Metal Additive Manufacturing
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Lecture 32
Reverse Engineering in MAM
Laboratory Demonstration-1

Welcome to the third lecture of the course, metal additive manufacturing. We are discussing about reverse engineering in this week, we have discussed about the reverse engineering process, the various steps and stages, why do we need reverse engineering? How do we justify it as a legitimate and legal technology, we have seen the kinds of the contact and non-contact scanners.

In this lecture, it is a laboratory demonstration where I will take you into the laboratory where we have Steinbichler Comet 3D 5 M scanner and we will have a look over the scanning process, how do we use this scanner.

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So, this is a 3D scanner that is kept at med tech facility IIT, Kanpur. You can see the sticker that is an ISO 13485 compliant sticker IITK MDT EMD 3 MD 009. Whatever we scan through this object, we get the real data of that object.

This is the scanner machine- Steinbichler German based Comet L3D 5 mm. There were two versions available when this was purchased- 3M and 5M. Now, we have multiple versions. So, 5M means 5 megapixels here, that means 5 billion points per second it can record. 5 megapixels majorly has two lenses, one is camera which is having 60 frames per second data capture camera.

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This is the object that we are going to scan today this is also known as the 3D scanning specimen object. This object you can see it has curvature, the straight surfaces which is priming pocket slots, dome, cavity dome, corners, fillet radius so we will try to use this object to scan the different kinds of the intensities of the scanning process.

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Now, if time sometimes the object is to be cleaned, then PC 5021B cleaner is used so that we remove all the dust particles and object to be scanned is completely clean. Sometimes the object is also shiny like this, aluminium is shiny so it does not capture the light and the data is not captured properly.

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So, we use the developer which is PD visor 31B which is a white colored chalk coated developer, we spray it over the object so that the refractive index does not come into play.

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Now, we have the second major part of the 3D scanner equipment setup which is the rotary table this rotary table is controlled by the controller box, this is also a Steinbichler controller box. So, the data that we put or that we get from here is obtained in real frame.

So, this helps us to visualize the object, you can see a red dot here, this indicates the object is exactly placed close to this point. So, it has to be placed close to the center, this is a major concern to set up this scanner. So, we have kept the object here you can see two dots. So, these dots are offset from the center to put it in the center exactly we have to adjust the alignment of the scanner.

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To capture the object correctly, it must be kept as close to center of the rotary table and also the two dots which is the focus of the light coming from the scanning camera is to be adjusted close to the center.

So, we can adjust the head of the scanner. So, we have also got a tripod stand that helps us to lock the scanner at the right position. So, first is this broad positioning. So, close to the center it is focused here it must coincide as close to the center as possible.

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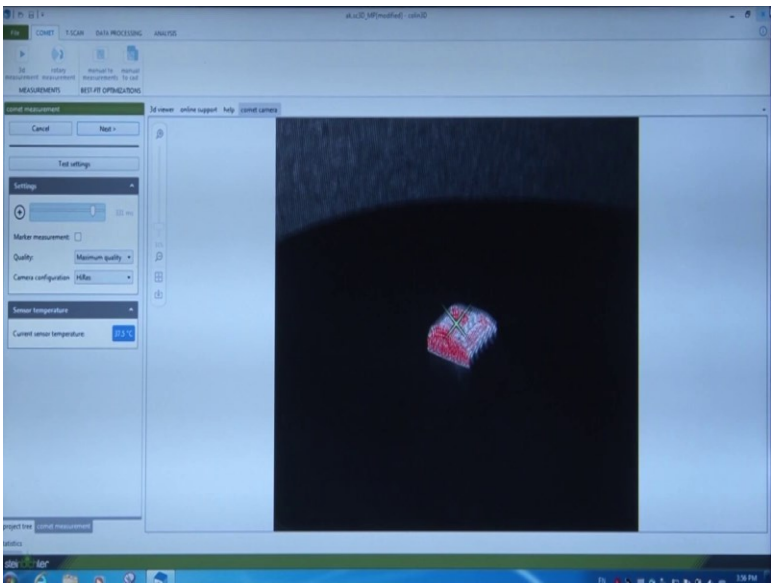

So, we can see this in the screen itself that it is coincided closer. Now we have come close to the computer screen and we have seen that the frames which are being produced, the fringes of the frames which are being produced or being put on the object we could see that, you can see this cross, the intersection point of the cross is the center of the scanner.

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Next is you need to open the software. It is provided via software known as colin 3D 2.1.0, it is starting, the license key is provided in the form of a dongle. So, we get this as a part of the setup that we get. So, without that dongle the scanner will not start or will not be interfaced with the computer or the laptop.

