Rapid Manufacturing
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Lecture – 15
Laboratory Demonstration, Co-ordinate Measuring Machine (Part 2 of 2)

Good morning, welcome back to the lecture on 3D measurements. Now we will take you to the machines and 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 coordinate measuring machine and this is a vertical bar. This is a bridge type coordinate measuring machine. We have 18 pneumatic bearings. So, one bearing is on this side ok, one on this column, 11 in this column.

So, may be removing the bellow from here. When we remove the bellow we can see there is a bearing inside. So, there 11 bearings on this side 1 on this side and 6 on this side; 11 plus one plus 6 is 18. So, this is pneumatic bearing ok that helps to move the columns and various other movements ok. So, bellow helps us this bellow this 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 a air blow between the two surfaces, it can com compress and produce the spring motion. So, that can move from one side to the other side. So, there are six bearings on this side.

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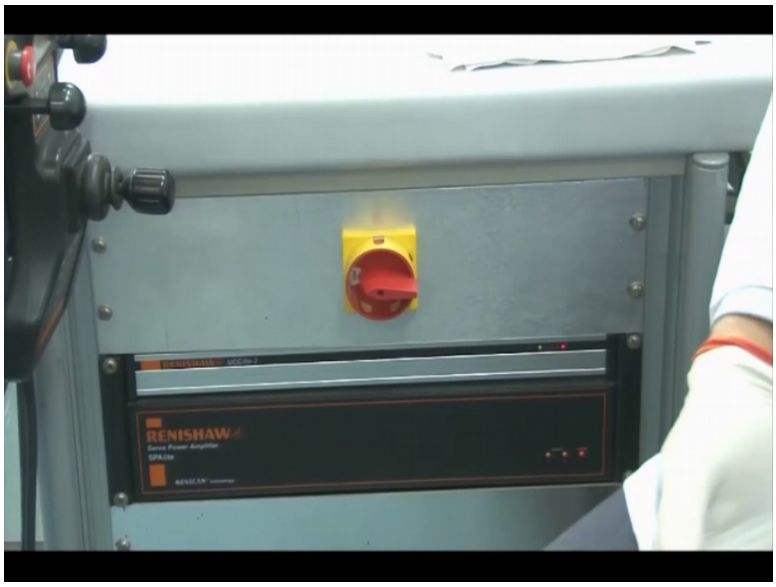

So, this side to side mild movement is possible and microfilm flows due to complete dry air. So, this is the controller; this is the controller that is used to switch on and off the compressor so this is the controller knob. So, we have Renishaw server power amplifier ok; Renishaw is the company it is the make.

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So, this is the tube pipe from which compressor is coming from the compressor. So, this is the Kaeser compressor it is refrigeration type wave compressor. It is 100 percent moisture free ; that means not going to harm the machine. So, the compressor that we have to use here has to be moisture free.

You know we are trying to save the machine using this bellows from the dust and other impurities. So, that this dust particles these are come in between the moving components and does it acts as a braze way 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 is looks like this it is Kaeser air compressor. So, this is our coordinate measuring machine as I said this is used to measure the parameter of 3D objects the objects maybe complex geometry or maybe some specimen. So, we can measure with the help of this CMM.

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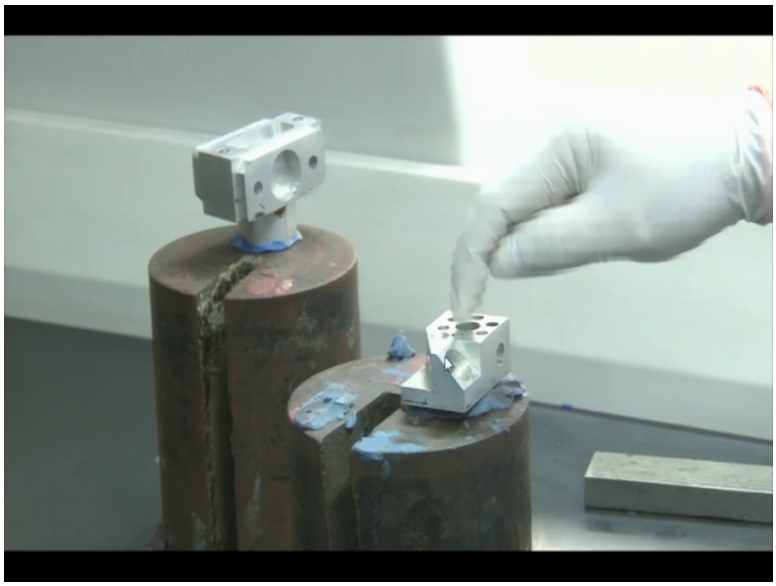

So, it has 3 axis ok; so x y and z this is a 3 or 3D object that will measure using this coordinate measuring machine. We will try to measure the features of the job this component. So, you can see their number of circles here their central circle here central cylinder here; we have circles here ok. And then we have 6 cylinders around this center cylinder ok.

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 six circles notice 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 surface. This plane and this plane is at 90 degree. So, let me first talk about the axis ok.

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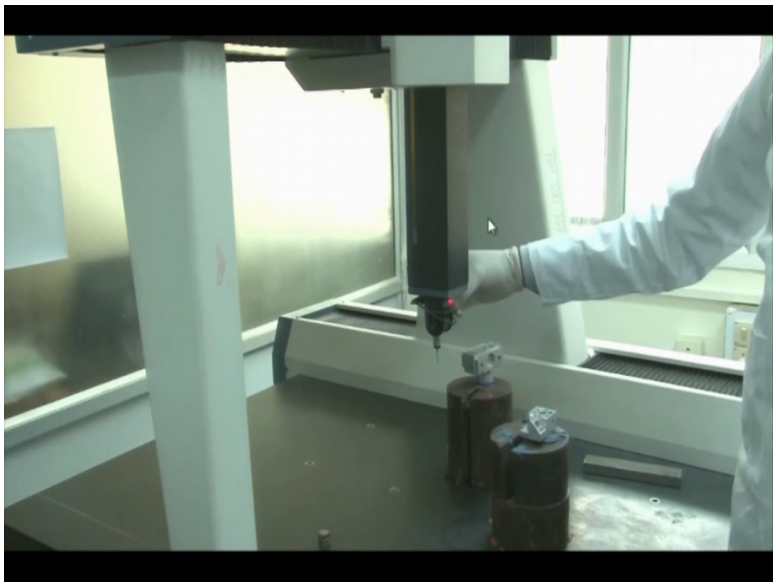

This is these are the there three axis when I switch on you can see that the indicator is on. So, this is our y axis when I moving this direction this is your y axis ok. This is our z axis this is z axis. We have actually this is LVDT this is LVDT; we have three LVDTs each axis has n LVDT.

