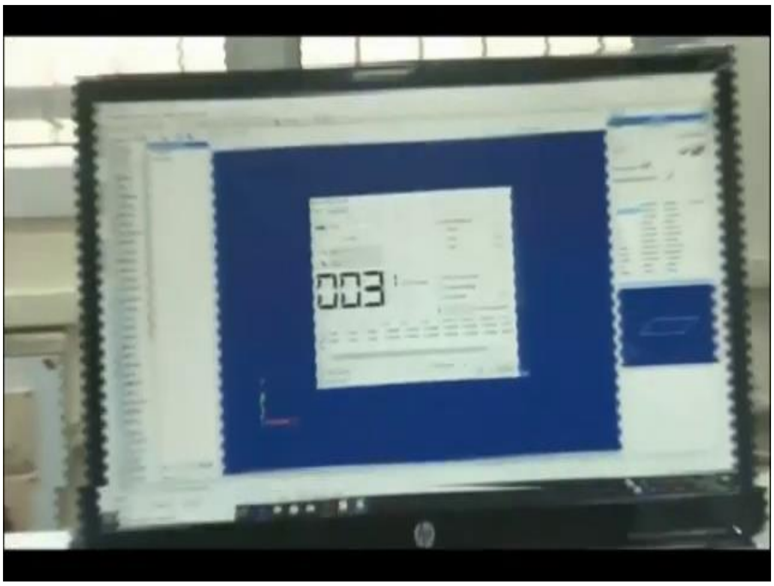

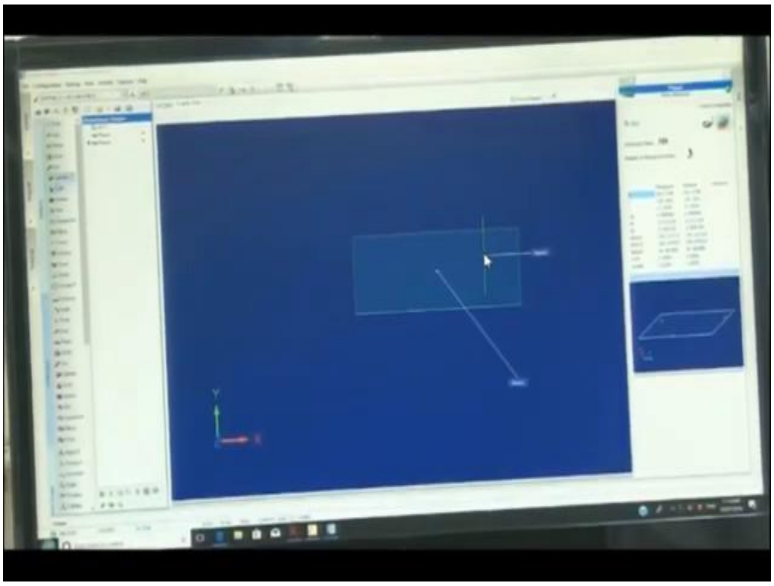

Now we will select the plane again. It is left plane 2, now I am selecting the YZ plane, 1, 2, and 3. You can see the light blinking when the light is blinking that is the probe has touched 1, 2, 3. 3 points are recorded and the second plane which is perpendicular to this one is generated. Plane 1 and plane 2.

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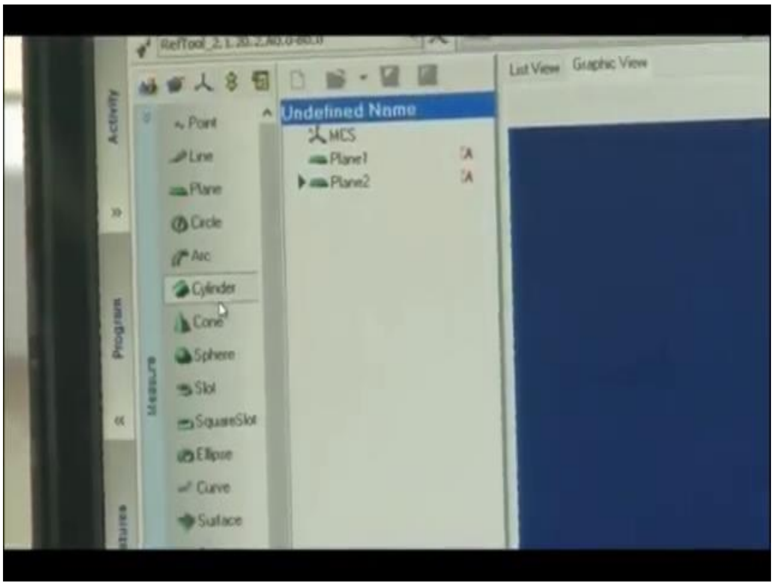

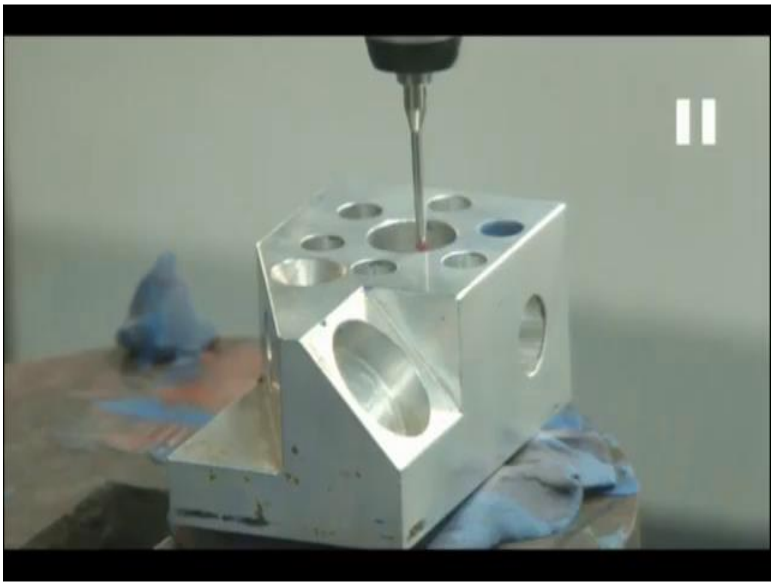

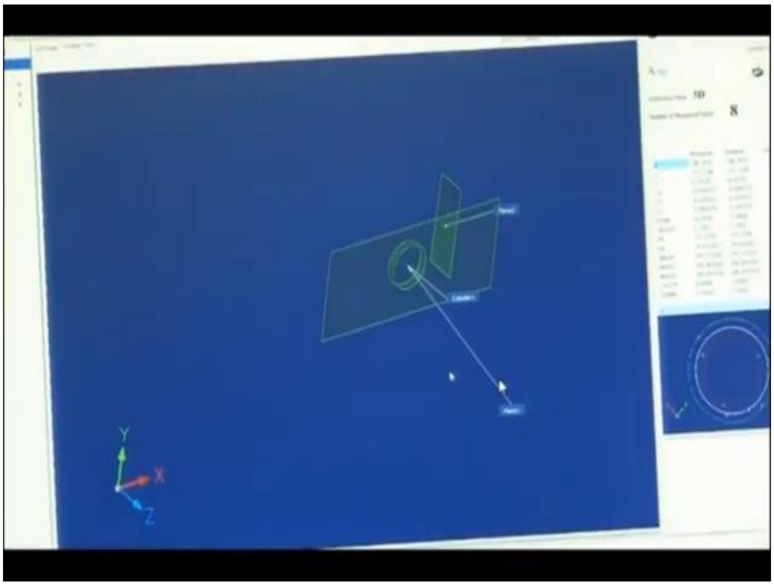

Now I will measure the cylinder. So 3 points for plane was selected for cylinder, we need 8 points, 8 points, 4 points in one plane, 4 other points in the second plane, 4 points in one plane means 4 points will give me the location of the cylinder that will mark one circle another 4 points it will depth than the initial plane would give the second circle.

These 2 circles would help us to generate a cylinder. The cone can also be generated similarly. So this is 1, 2, 3, and 4, okay. Similarly little depth 1, 2, 3, and 4. Okay. So this cylinder profile is generated. We can see here. So we have plane 1, plane 2 and cylinder.

Now we can set the reference system here. Reference system means what should be our reference point for the rest of the workpiece. So I can keep the center of this cylinder as a region.

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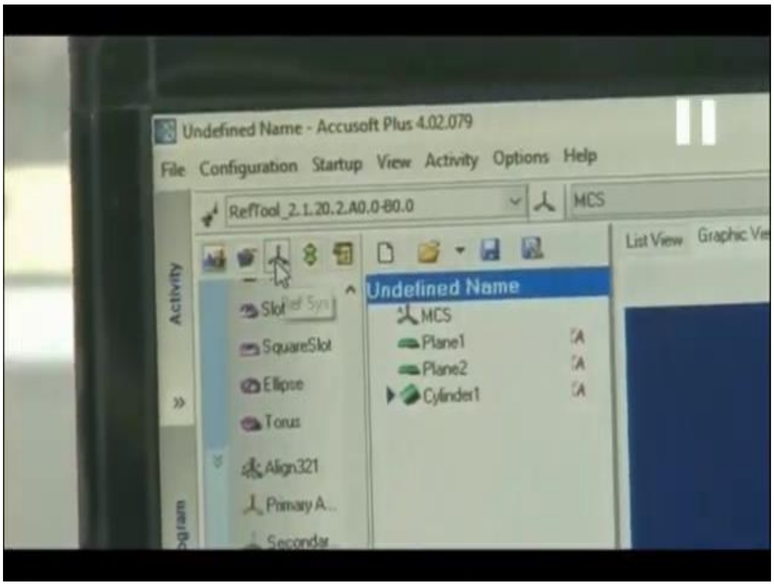

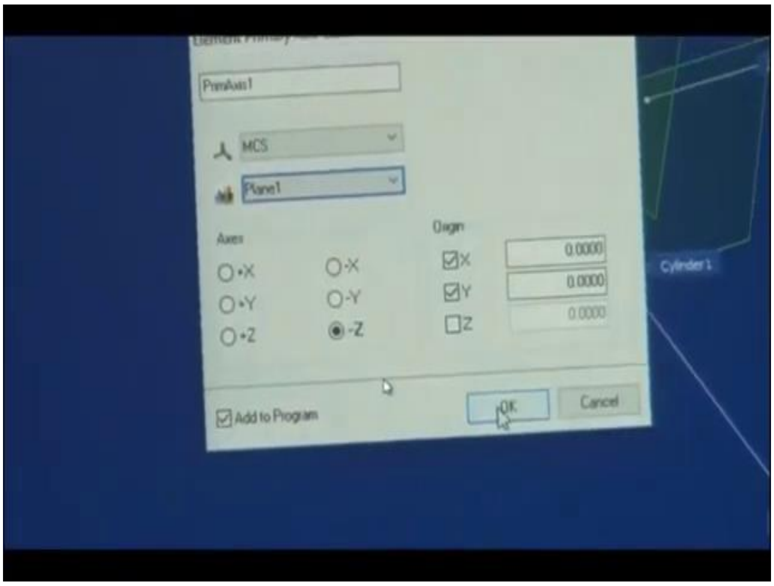

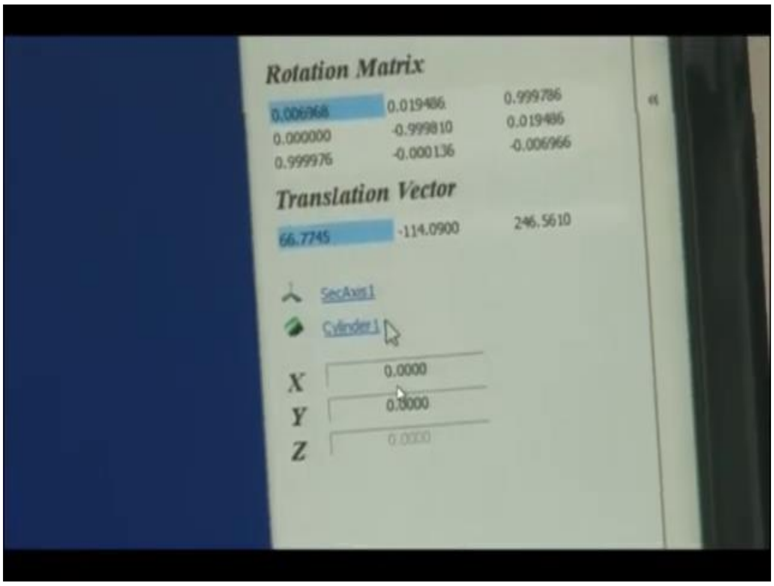

For that what I have to do, I select the reference system, select the primary axis, the primary axis here, the primary axis. After primary axis, I will select plane 1 minus Z direction, minus Z direction will be plane 1, plane 2, and cylinder.