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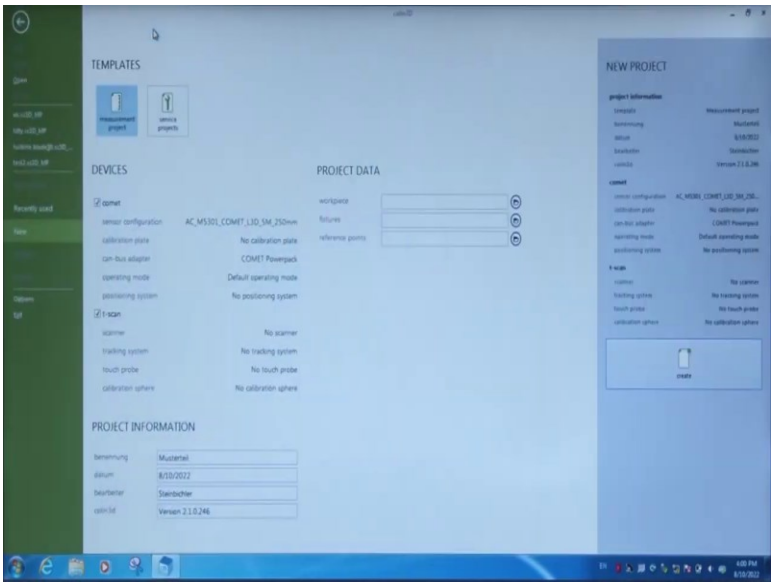

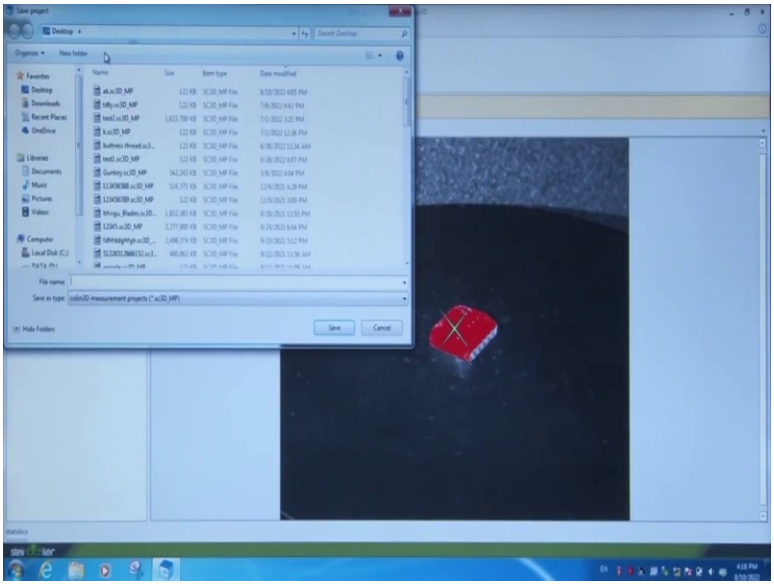

There are certain pre-settings which are to be taken care, number one is the service projects. So, we will put certain set parameters here about the power, about the general project that we are going to open. The measurement project is the object that has to be scanned, a project on that has to be opened when you open it, you go to the create option in the right when you click it, it opens a new window frame and it asks the file name.

So, now it is opened. So, it is asking. So, we have options in the comet tab here, when we click to the measurement here, it asks the file name that is to be put for this project. So, we can put a

test specimen or some file name here. T3 is the name put here the extension would be dot sc 3D under square MP we have saved this now a new project is opened.

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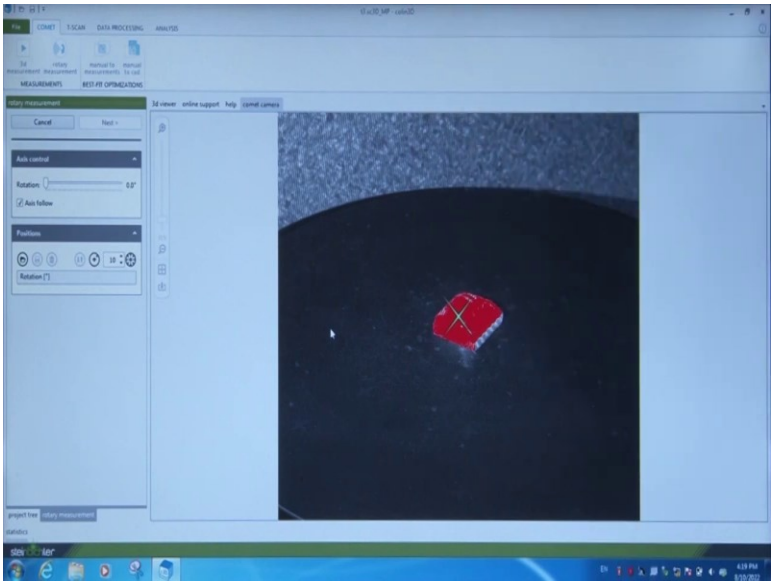

You can see the object on the screen only now, we have position that is to be filled now, we have access control as well in which rotation could be controlled. Rotation we kept at 00 only the position is to be set. So, to have minimum 36 readings we can have 360/10 that each 10 degree it would keep on recording the data.