These LVDTs for this LVDT is for z axis. So, they 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 ok. This is the probe this is the probe we can rotate it to 90 180 degree the other this is 180 degree, it can rotate into and this can be rotated to 90 degrees 0 to 90 ok.

So, we can index it index to 90 degree here. So, index the point to 180. So, this is the front position in a stylus. So, this is stylus if you see the tip of this stylus this is say fire ball. This is of say fire 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.

So, a can rotate up to 90 degree b can rotate up to 180 degree ok. 90 degree on this direction this can be rotate up to b can rotate up to 180 degree. Or we will try to explain it using the help of the software that the name of the software is Tangram software.

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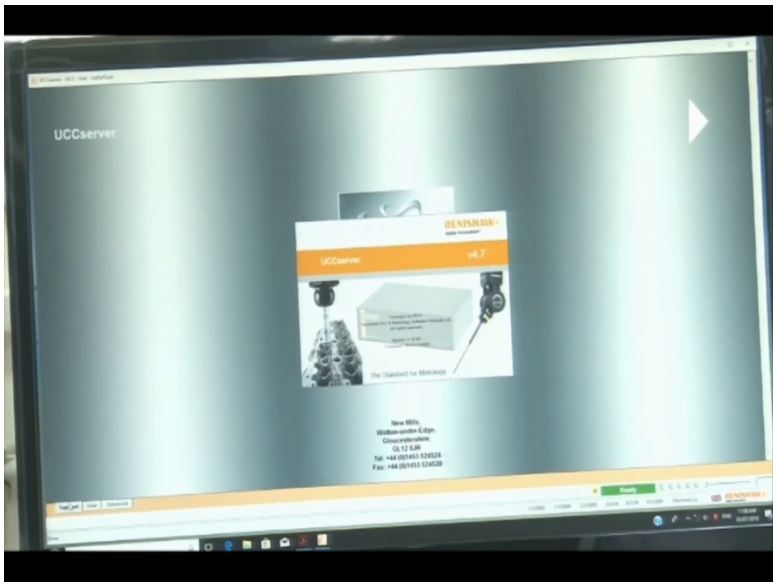

So, how to start here? You first click on the UCC serve, UCC as I said UCC is universal CMM controller. So, we have vanesa UCC controller which is designed to link the hardware of a coordinate measuring machine through the coordinate measuring machine host computer. So, this is the host computer we have the hardware machine. So, read heads, probes, probe head, controllers, limit switches, emergency stop, analog signals to server amplifiers joystick unit. All these things are the components of the coordinate measuring machine.

The purpose of UCC is to permit the control of CMM from the front end software the controller provides the control signature to CMM probe system necessary to give the required response; for example, to position the target to the given parameters.

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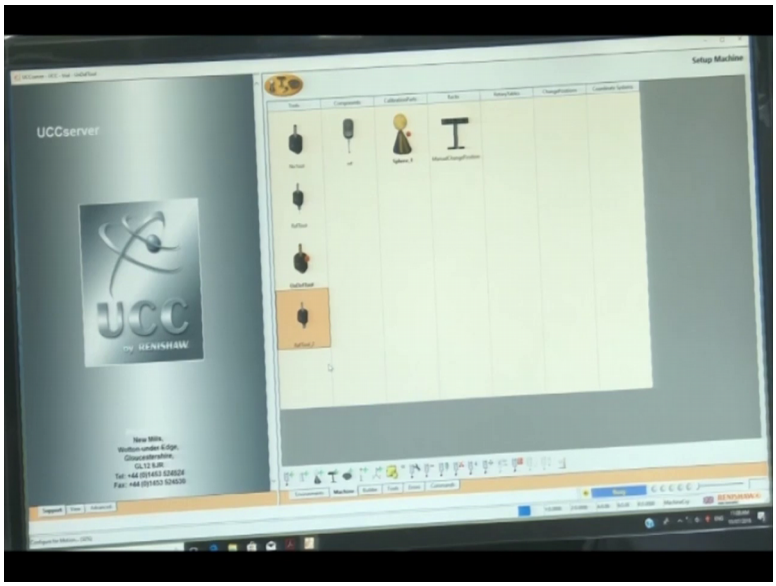

So, their certain purpose is that this UCC controller accomplish. For instance data transfer and control so then communication with a controller. Then specialized control features also there like CMM measuring accuracy enhancement. Then measurement coordinate systems we can use different coordinate system. Digitizing and scanning abilities are also there.

Then data filtering can also happen using this controller here on 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 a lot of codes can be produced.

One who has some information of the codes can also use those that format when will produce a shape. One thing is that 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 component is also possible through this UCC controller. So, next I am trying to generate the platform to measure the features of the object. So, we click on the machine here ok, we right click here and click set.

So when we click set here so a when then I can click yes the machine is going to home position now is the reference tool is when we click machine is going to the home

position. So, I will come to machine you can see the machine is going to home position by itself.

So, going to home position multi purpose purposes. One thing is it is made sure that each and every component are working properly second thing is that machine is now free to take it to the desired position whenever 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 as moving simultaneously y and x home position. So, it has now went to the home position. Now machine is homed I can say there here. Now machine is home now x is now machine is homed ok.