Plane 1, plane 2, and next is cylinder. Now the center of the cylinder is my origin, you can see here. The center of the cylinder is my origin. So this is my reference, the two planes in one cylinder center has made us to select the reference system.

(Refer Slide Time: 34:07)

So we have got the origin point here that is a centre point, origin point here, the centre point of the cylinder is the origin. So next is how to measure all the parameters? We can select the circles here, these 6 circles, okay. This is cone here as well.

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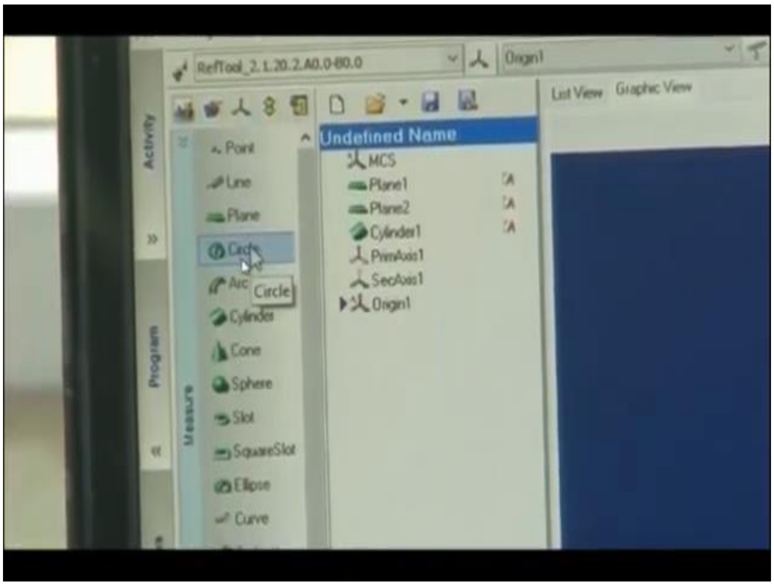
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List View
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Program
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Point
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Plane
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Arc
Cylinder
Cone
Sphere
Slot
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Ellipse
Curve
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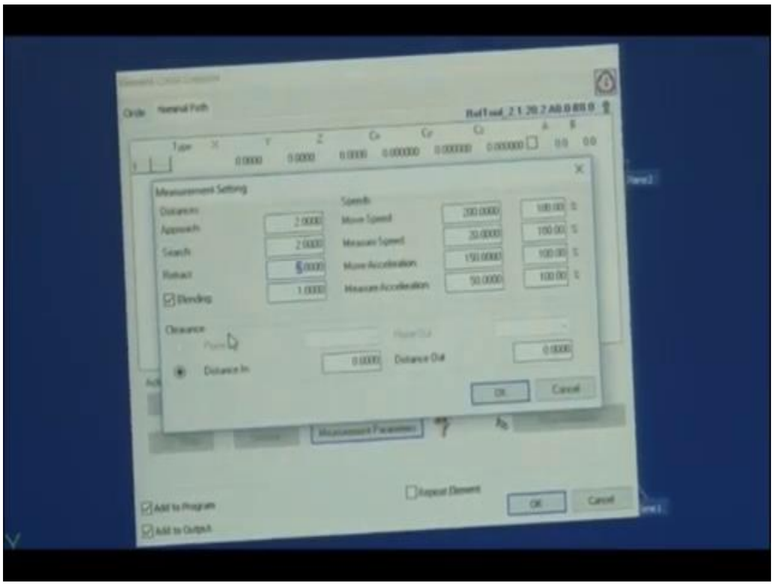
MCS
Plane1
Plane2
Cylinder1
PrimAxis1
SecAxis1
Origin1


Measurement Setting
Speeds
Approach
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Retract
Blending
Move Speed
Measure Speed
Move Acceleration
Measure Acceleration
Clearance
Distance In
Distance Out
OK
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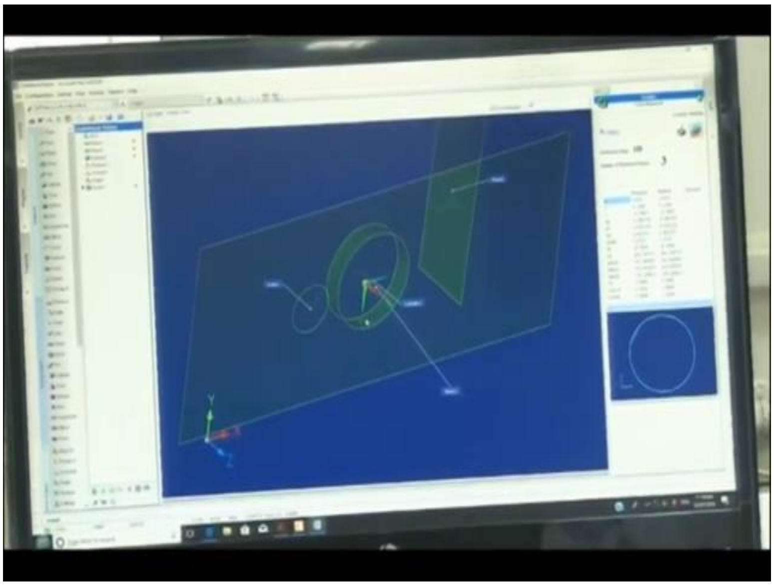


So to measure the circle, we will select circle from here, then measurement parameters, so it is trying to retract from the 2 mm, we have entered 1, so at least 3 points are required to locate a circle.

So we retract at 1, so this is 1, 2, 3. The circle is now located because the origin we already have. This origin we already have here. Okay, at this point we have the origin. The distance of this origin from here and this circle would be located by itself. First circle, another we can, this circle is generated here.

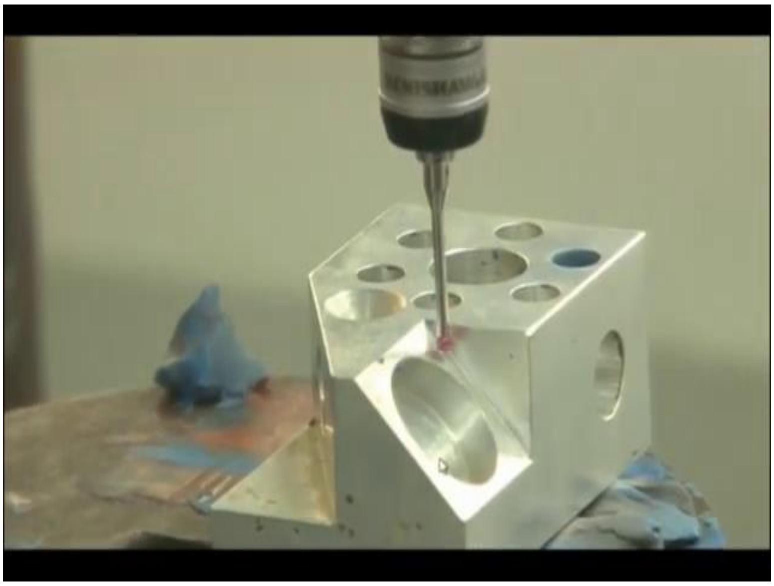
So I am not producing a cylinder here, I am just producing a circle. We can also produce a Y taking 8 points in a similar fashion as we did for previous cylinder or the center cylinder. Now second, second circle, so let me try to show you the laboratory conditions that what is the voice in the laboratory I will just switch on my sound here.

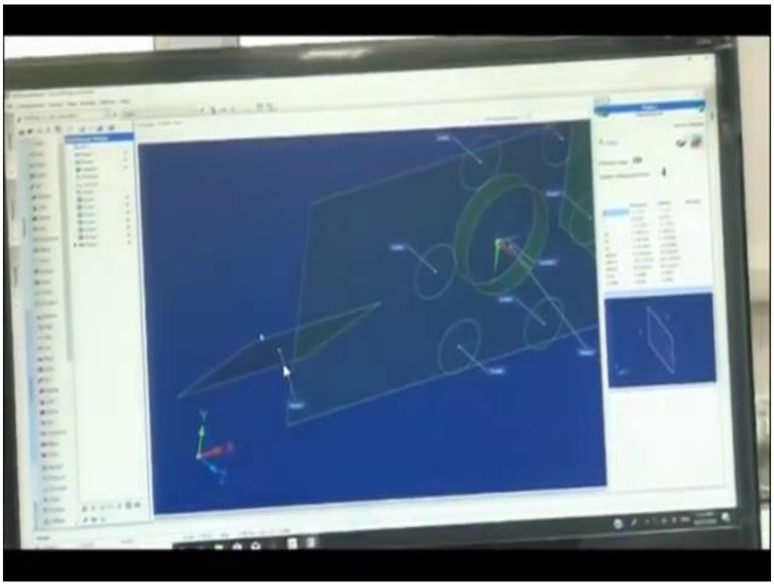
(Refer Slide Time: 35:47)

You can see. 1, 2, 3, 4. We have marked 4 points, 3 points were the minimum, 4th point can also be marked. So you can see in laboratory conditions there is a lot of noise. That we why we are trying to record separately in the laboratory. So you can see, you can just now watch that the blink of the indicator is also there and the beep is also there. 1, 2, 3, 4. 4 points are marked.

We can start it, for the circle 4 points are better to choose. So similarly we are trying to make these circles 1, 2, 3, and 4. When that probe is touching the surface, these points are being marked here. So these 6 circles are located here. Now again select the plane, so it will measure the slant plane, let us make the slant plane, this slant plane here.