So, according to the intricacy of the object that is there and according to the kind of the time limit that we have, we can have this, you can see if I divided this by 15 it will keep on, it is divided 360/15 that at 24 48 72 to start getting taking readings.

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Then we go next if select set option, then we go again next it will ask about the current sensor temperatures out of the calibrated temperature range. So, you do not want to anyway so we say okay yes, we can start it.

So, it is not showing the fringes of the light, the back black lines that you can see here is the difference between frame and the camera. So, 60 frames per second is the rate so it initializes and it merges the two objects.

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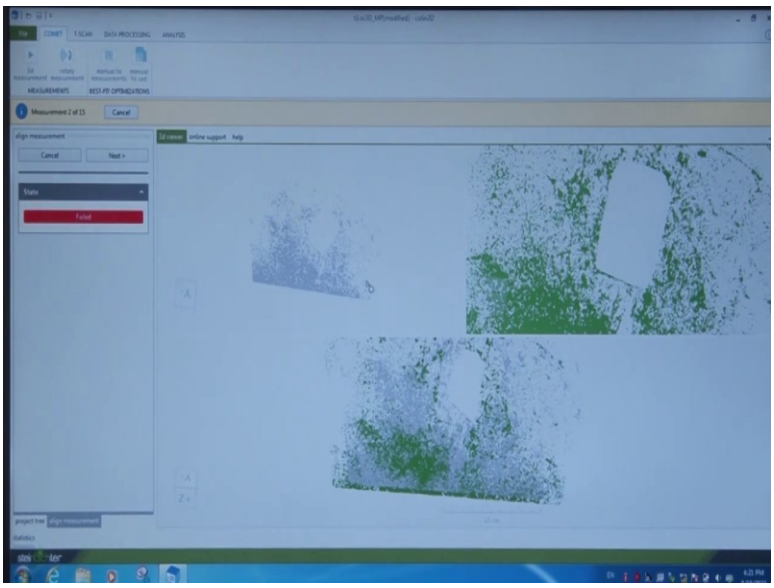

So, down there in the status bar and above there in the leaf bar you can see the system is going on its 72 percent, 100 percent so two measurements I have completed now. So, you can see they are exactly in the status bar down there. The scanning is happening at each rotation. So, it is showing field here. So, that means when it is trying to merge the initial and the recent scan, it is not able to merge.

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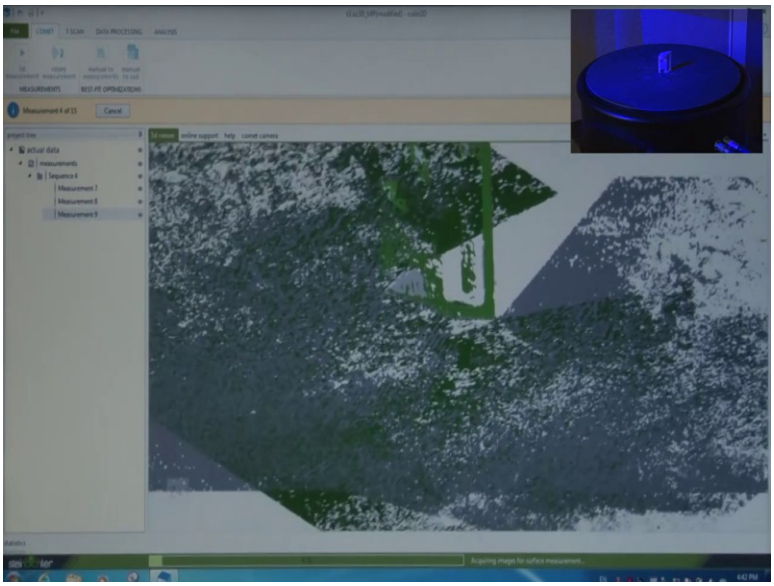

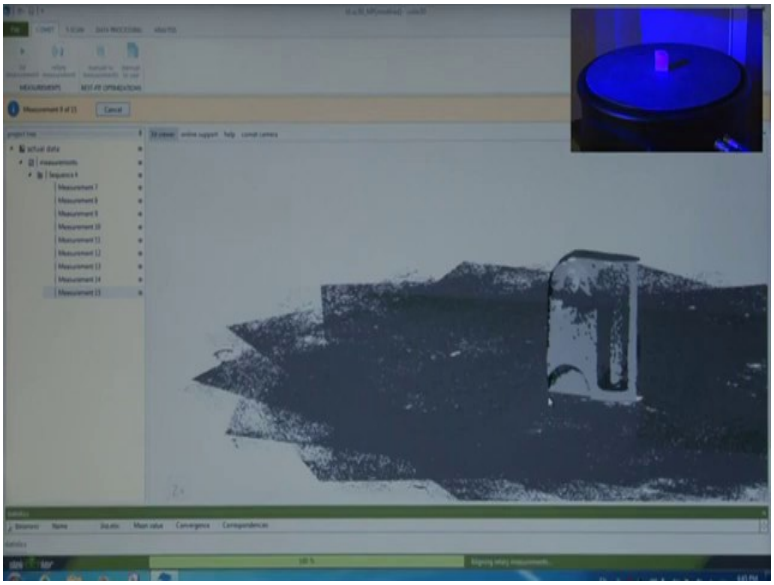

So, the scanning is happening now. The scanner is started it has started to stack scanning now the object, so it is trying to connect the frames, the previous one and they are recent one, it is trying it keeps on, keeps on trying to align and capture the data simultaneously.