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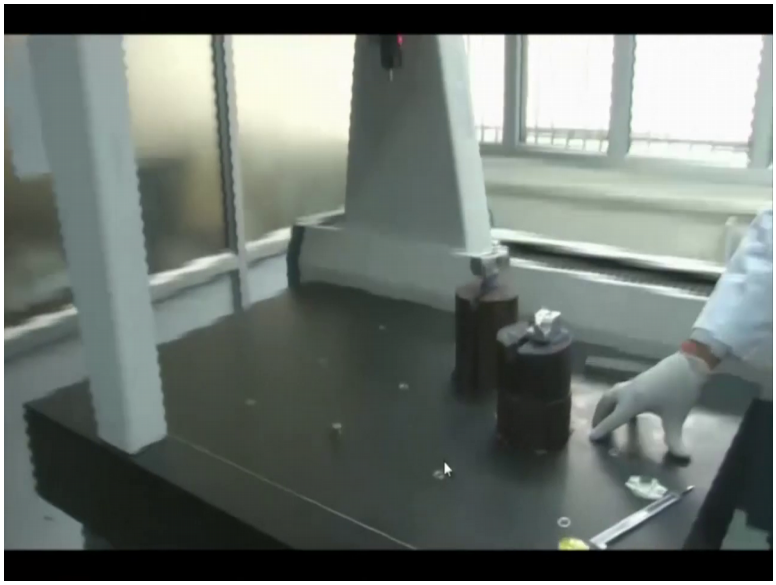

Other components we have this software and we have this granite surface plate or surface stable here. This is 0 grade; surface plate as I said the accuracy is quite high and the thermal expansion is 0 ok. So, the size of the machine is 500 ok.

This distance x distance x distance this distance is 500; 5. 6. 4. 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 ok.

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So, when we rotate this joystick clockwise it moves z direction downwards. When I rotate it anticlockwise it moves the z up wards ok. So, this is left x motion x axis motion. And similarly I can have right x axis motion, y axis again back side then forward side so this simple joystick ok.

Now the operator then controlled probably y and x axis are very similar to the movements there. So, only the thing is that rotation of this rotation of this knob anticlockwise and clockwise makes it to move makes the z axis this is for 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 won't work on this the software here is tangram. We have the indicator here indicator would blink and when this will touch and also a beep voice would come.

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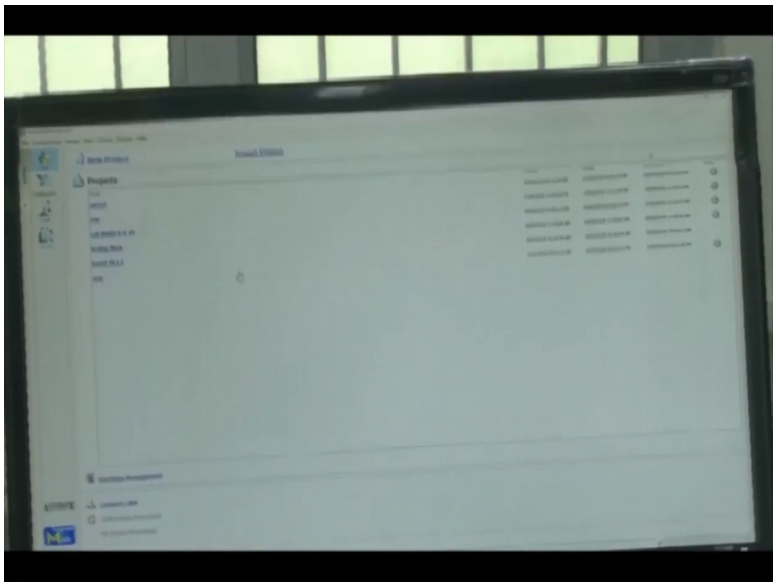

So, we actually trying to put the voice over the recorded video. So, the laboratory actual laboratory conditions are quite noisy. We will also try to show you the actual laboratory conditions when we will start the measurement and like to hear the voice and the noise there as well.

Now we open the new project the projects we open the new project then screen opens. So, first we take the reference system then we take three points top plane and three points are taken from the other plane and cylindrical point from a region then we select the plane and move the joystick. So, this is our work piece the features of which we are going to measure.

So, we will take three points from this plane three points from this plane ok. So, this is our cylinder, this is cylinder what is this plane this is z y plane. This is z x plane what is this top plane this is x y plane.

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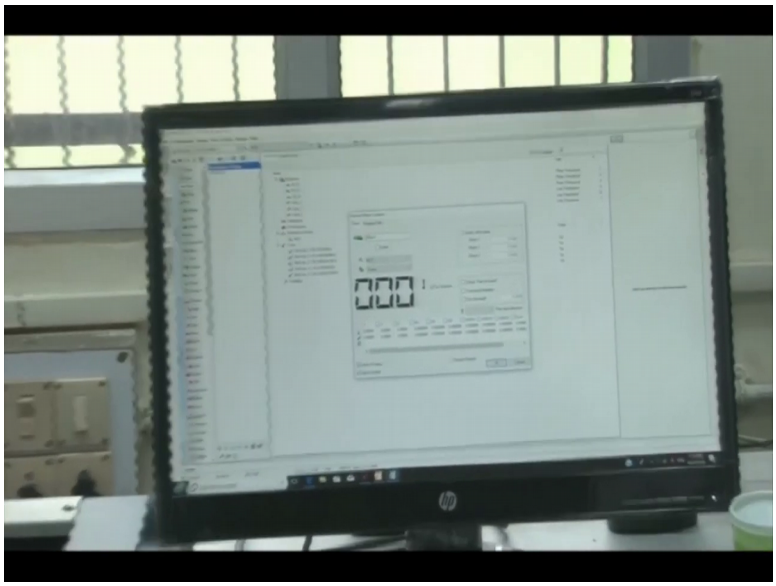

So, this we have selected plane; plane one, it will try to record the points at least 3 points are required to define a plane. So, we will record the points using joystick we are trying to move the probe close to the component. When we will touch the tip of the probe that is a fire material, we are doing it again we are selected the plane from here selected.