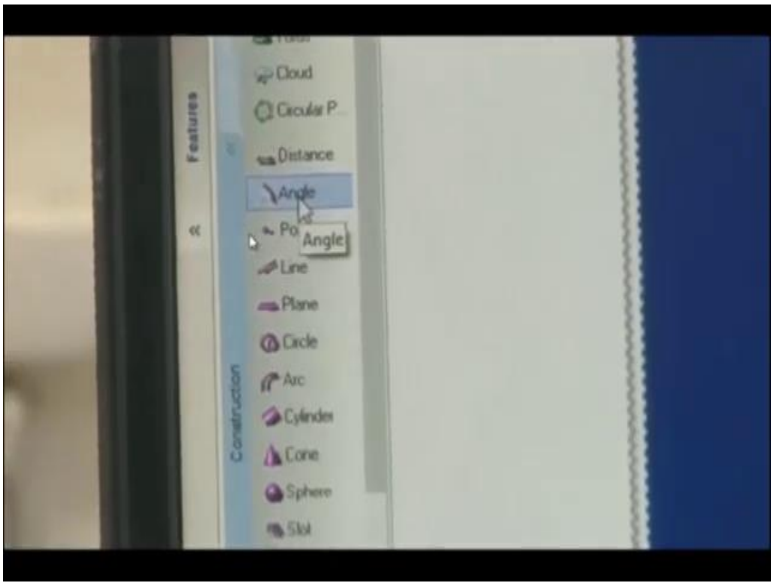
(Refer Slide Time: 36:58)

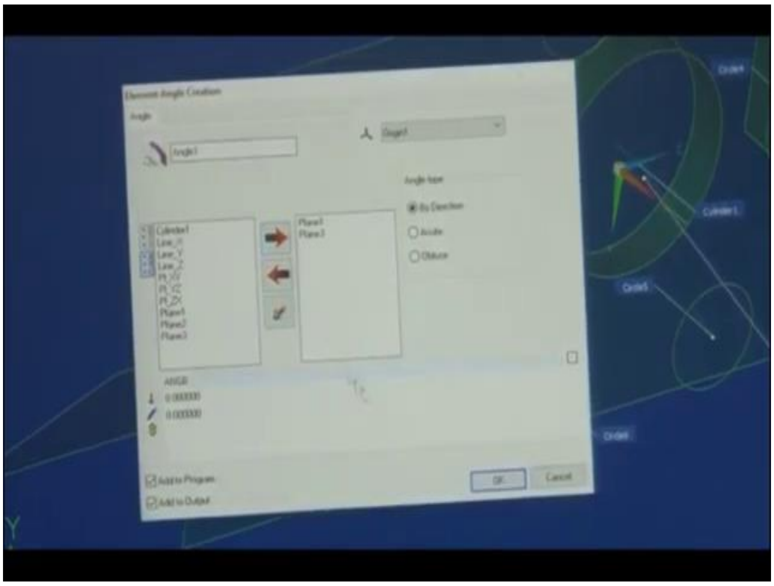


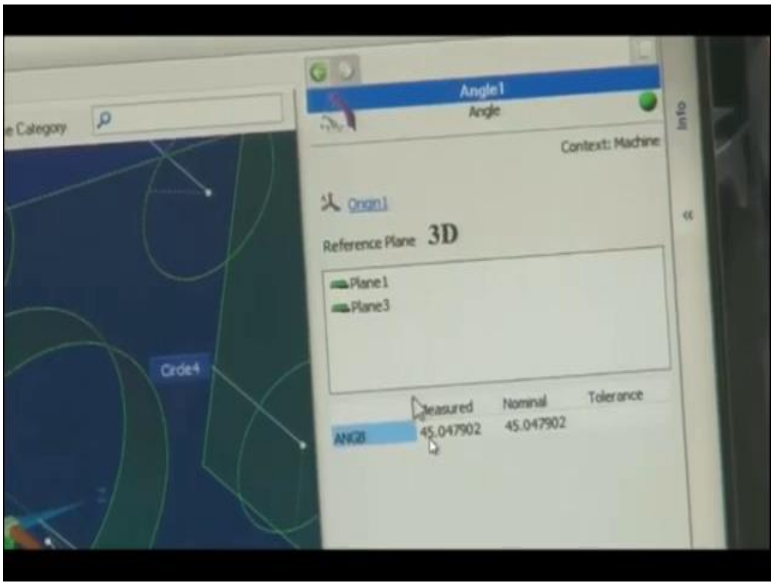


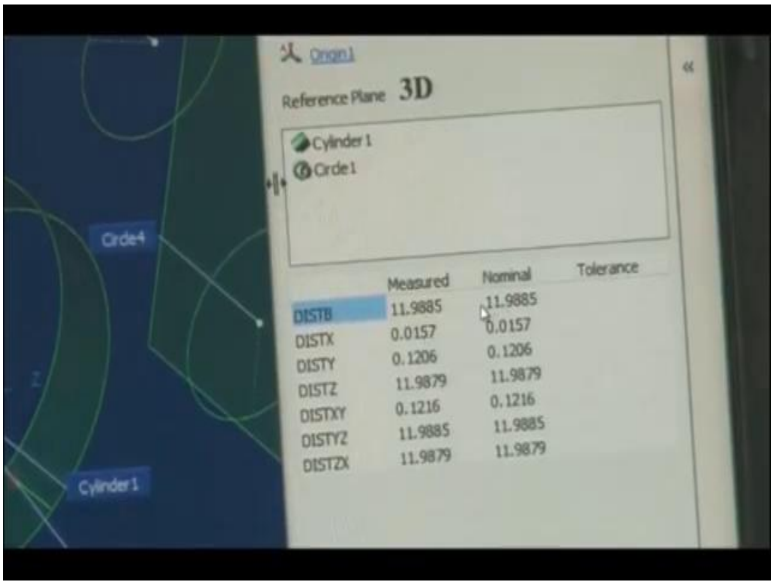
Okay, this slant plane here. Also, we will try to fill 1, 2, 3, 4. We can mark more than 3 points as well. So this slant plane is also located here. So what is the angle between the plane between these two planes, this slant plane, and this XY plane? So we can go to construction. You can see, we have measure here, measure and we have construction here.

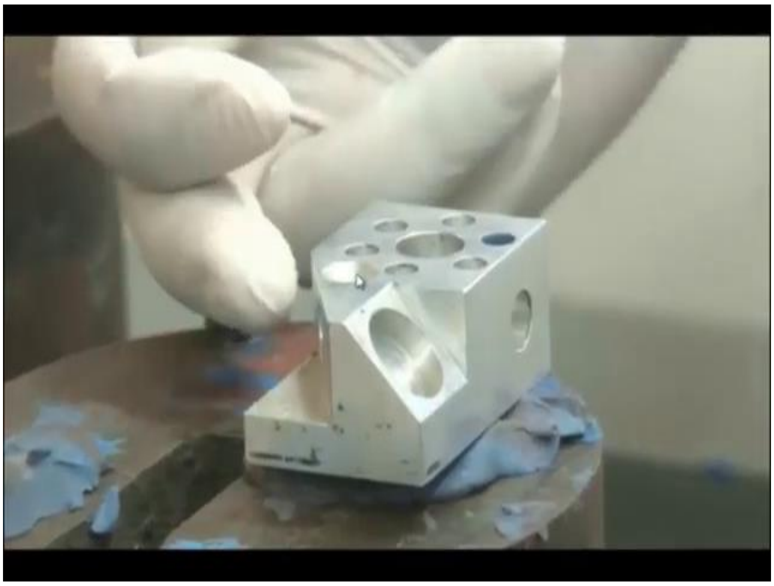
(Refer Slide Time: 37:41)






Angle1
Angle
Context: Machine
Info
Category
Origin1
Reference Plane 3D
Plane1
Plane3
Measured
Nominal
Tolerance
ANGB
45.047902
45.047902
Circle4


Origin1
Reference Plane 3D
Cylinder1
Circle1
Measured
Nominal
Tolerance
DISTB 11.9885 11.9885
DISTX 0.0157 0.0157
DISTY 0.1206 0.1206
DISTZ 11.9879 11.9879
DISTXY 0.1216 0.1216
DISTYZ 11.9885 11.9885
DISTZX 11.9879 11.9879
Circle4
Cylinder1

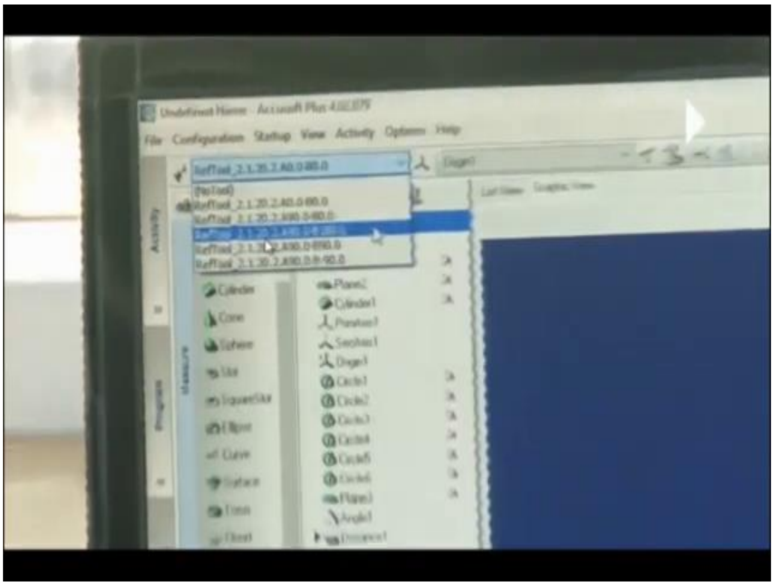


In the construction, we can click angle, now it will ask between which entities you need the angle? Plane 1 and plane 3. So the angle between plane 1 and plane 3 is 45 degrees. So this is the angle it is showing 45-degree angle. So similar to the angle we can also measure the distance between cylinder 1 and circle 1.

Between the cylinder 1, this is a cylinder 1. This was cylinder 1 and circle 1. So we will select the distance, distance we have selected distance here between cylinder 1 and circle 1. So we have selected distance here, distance in place of angle. Distance between cylinder 1 and circle 1. So distance between cylinder 1, this is circle 1 and cylinder 1, that is a region is 11.98.

It is showing the nominal and measure. Okay, different plane is here, this is XY plane, this YZ plane, this is XZ plane, this is again YZ plane, so this is again XZ plane. So now I rotate it 90 degree A, 90 degree, B, 180. Let me repeat this. This is A 90, B 180. If I have made this change, I have to put this change in the software as well. So I will put a 90, A movement is 90, and B is 180.

(Refer Slide Time: 39:24)



So I am putting this movement that means to if you see this is A 90, B 180. Okay, you can see A 90 here, B 180. Okay A 90, B 180. We click yes because we are going to measure now the YZ planes. That is why we have turned this to this direction. Easy locking nut on this side, locking screw on the other side. We have locked the probe here. Now we will measure this YZ plane.