So, 5 of 250 measurements are completed. Now, data acquisition, data alignment next generation where the steps so, acquisition and alignment is going on hand in hand, manual alignment is almost going on, we can also do some more detailed alignment after the data acquisition is completed when all the scanning happens throughout. So, as we discussed the 3D Scanner's main purpose is to turn a physical object into digital one, the scanner gathers or records data on the precise size and shape of the object.

So, it is important for digital manufacturing and it is crucial for the decent industrial revolution that we have. So, this candidate we are using here uses blue light to capture the image of the physical object. So, we can see while the scanning is going on, we can see the number of scans test take and you can see the area down there that different rectangles are being built see through to the rotary table surface area.

So, modifying product designs can increase its value. 3D scanner is a great tool to use this. So, in this case, we can keep on doing scan and then we can keep on zooming in zoom out when the scanning is going on. So, just be sure to see the real time data and real time data collection so I am not pausing the video.

So, 14 readings not 14, 9 reading has now been taken out of the 15 you can see that at the status bar the yellow status bar up there, this is a noncontact 3D scanner that produce the structured light through we can have laser or light-based radiations and then use a camera and a receiver to capture the reflection. So, the point cloud of geometrical shapes of the object or the surface is produced using this.

So, it gives us everything in x, y and z coordinates of each point on the surface of each point. For most of the objects, the single scan is not suggestible. So, we need to have the additional measurements we need to have the measurements at different orientations like we are doing right now.

So, full scanning of the object is obtained only then. Depending upon the resolution of the camera, each line is scanned that comprises of several dots that will be spaced apart by a specific pitch distance that these scan data are combined using the triangulation method. That is the principle of the operation of the scanner. So, it brings it into the common reference system that is what we call as alignment.

So, this is how it applies to the digital models which are developed by the 3D printing. So, now we are close to 30 measurements out of which 15 is taken now. The technique or the principle is triangulation method, but 3D scanner project a series of linear life patterns. Only the fringes are always linear that is why triangulation method comes.

So, the angle of distance of the object from the scanner which is generally 750 mm, it is recommended distance that is known also known as the field of view is set accordingly. This is how it works.

So, the margin of each line in the spectrum that is created through the fringes, figure out how far the object or the item or the specific surface or the point is from the scanner. So, the data from the fringe images is then recorded with a scan of this camera in a single measurement. So, now 15th measurement is going on so, the status bar, the yellow status bar up there is showing that 15th measurement that is, is going on now, it is completed yes, it is showing the following measurements for acquired by the sensor worn-out.

So, at certain points you can see the data is based wherever you see green color it is correct otherwise we have to align it properly. So, let us process the data, there is a data processing bar up there we click that data processing bar.

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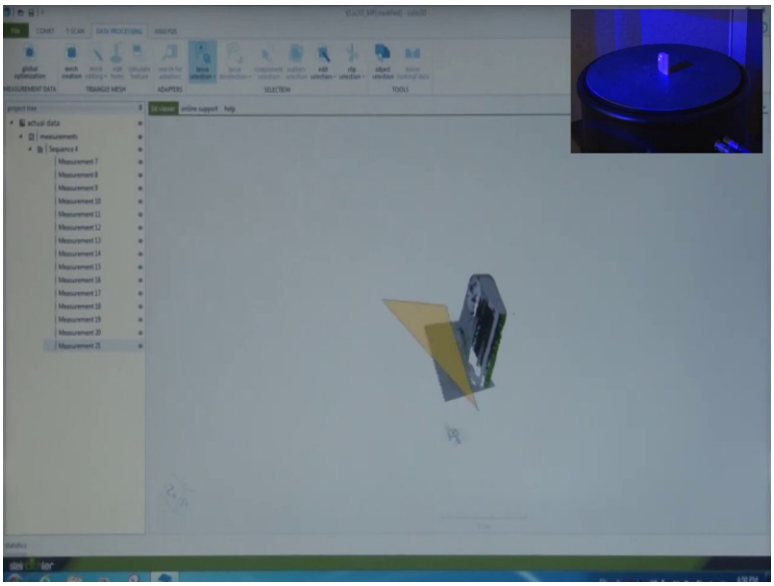

Menu bar we have various tools here in the selection tab, we have lasso tool, lasso tool means we can cut using this tool the non required or unwanted area. So, we should delete the points which are not required otherwise the file size will be so heavy that it will not be easy to handle. So, we select this and try to clip everything using clip tool that is given in the selection tab. So, it is a clearer data.