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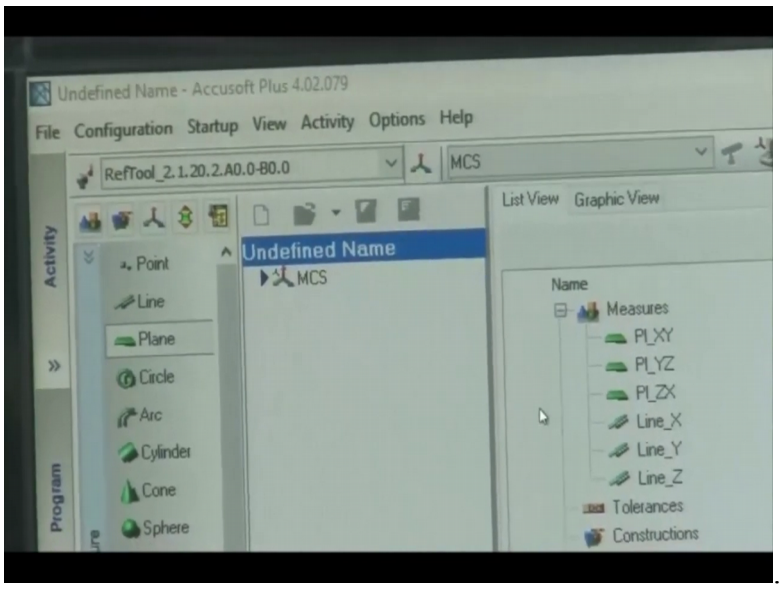

So, before moving the all the components we have point, line, planes, circle, arc, cylinder. 8 points are cone 8 points, sphere we need multiple points for this layer Sphere

slots, square slots, ellipse curve, surface torus, there are. You know they are multiple objects here in this software.

And this is just the general or the structures of this is free form surfaces are when we just imagine the free forms. Then we have distance angle point these are the construction measures what we need to measure the measure plan measure the line. So, this is general measure ok, that was construction then we have various other tools like a three dimensional other forms etcetera. So, we are just touching it to 1 2 and 3 ok; three points are now recorded in our software.

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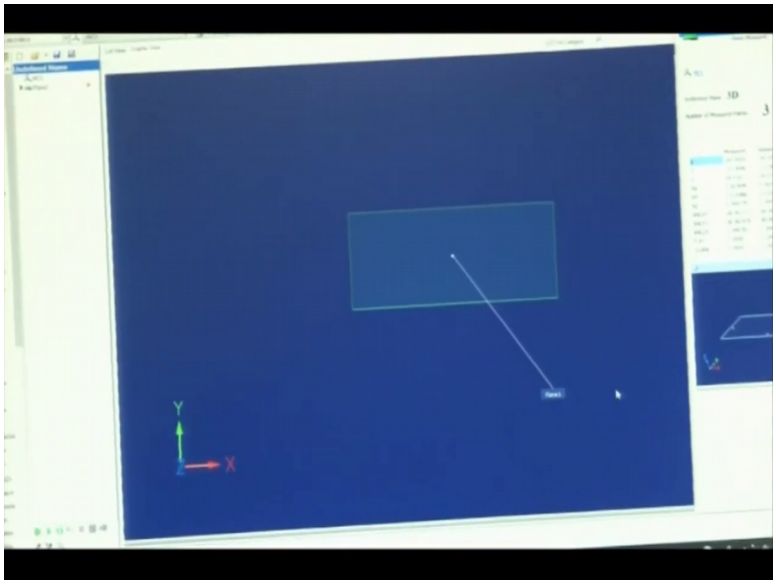

So, it has shown this plane here this plane one is now defined. We can name the plane as well we can name it x y plane we can mark it whatever name we will like to give we can name the plane as well,. But it has just marked it plane one because we did not change the name the default name was plane on. Now we will select the plane again it is select plane 2.

Now I am selecting the y z plane 1 2 and 3 you can see the light blinking that is blinking that is the probe has touched 1 2 3 three points are recorded. And the second plane which is perpendicular to this one is generated plane one and plane two. Now, I will measure the cylinder. So, 3 points for plane was selected for cylinder we need 8 points 8 points 4 points in 1 plane 4 other points in the second plane.

4 point will for 1 plane means 4 points will give me the location of the cylinder of the that will mark one circle. Another 4 points at the at little depth then the initial plane would give the second circle. These two circles would help us to generate a cylinder the cone can also be generated similarly. Now, this is 1 2 3 and 4 ok; similarly little depth 1 2 3 and 4 ok.

So, this cylinder profile is generated you can see here. So, we have plane 1 plane 2 and cylinder. Now we can set the reference system here reference system that what should be the ours rest reference point for rest of the work piece. So, I can keep the center of this cylinder as a origin; for that what I have to do? I select the reference system, select the primary axis the primary axis here the primary axis.

Now I will select for the after primary axis has 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.

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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 and one cylinder center has made as to select the reference system. So, we have got the origin point here that is a center point origin point here the center point is center that is the origin.

So, next is how to measure all the parameters? We can select the circles here these six circles this is cone here as well. So, to measure the circle we will select circle from here,

then measurement parameters. So, it is trying to reads at from the 2 mm we have generated 1. So, at least 3 points are required to locate a circle.

So, we retract at 1 so this is 1 2 3 this circle is now located. Because origin we already have this origin we already have here ok. At this point we have the origin the distance of this origin from here and this circle would be located by itself ok. 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 via taking 8 points. In a similar fashion as we did for the previous cylinder for this central cylinder. Now 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 you can see 1 2 3 4.

We are marked 4 points there points were the minimum fourth point are also we marked. So, you can see in laboratory conditions is a lot of noise ok. That is why we are try to record separately in the laboratory. So, we 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 stared with for the circle 4 points are better to choose.