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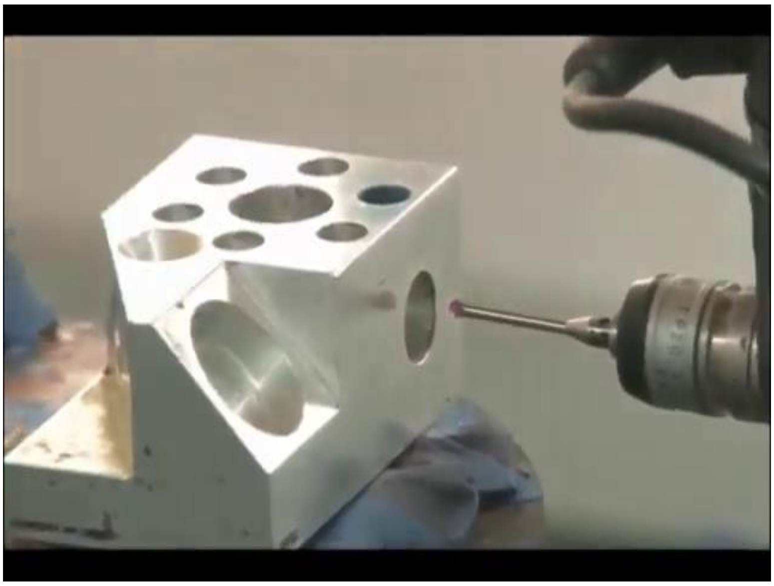
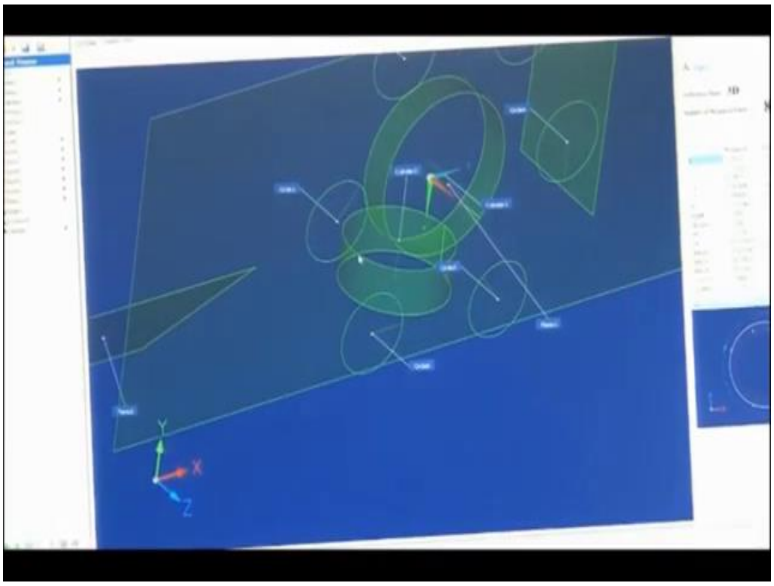
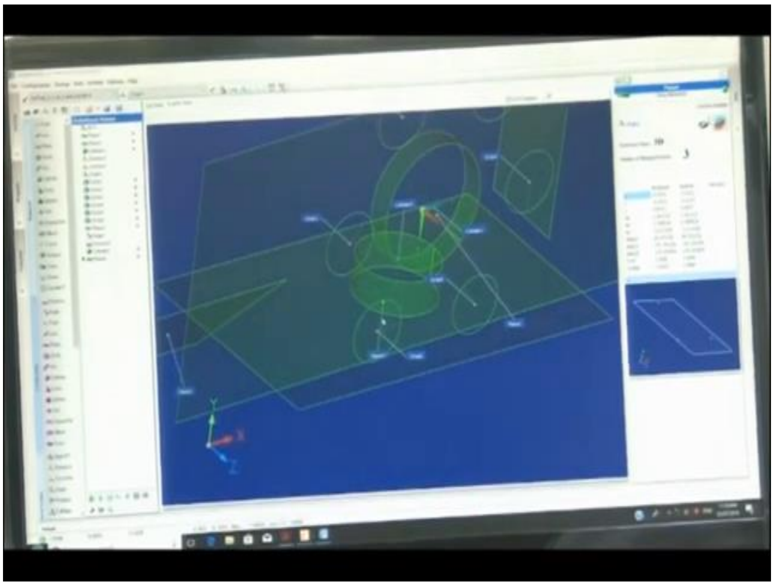


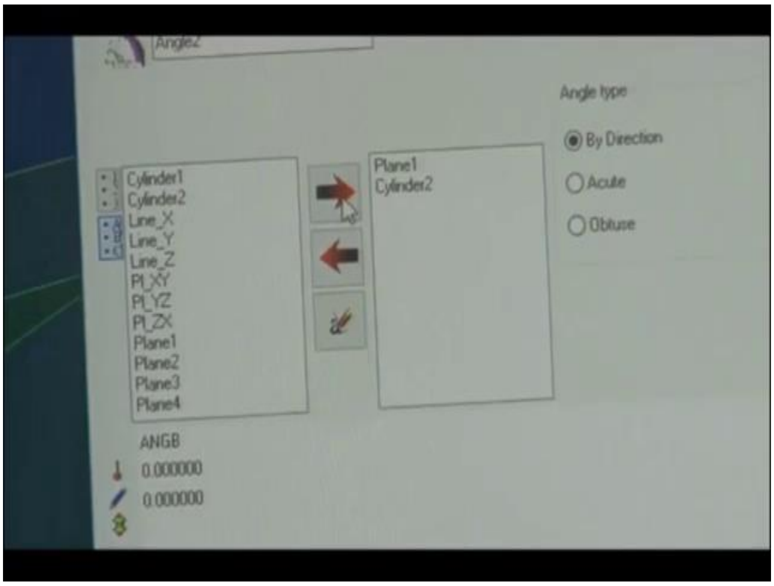




Again laboratory, so we will measure the 8 points here 1, 2, 3, 4, in the laboratory conditions 1, 2, 3, 4. So we have located another cylinder here which is at 90 degrees to the cylinder 1. Cylinder 2, this is cylinder 2, this is 90 degrees to cylinder 1. So how much is the depth from the planes?

So we select the plane again, now this is YZ plane. 1, 2, and at any point you can just touch it 3, this is YZ plane. So we go to this construction, we go to the construction and try to see the distance from the plane. Let us see the angle, angle of the plane with cylinder 2.

(Refer Slide Time: 41:38)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Angle type
By Direction
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Obtuse
Cylinder1
Cylinder2
Line_X
Line_Y
Line_Z
Pl_XY
Pl_YZ
Pl_ZX
Plane1
Plane2
Plane3
Plane4
Plane1
Cylinder2
ANGB
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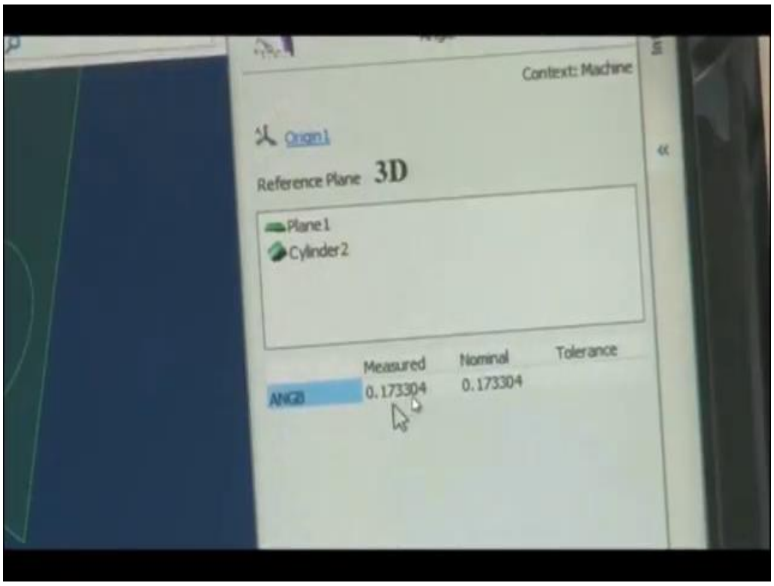
Context: Machine
Origin1
Reference Plane 3D
Plane1
Cylinder2
Measured
Nominal
Tolerance
ANGB
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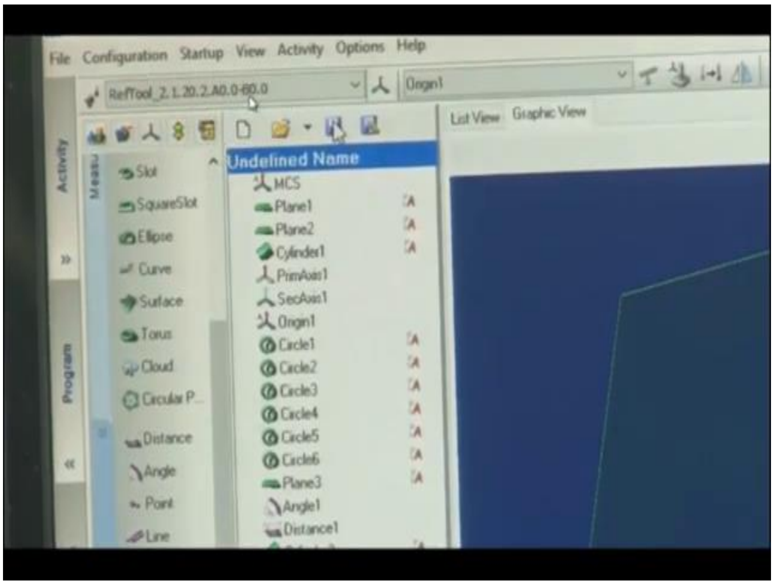
File Configuration Startup View Activity Options Help
Origin1
List View
Graphic View
Undefined Name
MCS
Plane1
Plane2
Cylinder1
PrimAxis1
SecAxis1
Origin1
Circle1
Circle2
Circle3
Circle4
Circle5
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Angle
Point
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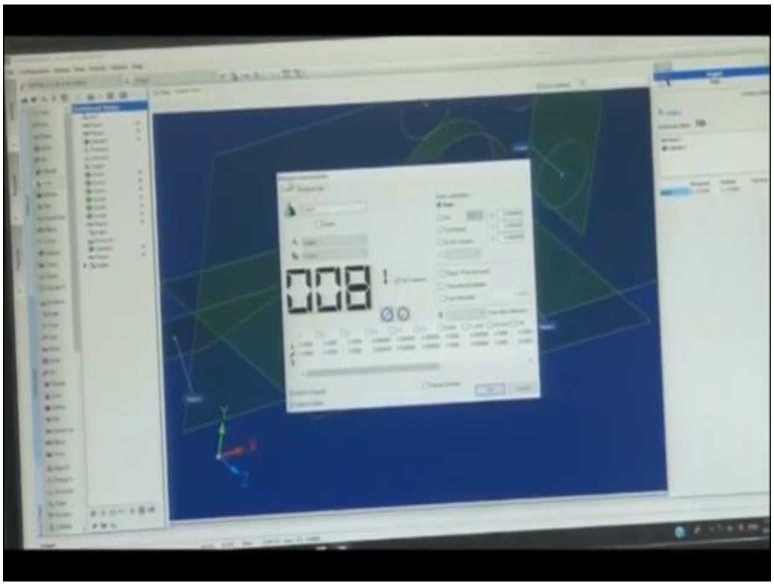
Activity
Program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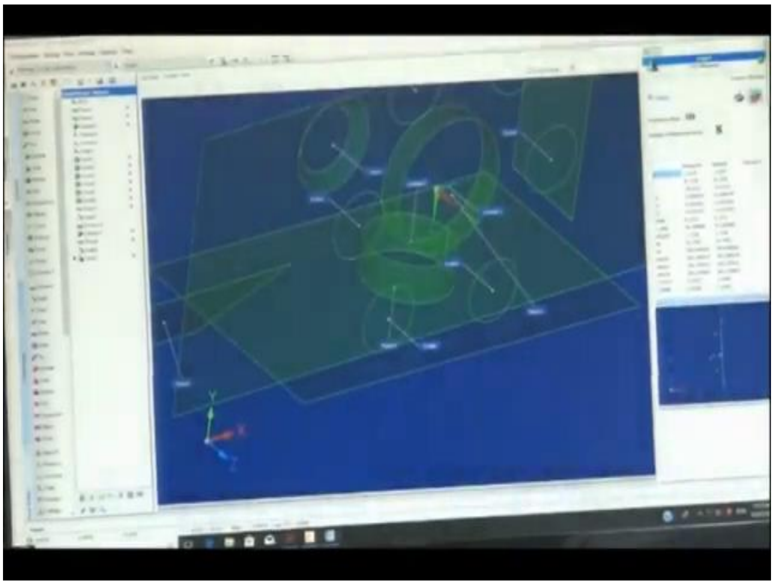