So, we can still clip using lasso tool and then clip the red area it is showing that if I now click on the clip selection, it will delete this area. I am further selecting the area that is not required clip selection so, we try to bring it in the center and then again try to reduce the unwanted area as far as possible so, we can also now do the global meshing.

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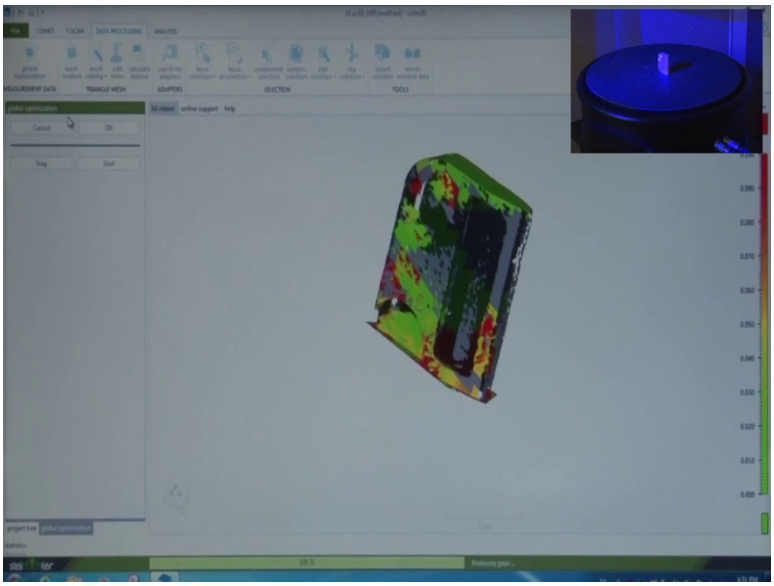

Global meshing means overlapping of all the different orientations data and meshing them together, meshing them means putting them together, mesh should be separate, it has now collected the whole data and the global meshing has now been taken so there are different colors. I will just let you know what are the meanings of these colors- from green to red it is some different colors and it will also show the gray areas here, global optimization is the global alignment I will say okay then we come to the comet menu bar and again I start rotary measurement.

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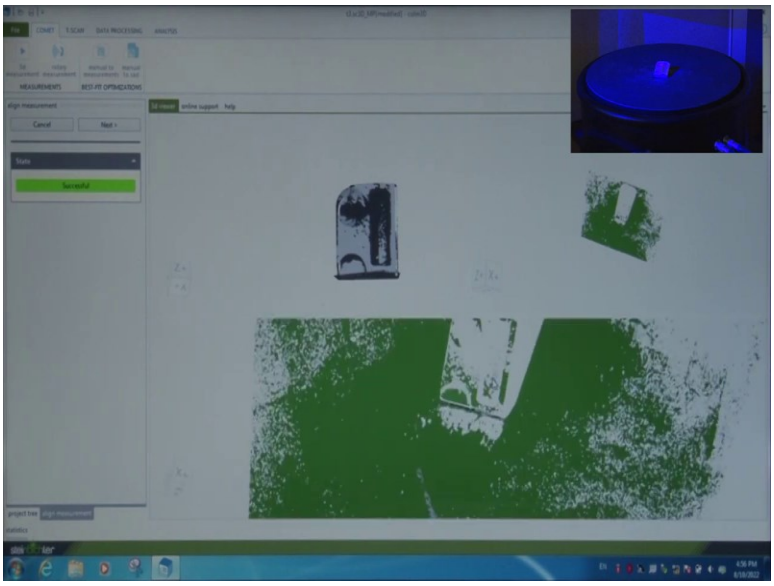

Now, in this case, we have changed the orientation of the object because in the previous scan there are certain portions which were not clear. So, in the second orientation, we have started the scanning again, it is now showing successful, successful means the previous scan and the recent scan that has been taken both orientations are matching.

The previous scan and the recent one is being compared, this are kept at an angle so millions of these points are there that depict an object's shape on a computer screen. So, these are only referred as the point clouds as I said the capacity of the camera is 5 megapixel that is 5 million points each second which is extremely accurate to 0.0005 inches.

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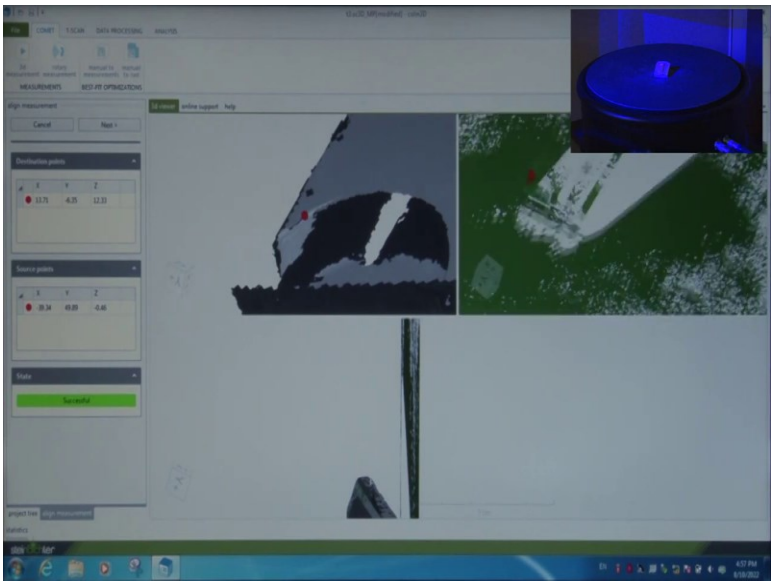