So, similarly we were trying to make this circles 1 2 3 and 4 when that probe is touching the surface this points are being marked here. So, this 6 success circles are located here ok. Now again select the plane. So, it will measure the slant plane let us may this slant plane this slant plane here this slant plane here.

Also we will try to see 1 2 3 4 you can mark more than 3 points as well. So, this slant plane is also located here. So, what is the angle between the plane for between these two planes this slant plane and this x y plane. So, we can go to construction you can see we have measure here measure. And we have construction here in the construction we can click angle.

Now, it will ask between which entities you need the angle ok. Plane 1 and plane 3 so the angle between plane 1 and plane 3 is 45 degree so this is the angle this showing 45 degree angle. So, similar to the angle we can also measure the distance between cylinder 1 and circle wall between this cylinder 1 this is our cylinder 1 this was cylinder 1 and circle 1. So, we will select the distance.

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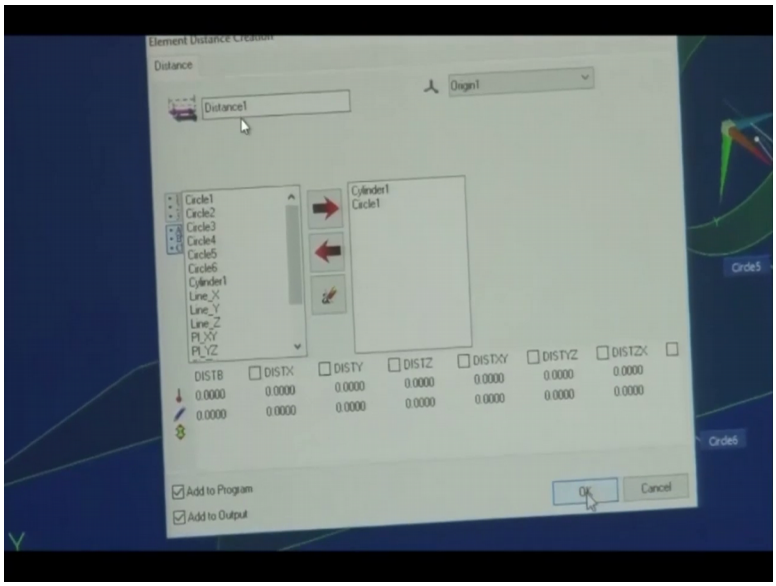

We have selected distance here between cylinder 1 and circle 1. So, we have selected distance here distance in place of angle distance between cylinder 1 and circle one ok. So, distance between cylinder 1 this is circle one and cylinder 1 that is a origin is 11.98 ok. It is showing the nominal and measure.

But different planes here this is xy plane this is y z plane this is xz plane this is again yz plane so this is again x z plane. So, now, a rotated 90 degree a 90 degree b 180 let me repeat 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 moment as 90 and b as 180. So, I have putting this moment let me do.

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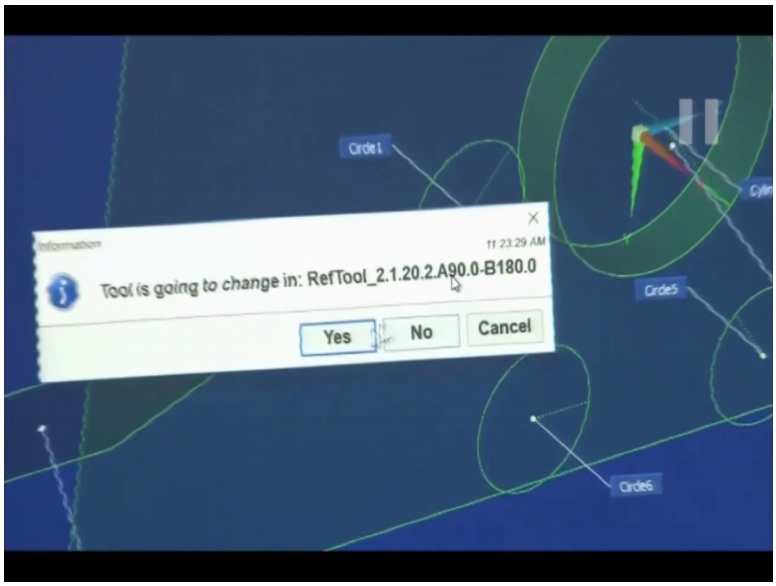

If you see this is a 90 b 180 you can see a 90 a 90 here b 180 a 90 b 180 we click yes. Because we are going to measure now the y z planes that is why we have turned this to this direction this is locking nut on this side locking screen on the other side we have locked the probe here now we will measure this y z plane again in laboratory.

So, we will measure the 8 points here; 1 2 3 4 in the laboratory conditions 1 2 3 4. So, we are we have located in the cylinder here which is at 90 degree to the cylinder 1 cylinder 2 this is cylinder 2 this is 90 degree to cylinder 1.

So, how much is the depth from the planes? So, we select the plane again now this is y z plane this is y z plane 1 2 and at any point you can just touch it 3 ok. This is y z 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 of the plane with cylinder 2 ok.

We have taken in to some high position and we will go to construction here. Then we will select the angle ok., this angle is selected angle between you can see plane one enter and cylinder 2 should be there cylinder 2 enter ok.

Now we will click and yes now this between this cylinder and this plane. What is the angle? What should be the angle between the cylinder and this plane? Is there any angle? No, the angle should be 0. Let us see what is the angle? What is the computer reports?