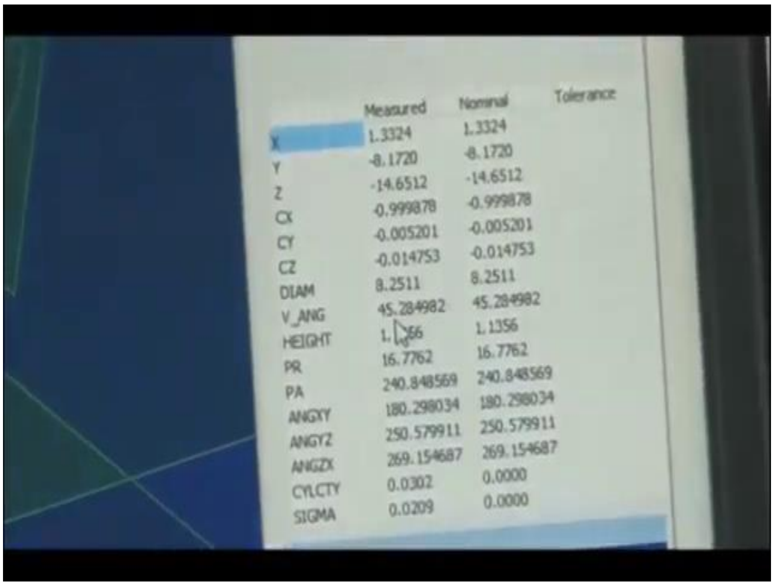

We have taken into some high position and we will go to construction here. Then we will select the angle. Okay, this angle is selected, angle between you can see plane 1, enter, and cylinder 2 should be there. Cylinder 2, enter, okay. Now we click okay and yes. Now between this cylinder and this plane what is the angle?

What should be the angle between this cylinder and this plane? Is there any angle? No, the angle should be 0. Let us see what the angle is, what is the computer reports? It is showing the angle as 0.173004, it is quite close to 0, 0.1. So it is 0. So this angle is 0 which within construction we can measure the angle, distance then the depth, the arc, all those things can be measured.

Now we will measure this cone, this cone here. Again we will change the position to measure this cone, A has to come back to its 0 position. You will select A0 and B0, okay. A0 and B0, so we click okay, yes, okay. So A is again brought to 0 position and B is again brought to 0 position. The angle is 0 0, lock the nut here. Okay.

Now we will measure the cone. So it has appeared here, now we will mark the points. We will measure the cone 1, 2, 3, 4, a little depth in another plane, in the second plane. So the 4 points in 1 plane, the 4 points in other plane were marked. So it has generated 4 plus 4, 8 points in 2 different planes. So this is the measure and the nominal dimensions here. So let us see it is also giving the height of the cone from the reference plane, so here is the cone.

So the cone angle here shown, the cone angle is 45 degree. You can see the cone angle here. Cone angle is 45 degree. So then we go for A 90 and B 0, A would be 90 and B is kept at 0 position only, let me turn A to 90, okay. A is turn to 90 degree and B is at 0 position only. So let us measure the plane on the other side. This will be named as plane 5.

So this is YZ plane, YZ plane that is Y axis and Z axis. So we will select 3 points, we will check another plane here. YZ plane.

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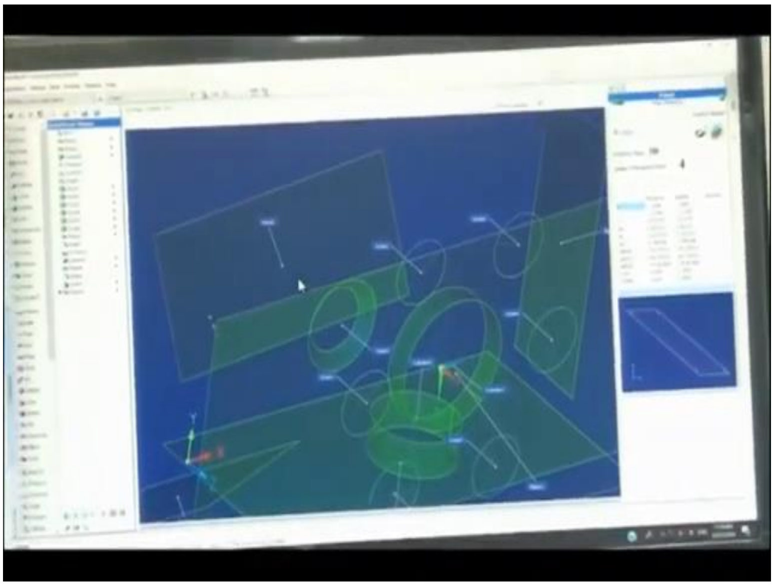

We will check 3 points near to YZ plane circle, so we are measuring this plane with an angle 1, 2, 3. So we select the plane, take 3 points near to YZ plane circle. This is a plane at an angle.

Now this is the potential or the beauty of the CMM that by using a single setup, we can measure all the parameters in different direction in different you know this is a structure or this is a structure of the known parameter cylinder, cone all those things. Also, free form can be measured. So we can store the data files in .igs format, so these all parameters can be exported then we can say we do the file, all these things can happen.

So they are now measuring the circle on other side on the YZ plane. So we can save the data in excel format. Now this circle is again measured, this plane is again measured YZ plane. YZ plane is measured.

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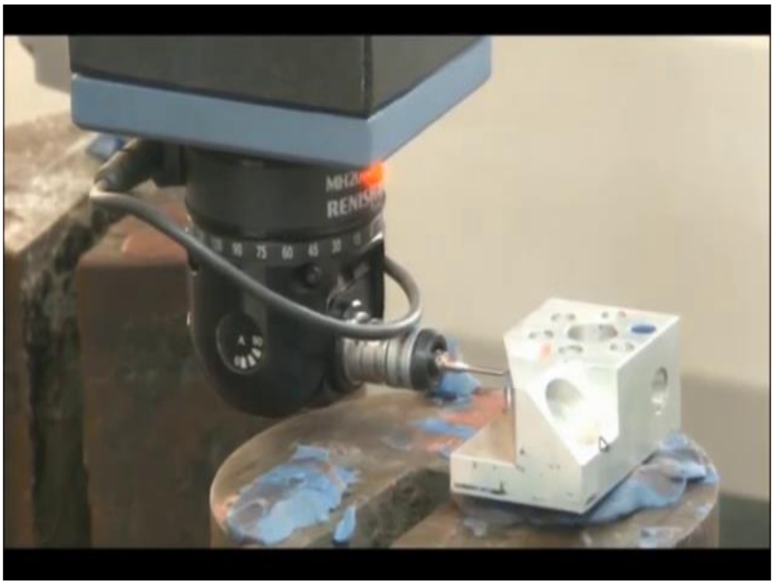

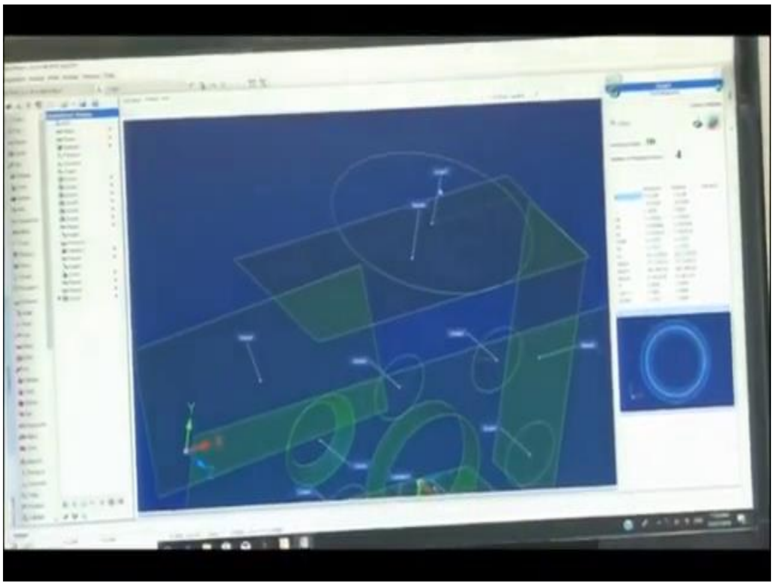

Now we are measuring the circle on the YZ plane. There is a circle on the other side like this. Actually cylinder on the other side as well, but we are just measuring the circle. 1, 2, 3 and 4, So you can see this circle is located, big circle on this plane, okay circle 7 on plane 6. This is plane 6, this is circle 7, this is located here. Similarly we can locate all the features but now I like to move forward. So we will try to see how the data is stored.

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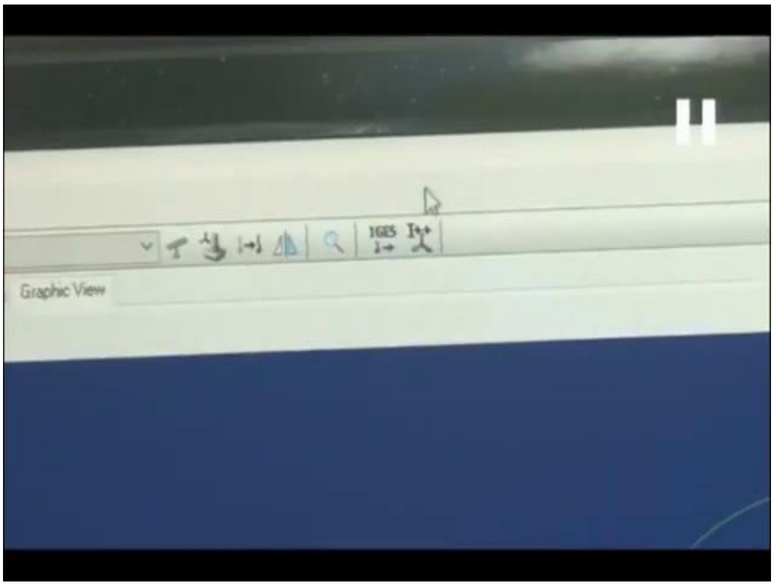

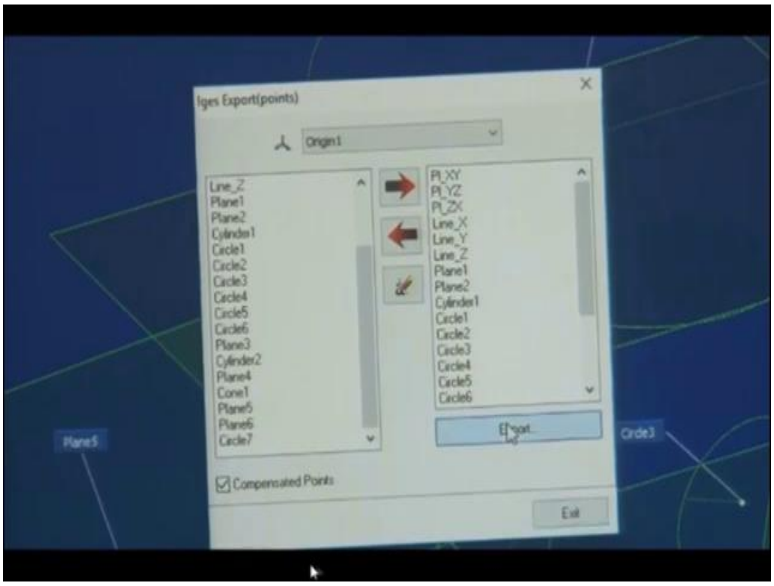

So IGES format is there. Okay IGES format, it can be stored in IGES format. I clicked at IGES, so what data we like to store? What points? All the compensated points okay, then we export it into the IGES format. So it is located in desktop frame curve. IGES format is located there. So we can read the IGES format also the data can be generated in the excel and also we can have the PDF file. We are now making a PDF file. We just named it ‘abcd’. Now we will save it is as PDF is already saved here. So now I am opening the PDF file.