See the two points are matched. So, first we need to do the manual alignment as close as possible. we just click two points here which we think are closer. So, to select the points generally the edges the corners are taken, the two points you can see red point on the scan that was not previously and the current scan. I will product scan A and scan B through the other line.

Now, the yellow point on scan A and yellow point scan B these are tried to be aligned. So, we can also delete if something is not required. Now, again red point is put here on scan A and scan B. So, putting another point on scan B and on scan A at the almost closest area. He will just let us know that how far it is.

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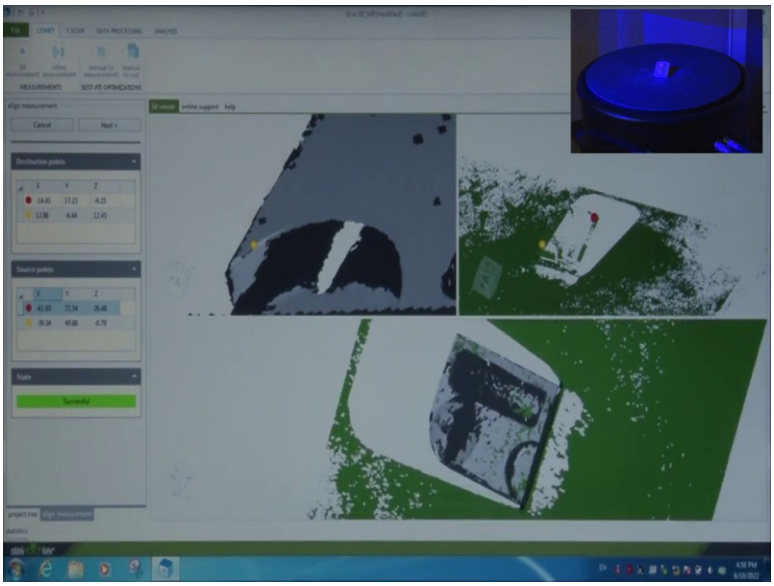

We can also see whether how close the object is to the previous scan. We can see it is showing close almost occluded. So, let us take another point third point so, to put the third point is to pick a place. We can pick at this surface here, at this surface at around this place, the result is there in the lower window frame that did not match much. So, another point is taken at a different location.

So, these iterations keep on going when we try to scan something. So, there are certain iterations which are taken care and we need to scan the things while considering the known feel of the object. This is the corner of the previous scan, the similar things keep on going so, we are trying to match this.

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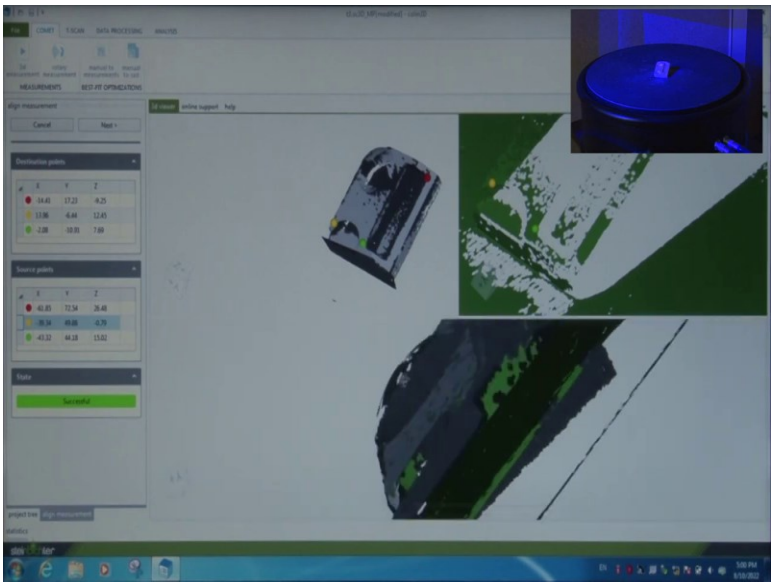

So, now the 3 points are scanned and aligned here so, it takes time. It is the skill of the operator, the one who is scanning that how close, how less time does he or she takes to produce the object closest to the pattern or the final object that is required.