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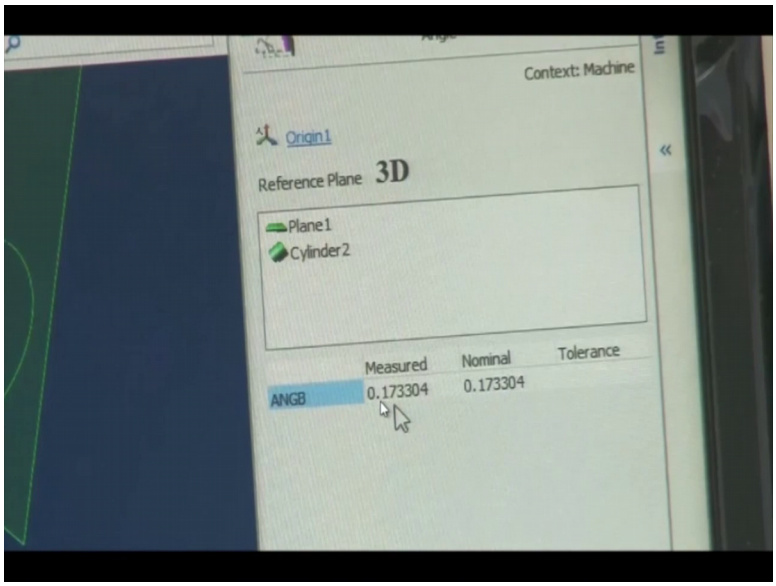

So, it is showing the angle as 0.173304 is quite close to 0.1 so it is 0. So, this angle is 0 using construction we can measure the angle distance then the depth the arc all those things can be measured Now, we will measure this cone this cone here. Again we will change the position to measure this cone a has to come back to it is 0 position you will select a 0 and b 0 a 0 and b 0.

So, we click yes ok. 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 ok. Now we will measure the cone. So, it has appeared here now will mark the points. We will measure the cone 1 2 3 4 then little depth in another plane in the second plane. So, the 4 points in one plane 4 point in other plane were marked. So, it has generated 4 plus 4, 8 points in two different planes

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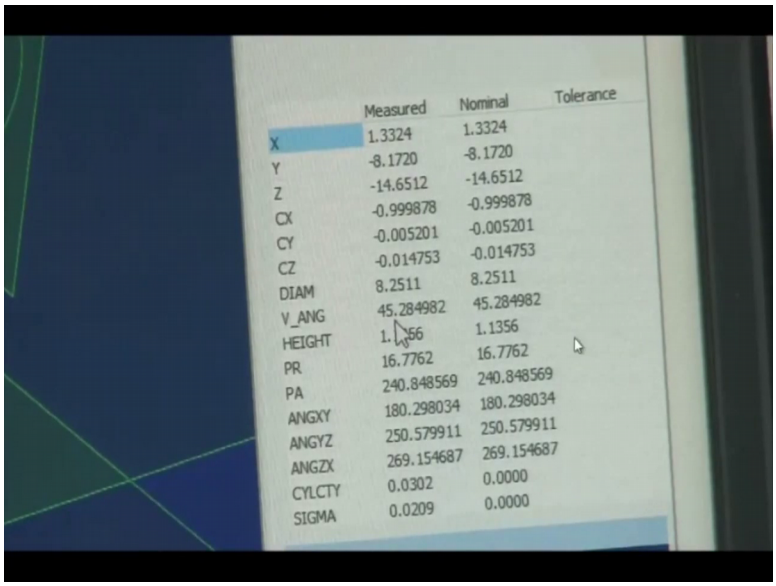

So, this is the measured and the nominal dimensions here. So, let us see it is also giving the height of the cone from the reference plane. So, here is the cone. So, the cone angle here shown is the cone angle is 45 degree you can see the cone angle here cone angle is 45 degree. So, then we go for a 90 and b 0, a would be 90 b is kept at 0 position only let me turn a to 90 ok; a is turned 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 y z plane y z plane that is y axis and z axis. So, we will select 3 points we will check another plane here y z plane we will check 3 points near to y z plane circle. So, we are measuring a this plane at an angle 1 2 3 ok. So, we select the plane take three points near to y z plane circle.

So, this is a plane at an angle this is plane at an angle ok. Now this is the potential or the beauty of the CMM that we can by using a single setup we can measure all the parameters in different directions. In different you know this is a structured or this is a structured or the known parameter cylinder cone all those things also free form can be measured ok.

So, we can store the date files in IGS format. So, this all parameters can be exported then we can save it to the file all those things can happen. So, they are now measuring the circle on other side on the y z plane. So, we can save the data in excel format ok. Now

this circle is again measured this plane is now this plane is again measured the yz plane the y z plane is measured ok.

Now, we are measuring the circle on the y z plane there is circle on the other side like this actually cylinder on the other side as well ok, but we are just measuring the circle; 1 2 3 and 4. So, we can see this circle is located big circle on this plane. Ok 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 will like to move forward. So, we will try to see how the data is stored.

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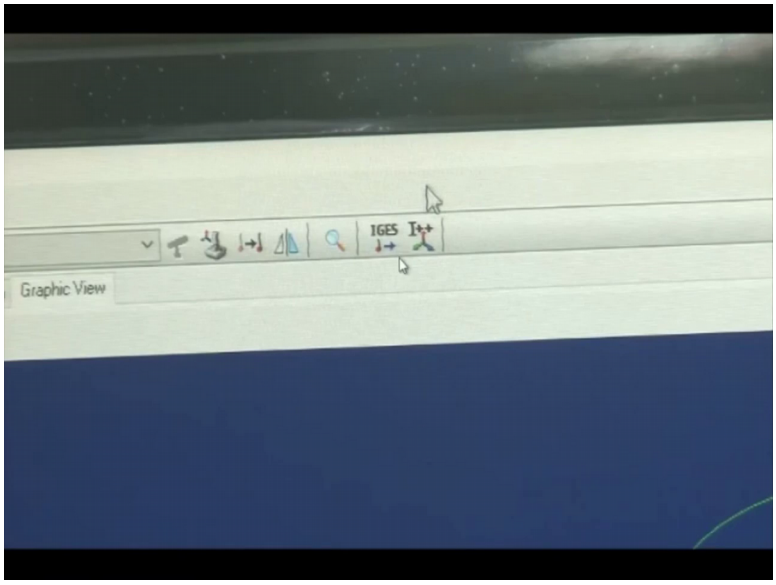

So, IGES format is there IGS format data can be stored in IGS format you can dictate IGS 1 2.