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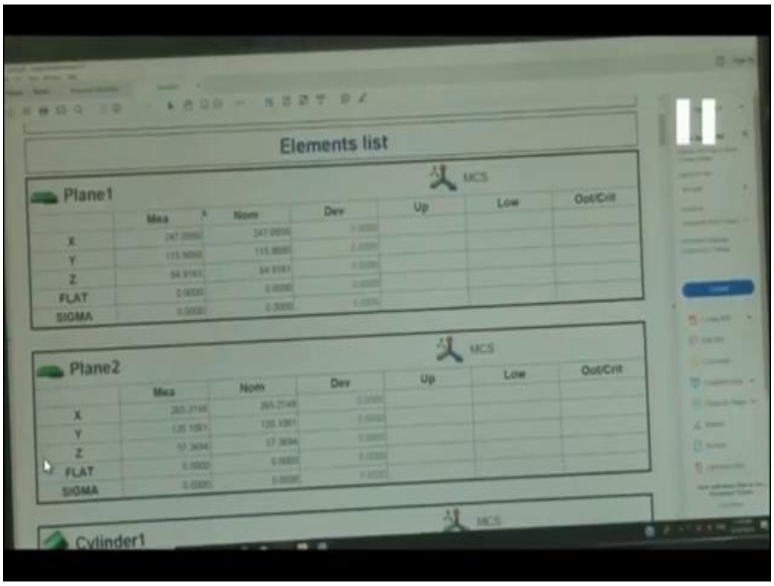

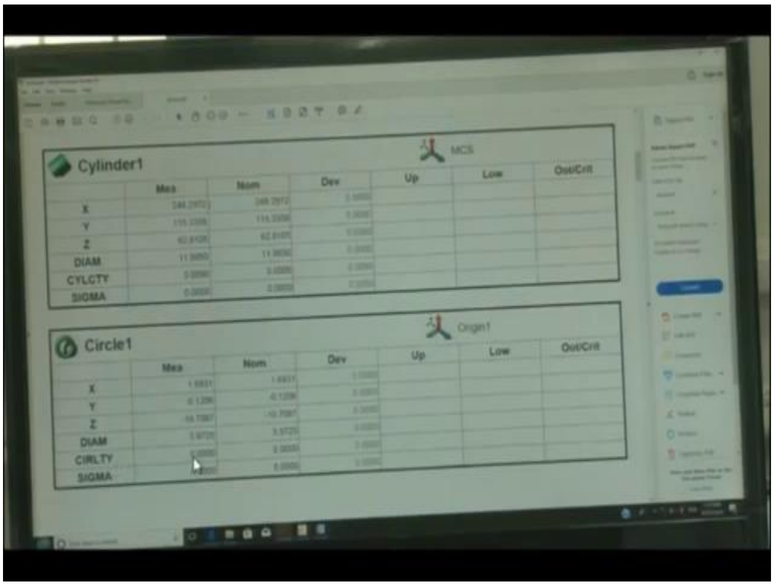

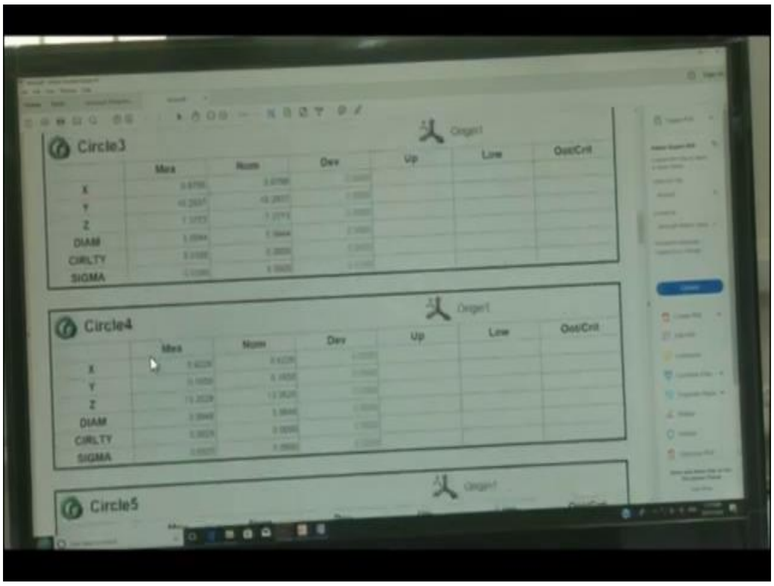

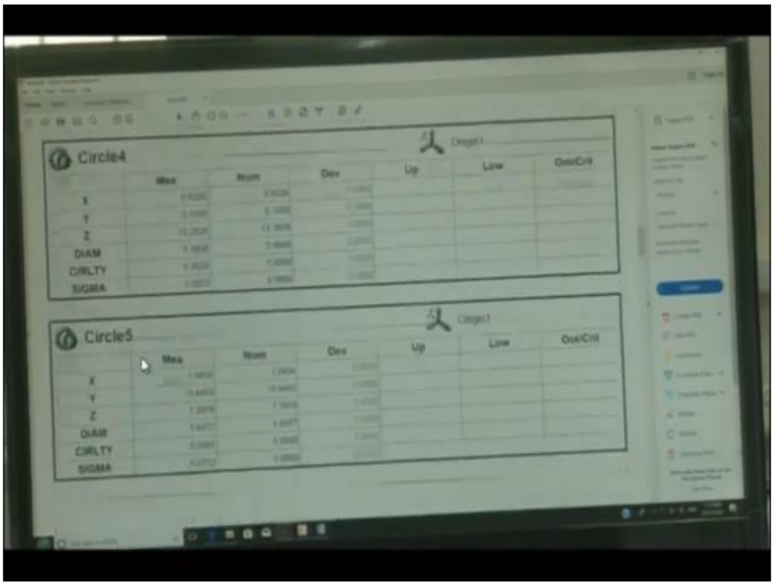

So this is an element list. We have generated this plane and the dimensions of the plane X, Y, and Z, measured nominal, what is deviation. Then up-low and did you know these deviation these distribution, not exactly distribution but tolerances can also be obtained from here.

Then plane 1 we measured first, then we measure plane 2 dimension for that. For the cylinder, we have X, Y, Z diameter of the cylinder, cylindricity is close to 0. Then sigma value for that, then for circle also circularity, circularity is 0 0 like its perfect circle, so X, Y and Z co-ordinates and diameter of the circle, it is 6 mm dia, so it is showing quite close to 6, this is 12 mm dia, so this is 11.99mm it is quite close to the 12 mm. Then the circle 2, okay, circle 3, circle 4, circle 5 all these circles, okay.

The co-ordinates of the circles, the first circle or the cylinder that we have similarly the circle 2, circle 3, circle 4 okay, circle 5 the dimension for that.

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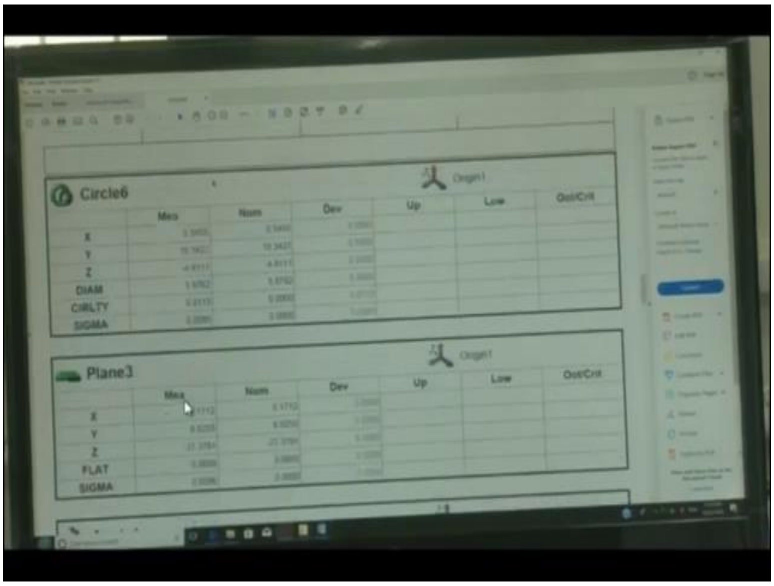

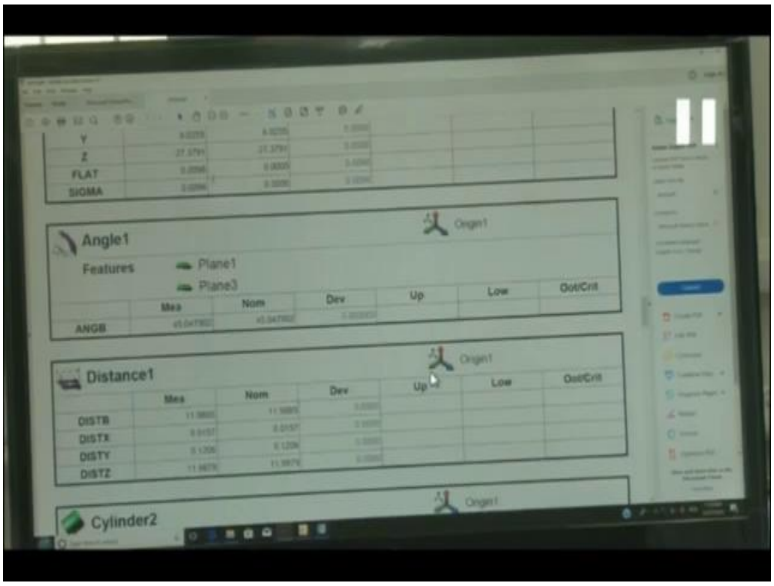

So then we have circle 6, plane 3, that was XY plane, the angles that we measured, the angle, for the first angle that we measured between plane 1 and plane 3.

Plane 1 and plane 3, the angle was 45 degrees. Then distance we measured between the origin, origin that is the cylinder and the circle, that distance is given here.