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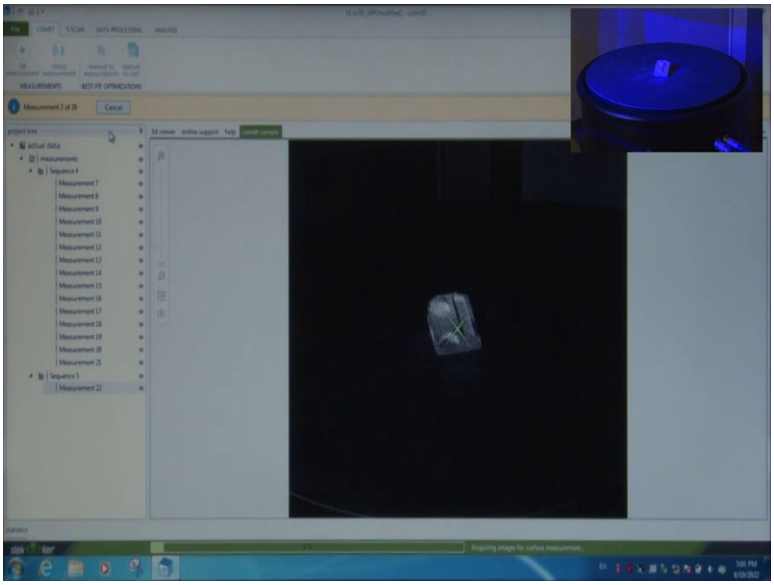

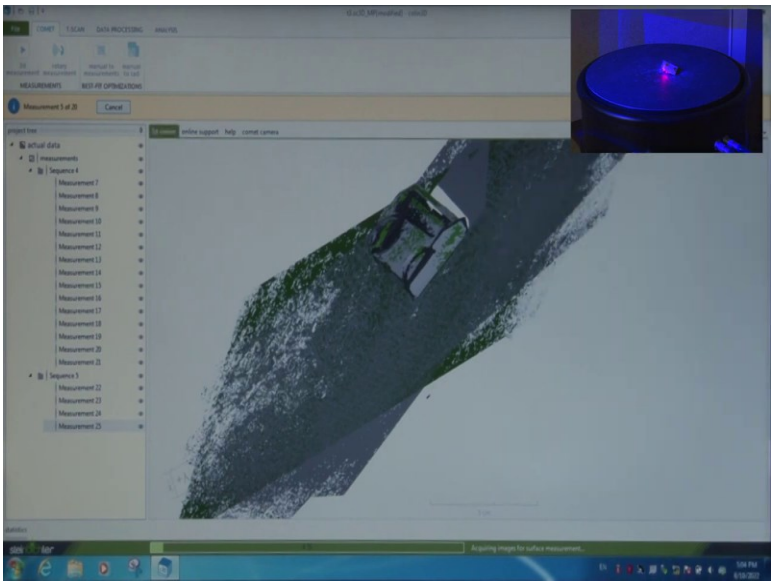

So, because this is a manual scanning that what we were trying to teach you so, it took a little time. There are automatic scanning systems as well or scanning options as well which will try to take the points by itself and try to match it. So, let us now again try to scan at an angle where it is kept, the scan has been, now the 20 readings would be taken. Measurement number 2 of 20. So, all the readings are being taken here it is now showing the object that is being scanned.

Now, the 20 readings in a different orientation are to be taken. So 5th of the 20th reading is there. So, similarly the readings are being taken here. So, let us wait till all readings is complete. So, the fringes which are put onto the object or into the software control and the camera will record this as a point cloud data so, it is now into the 19th measurement of the second scan.

So, I have fast forwarded it because you have seen the real time data that was collected in the previous scan all the 15 measurements when taken. Now is taking the 20, 19th measurement that is that it takes the 20 measurements complete. 20th measurement is going on, you see down this area under status bar.

Now, there are certain softwares which help us to do the alignment or do the cleaning or the next part of the 3D scanning process which is mesh generation simplification before that alignment and now the 20 measurements are completed here, the rotary table job is now over.

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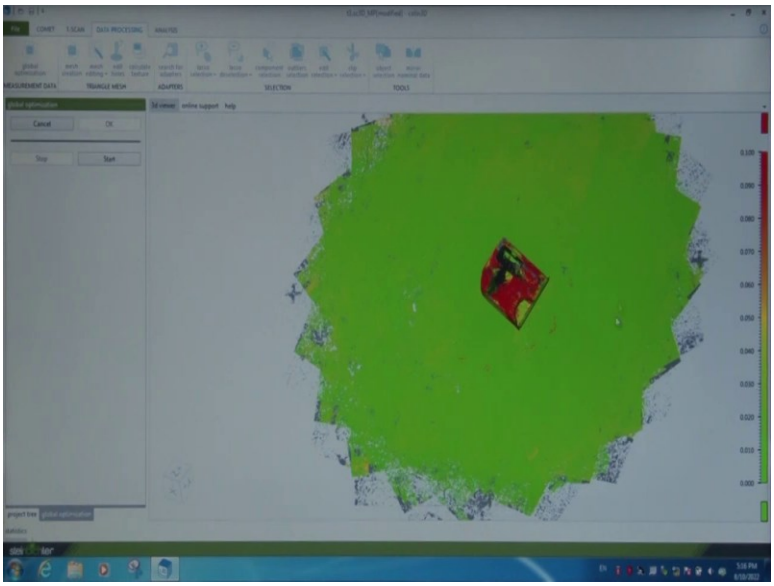

Now, the extra features which are there again, we can move using the lasso tool as we did it before so, we go to the bar data processing bar, we have global optimization, the ribbon here and again try to do the global optimization. So, the green boundary here shows the object is in the same orientation as of the scanner.