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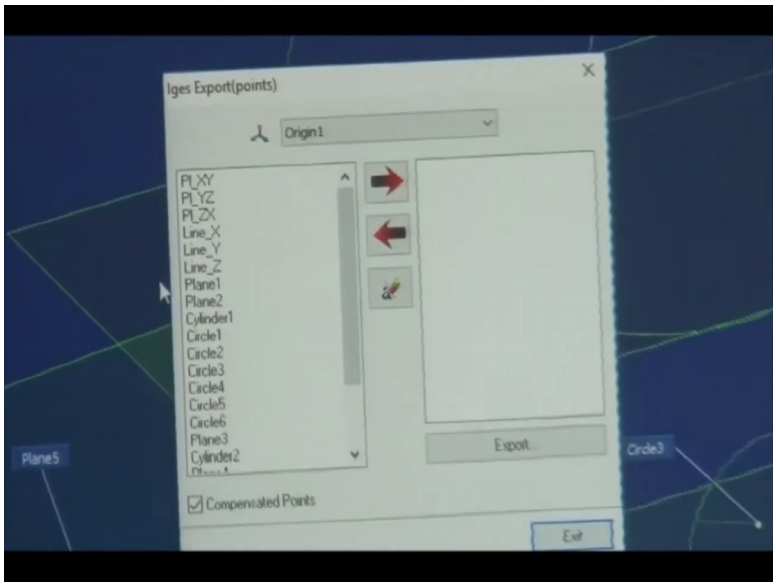

So, what data will have to store? What points all the compensated points ok? Then we export it into the IGS format ok. So, it is located in desktop frame curve IGS format is located there. So, we can read the IGS format also the data can be generated in the excel.

And also we can have the PDF file PDF may not making PDF file we just named it abcd. Now we will save it as PDF is already saved here.

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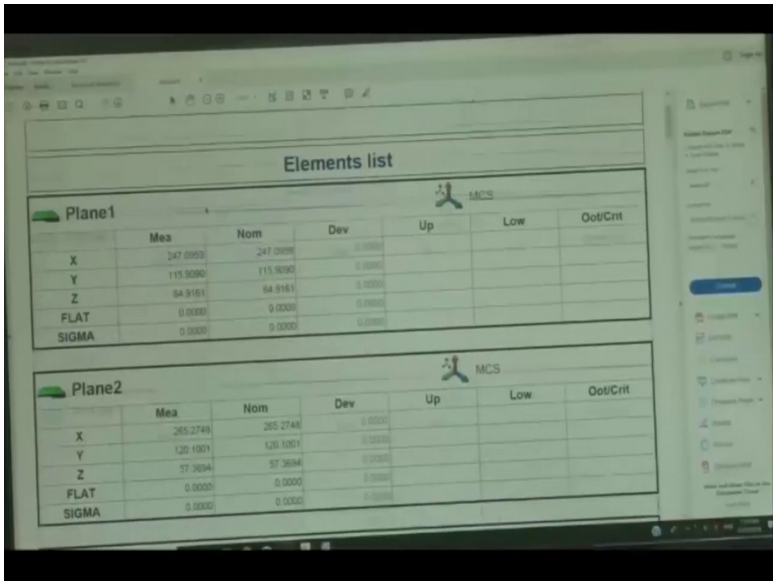

So, now I am opening the PDF file. So, this is the element list we have generated this plane and the dimensions of the plane x y and z measure nominal what is deviation ok.

Then upload and there is you know this the deviation this distribution not exactly distribution, but the tolerance is can also be obtained from here.

Then plane one we measured first then we measured plane two dimensions for that for the cylinder, we have x y z diameter of the cylinder cylindricity; cylindricity is close to 0. Then sigma value for that then for circle also circularity is 0 0 like exits perfect circle. So, x y and z coordinates and diameter of the circle it is 6 mm or dia.

So, it is showing quite close to 6 this is 12 mm dia. So, this 12 mm 12 11.99 it is quite close to the 12 mm. Then we circle the circle two circle three circle 4 circle 5 all these circles the coordinates of the circles which the. The first circle or the cylinder width that we have similarly the circle 2 circle 3 circle 4 circle 5 did I mention for that.

So, then we have circle 6 plane three that was x y plane the angles that we measure the angle for the first angle that we measure between plane 1 and plane 3 plane 1 and plane 3 the angle was 45 degree ok. Then distance we measured between the origin that is the cylinder and the circle ok; that distance is given here then cylinder 2 features.

So, these features are all stored here this distance between plane 1 and cylinder 2. If you remember this distance was 0.17 ok. So, this distance is shown here. So, all these features that we measured are also store here the data is stored. Not only this data the coordinates we can also generate the equation out of them. Also we can obtain the three dimensional this same three dimensional feature ok.

This shape like I said from this is point cloud I can read and write because this for the 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 plastic away we would not use the joystick and just using just we will command the machine that at each 1 mm for at each 2 mm it will locate the points. So, you can see I have just brought it close to the plane.

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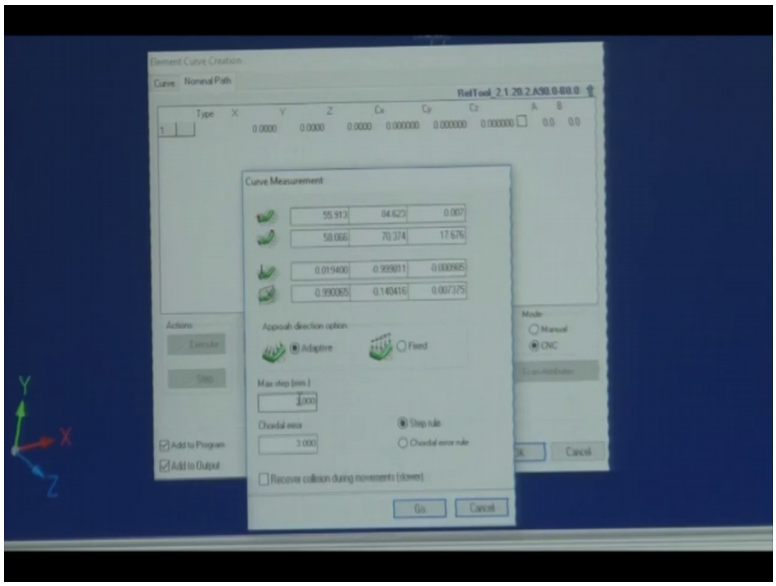

So, nominal path the auto measure auto measure the start point of the curve. So, we are this is automated mode. So, start mode is located this is start mode located. Now maximum step is 3 mm this step is 3 mm to locate a dancer mesh or dancer point cloud we can reduce this length ok. Let us reduce this to some shorter length 1 mm.