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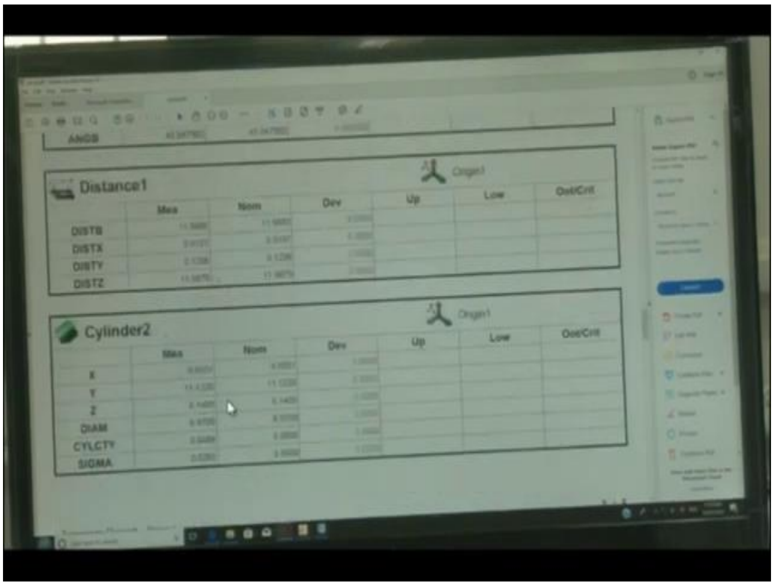

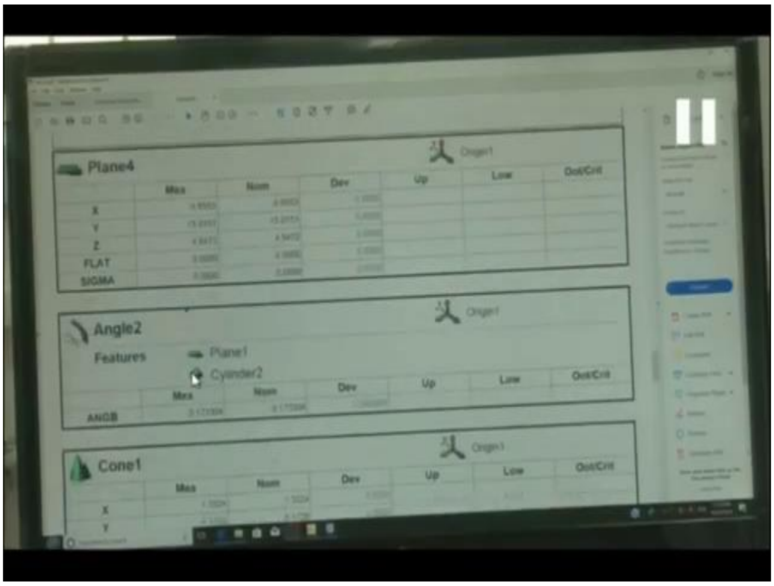

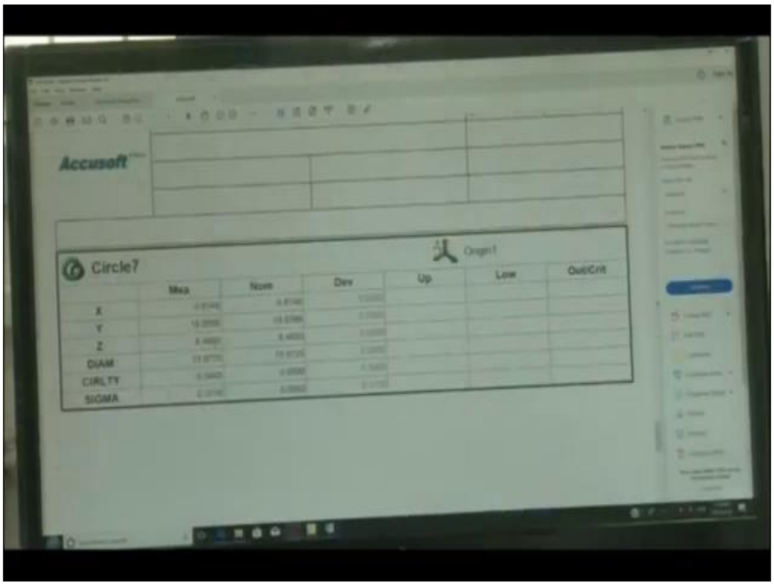

Then cylinder 2 features. So these features are all stored here. This distance between plane 1 and cylinder 2 if we remember this distance was 0.17, okay. So this distance is shown here, so all these features that we measured are also stored here.

The data is stored. Not only this data but the co-ordinates we can also generate the equations out of them. Also, we can obtain the 3 dimensional, this same 3-dimensional feature. Okay, this shape like I said, this is point cloud I can read because this was a structured form, so I just use the manual operation.

I can also use the CNC operation. In CNC operation what we do, what we do, we actually just put the joystick away, we would not use the joystick.

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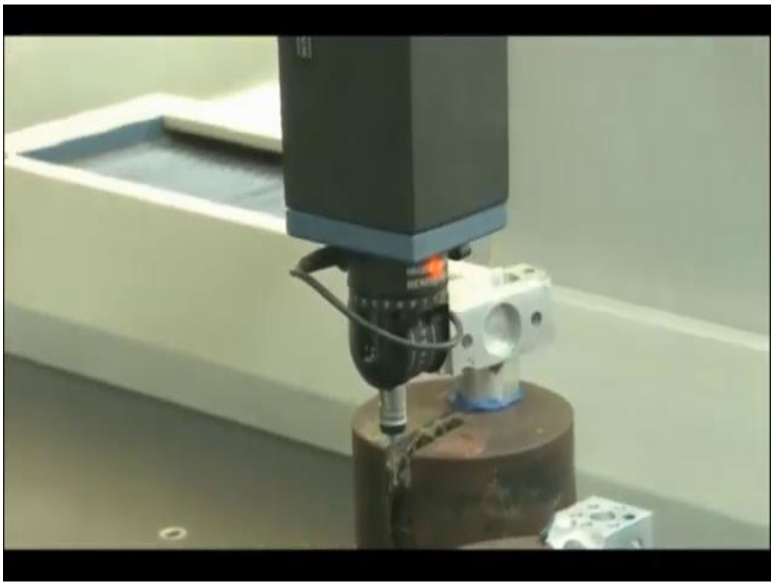

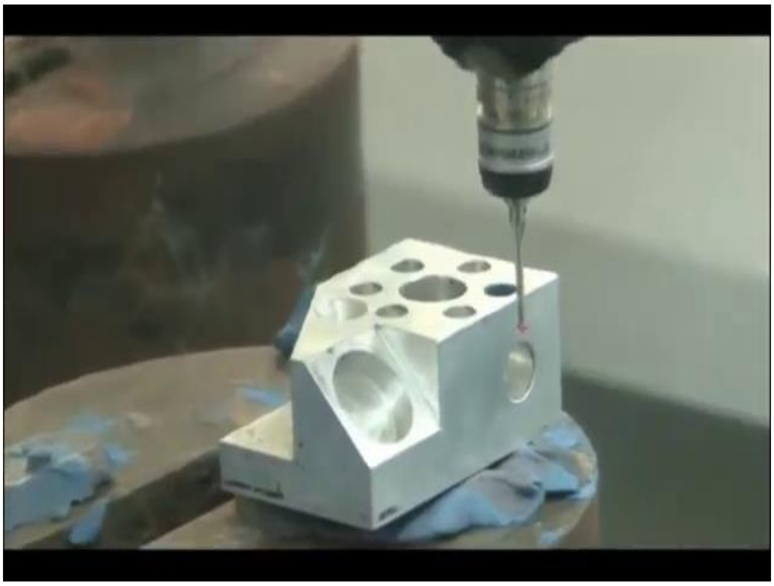

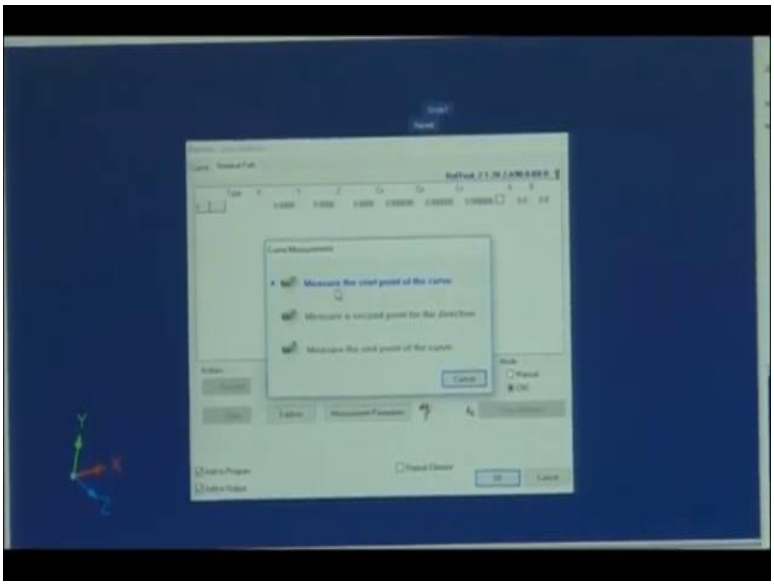

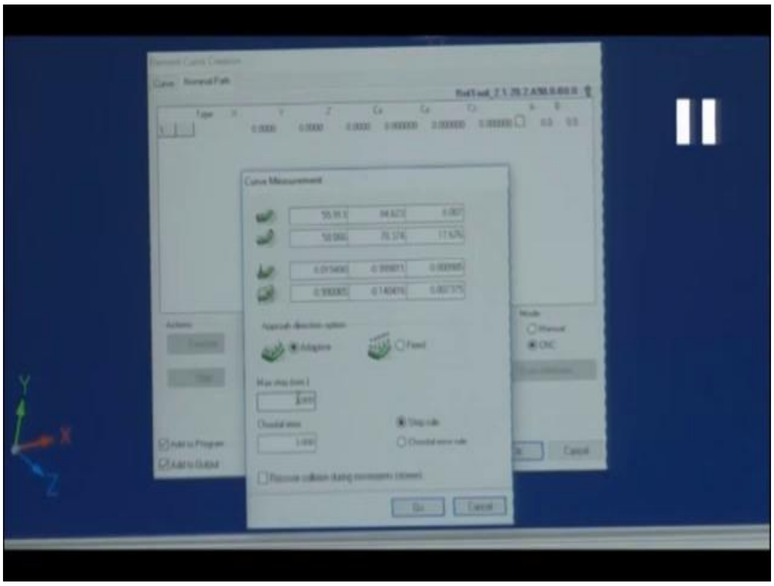

And just using, just by command the machine that at each 1 mm or at each 2 mm, it will locate the points. So you can see I have just brought it close to the plane. So nominal path the auto-measure, measure the start point of the curve.

We are, this is automated mode. So start point is located. This is start point located. The maximum step is 3mm, this step is 3mm, to locate a denser mesh or denser point cloud, we can reduce this length. Okay like as to reduce this to some shorter length 1 mm, go. Position, okay, yes, move the tip to position, clear the first point, and scan.