So, it is actually the surface of the rotary table, see if I put globe, if I start the global optimization here again I apply the lasso tool by selecting it from the selection ribbon.

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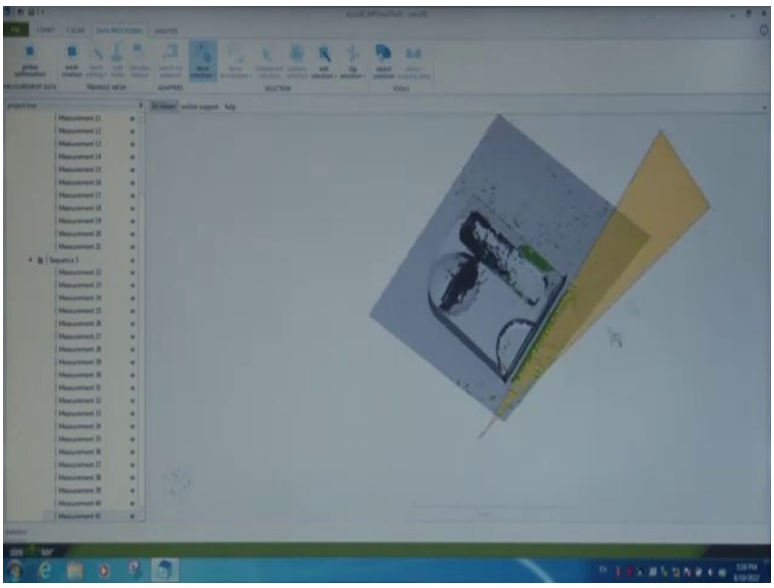

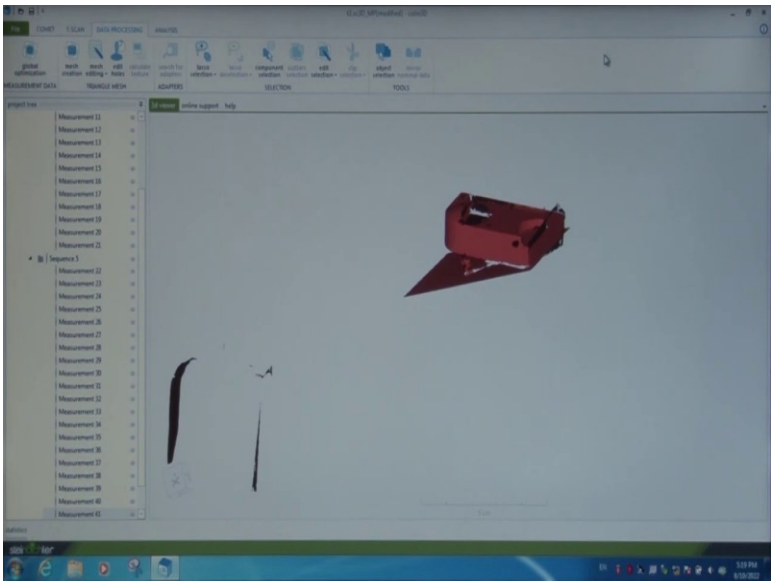

We will use lasso tool to again clean it, all the unwanted points will be deleted here in a similar fashion as we did before in the previous scan because it is kept at the center, we are now able to do that more quickly. When I say clip, it will clip down remove all the red area which was selected using the lasso, lasso if you know that is the kind of the noose or the rope that the common use to get the cattle or the horses into their control. Similarly, it is using lasso tool.

The next operation that we will perform over it is mesh operation it, the mesh operation decides the quality of the scan that is taken, the quality control, design, reverse engineering what are you going to do it asked about different options here.

So, in this case, now, we are only going to do the reverse engineering that is we are going to create a 3D CAD model out of the scanned object. So, we are going to create a solid model. So, we have selected reverse engineering it is showing the error maximum point 110 mm so mean value of the error edge length, it is showing the different parameters here. So, we will remove the unwanted areas.

Now, we will go to the Geo-magic design X software, and we will try to do the next operations of the reverse engineering that we will do in the next part of this lecture. This was the only equipment using part of the demonstration of the reverse engineering, we will try to see what rotary table is, what scanner did we use, the parts of the equipment setup that is rotary table, the

controller, the tripod, the scanner itself and how do we use them and when we use them a dongle is also part of the equipment setup only.

In the next part of the demonstration, we will use the design X software and we will see how we go about to have the final 3D model. Thank you.