Go activation yes move the tip position create a first point in the scan. Now at each 1 mm and we create at each at each 1 mm start locating the point in first reference point. We have started from this point we have kept joystick here it is moving by itself you can see. At each 1 mm it is measuring. At each 1 mm it is recording their points here you know the points are being added here.

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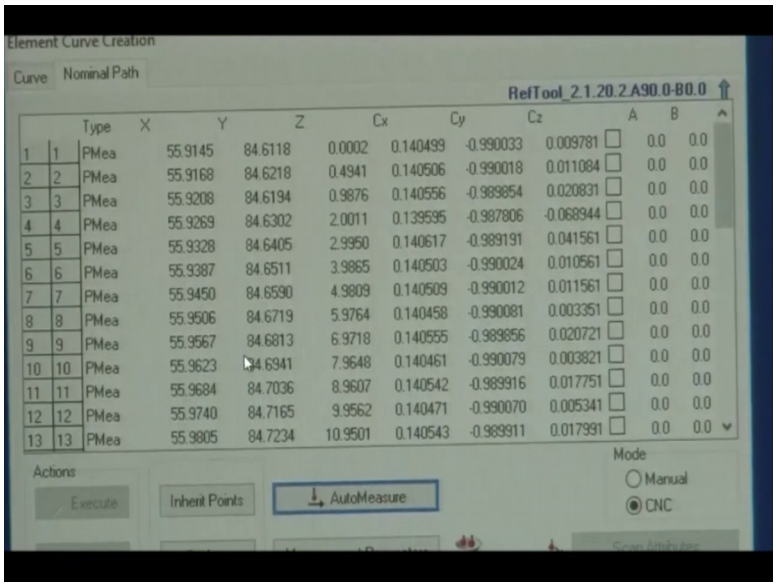

It will keep recording unless it limits exceeds like at the you know in this direction in the x direction 500 is the length it can move 500 mm. So, it can it can move moving up to 500 length all unless this work piece come finishes here it wouldn't find anything here. So, this is 1 mm so let me try do it again.

So, you know at the end now it has moved to the other direction 90 degree 90 degrees. Now again locating the points here the people are talking in the laboratory. So, it has generated only 13 point is shown here. It is generated more than may be I think 30 points it has made these points are located at each 1 mm distance you can see the points are generated. This is how the auto measure the CNC mode of the machine works.

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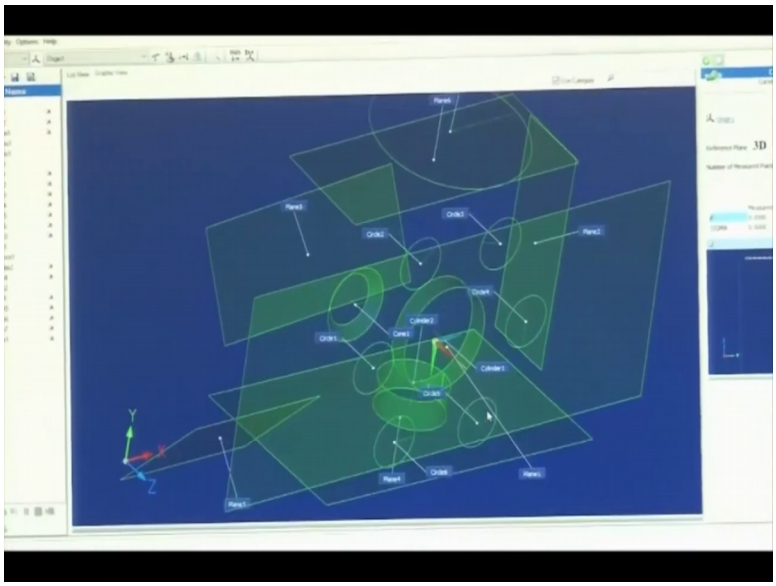

So, this is we have generated the features. Now this is we have generated the features we have generated the, it was (Refer Time: 38:05) which was structured point cloud and triangular mesh we can say we can instead of that. The next step was the alignment ok. The alignment of these shapes can be done 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 data generated a curve at a place at a distance from this surface were generated. So, let us try to do this again. 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 the start point will change a to 0 and b to 0 a 0 b 0 and measure it again. Now let us keep the distance as 2 mm and measure it again ok.

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We have kept the joystick here and it is now measuring now the gap is 2 mm. So, now, the machine is working in the CNC mode. So, this is how our software and this coordinate measuring machine works. You can see the points are generated being generated here. You can see the points are being generated here 6 points are generated at 2 mm distance each and auto measure again we can keep measuring like this.

So, this is how we use the coordinate measuring machine.this was just a very trivial or very basic use of the coordinate measuring machine that we saw in the laboratory. We can also measure the curves the unknown curves or the unstructured features the similar procedure would follow will just for generate the points. During CNC mode we can generate the point the point cloud can be generated. Then we can have the triangle mesh of that; if we need to do some analysis.

Triangle mesh is required when we need to produce the shape from the points from the point cloud. Then we optimize the mesh what size of the triangles do we require. Then we align them align them to get the final shape. And finally, the data can be stored in the HTL format for the production for the manufacturer or for 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.