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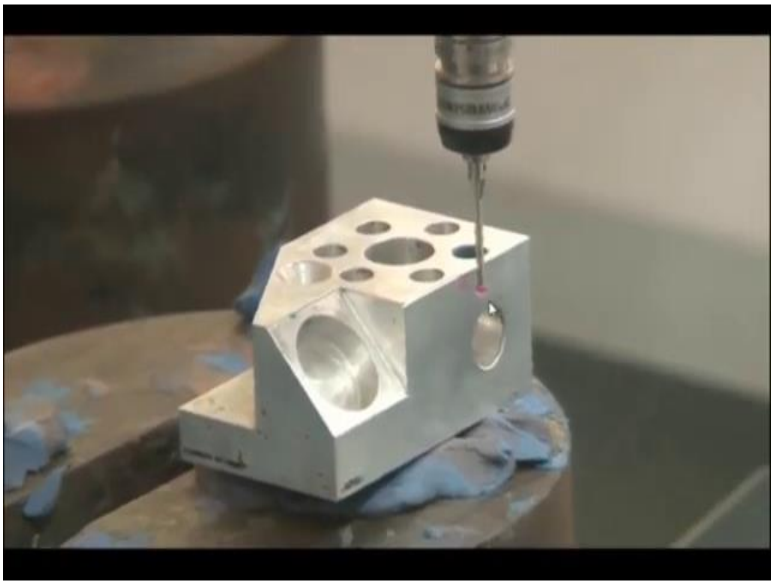

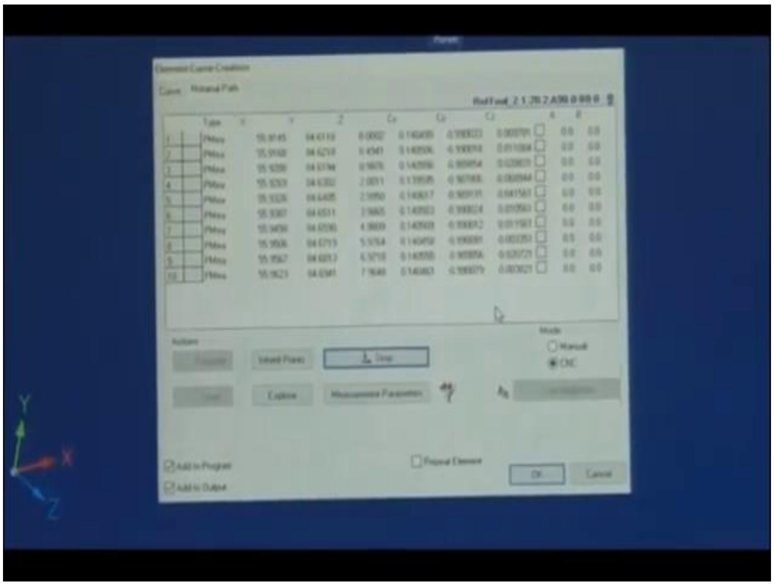

Now at each 1mm when we click at each, one will start locating the point. First reference point we have started from this point, we have kept joystick here, it is moving by itself, you can see. At each 1mm, it is measuring. At each 1 mm it is recording the points here. You know the points are being ended here.

It will keep recording unless it limits exceeds you know in this direction in the X direction 500 is the length it can move, 500 mm. So it can move up to 500 mm all unless this workpiece finishes here, it would not find anything here. Okay, so this is 1 mm, so let me try to do it again. So you know at the end, now it has moved to the other direction 90 degrees, okay. And it is now again locating the points here.

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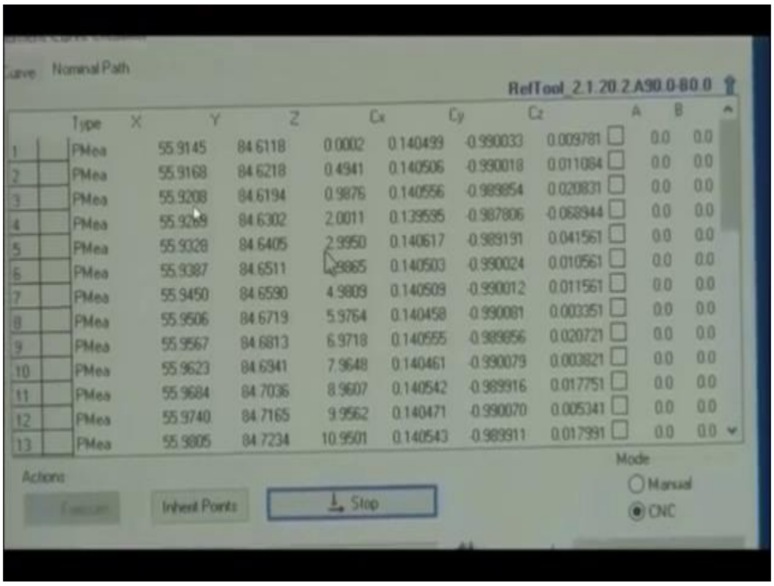

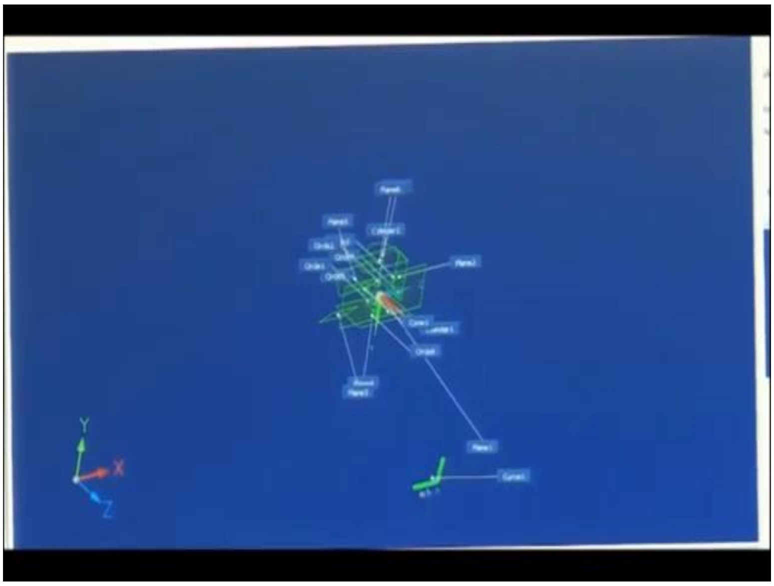

Okay, the people are talking in the laboratory. So it has generated only 13 points and we have shown it here. It has generated more than maybe I think 30 points. These points are located at each 1 mm distance you can see the points are generated here. This is how the automatic, the CNC board of the machine works.

This is we have generated the features. Now this is we have generated the features, we have generated the structure, it was a structured point cloud and triangular mesh we can say, we can that the next step was the alignment. The alignment of these shapes can be done to generate the overall this 3D shape.

So it has generated the curve at a distance, we did not actually define the home position before it has generated a curve at a place at a distance from this surface that we have generated. So let us try to do this again.

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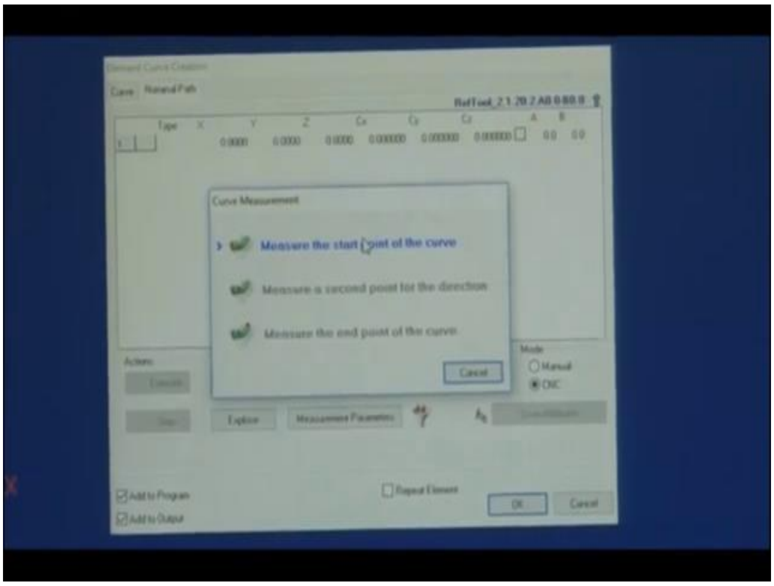

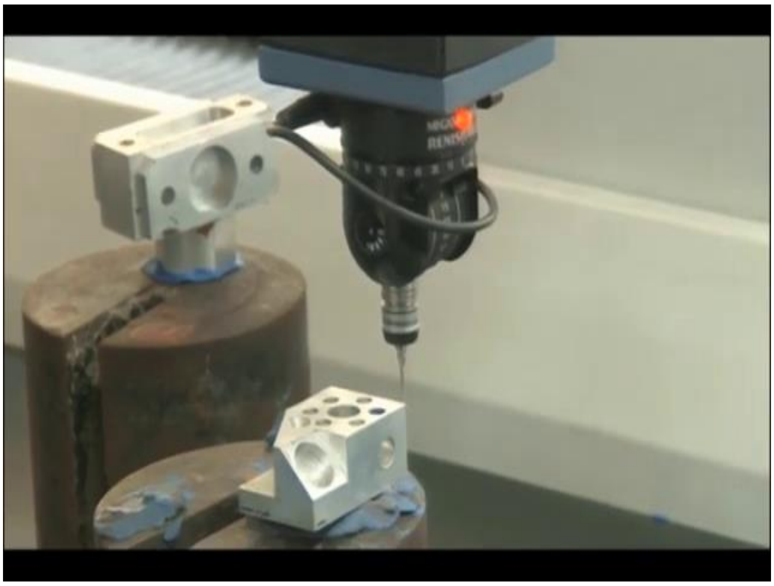

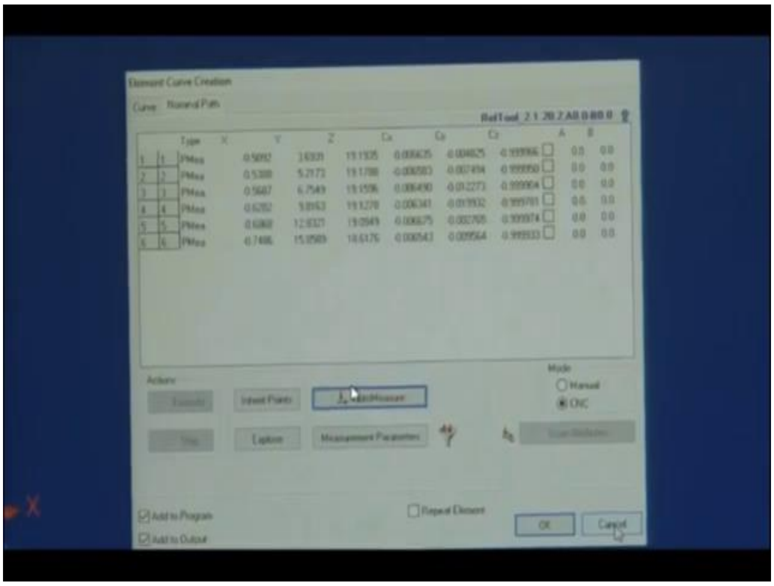

So it has come here. We did not change the A 0 and B 0. You know A 0 and B 0 was to be kept. So may at the start point we change A to 0 and B to 0. a0, b0, we will measure it again. Now let us keep the distances 2 mm and measure it again. We have kept the joystick here and it is now measuring. Now the gap is 2 mm. So now the machine is working in a CNC mode. So this is how our software and this co-ordinate measuring machine works.

You can see the points are being generated here, Okay 6 points are generated at 2mm distance each and auto measure again we can keep measuring like this. So this is how we use the co-ordinate measuring machine. This was just very trivial or very basic use of the co-ordinate measuring machine that we saw in the laboratory.

We can also measure the curves, the unknown curves, or the unstructured features. The similar procedure will follow just for generate the points okay. Using CNC mode we can generate the points. The points can be generated then we can have the triangle mesh of that if we need to someone else's triangle mesh is requited when we need to produce the shape from the point, from the point cloud.

Then we optimize the mesh, okay what size of the triangle do we require? Then we align them, align them to get the final shape and finally the data can be stored in the STL format for the production, for the manufacturer of what the engineers. So at this juncture this was all in 3D measurements, so thank you for being with us, we will meet you again next time. Thank you.