Micro system Fabrication with Advance Manufacturing Techniques
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Lab Session - 5
Vaccume Assisted Forming

Hello and welcome today to this foray lab of... And the process, we are going to demonstrate for you is a rapid prototyping process. So, let me just comment a little bit about, what this rapid prototyping process is... And how it helps in augmenting the industry bringing into sort of micro features or micro parts. So, the rapid prototyping is about sectional printing of materials. It is also known as three dimensional printing.

The whole idea is that, if there is any complex feature or shape or cad file, which is available. The system is tries to section that particular cad file into small elements. And each element is been deposited by means of plastics, which are typically two in kind. One is either poly carbonate or abs plastic. And this particular machine, has the capability of handling on the plastics.

Either, all though in the current domain of technology, their exists machines, which also do the same with metals. So, they are called fusion deposition modeling or metal fusion deposition systems. And they are used for non strategic parts. Particularly things like, let us say ((Refer Time: 01:29)) or you know aesthetic furniture's, etcetera, made up of metals. So, the advantage behind 3D printing, this area is also known as layered manufacturing, because you are manufacturing layer by layer.

And the advantage behind such manufacturing processes is typically, in terms of the saving of excess materials. That you otherwise incur, in other contact machining processes, where there is a lot of ways to which is generated, in forms of chips. Or even in other forming processes or associated, it is a casting processes which are primary manufacturing process. There is always a tendency of formulating a layer, which is eventually removed.

So, in this particular application the layer deposition process, the advantage is that such a

savings can happen in terms of, obtaining a direct surface finish without performing any other machining process, after this process has been done.

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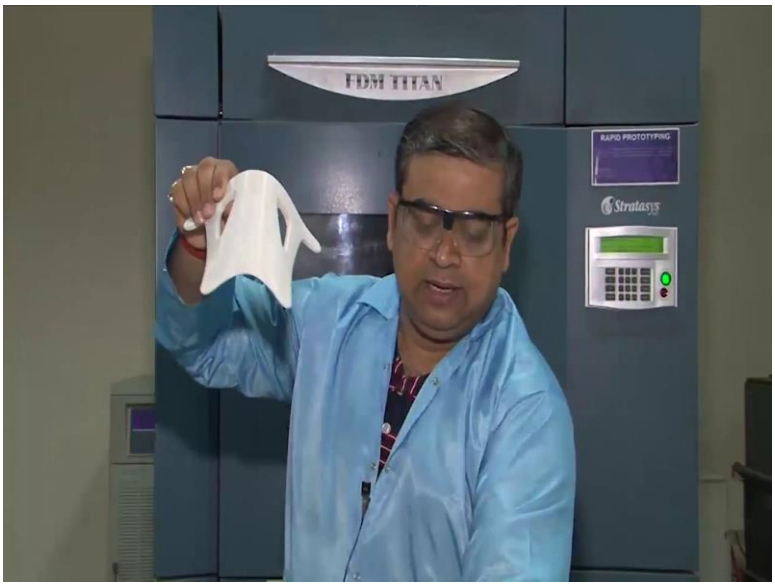

There are several processes, the several you know shapes and sizes, which have been fabricated with a rapid prototyping. This right here shows, the part of a horse saddle. I can see, this is a horse saddle.

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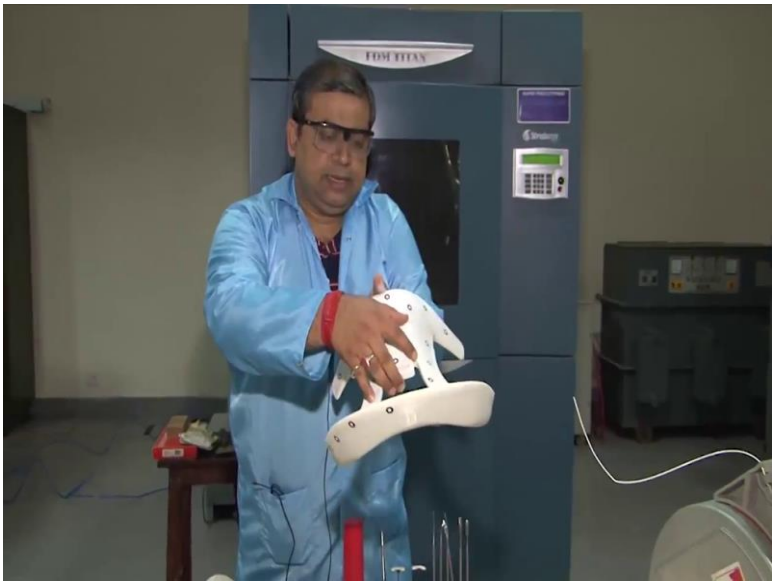

So, here for example, this actually is sought of you know, the way that a person customizes his requirements for tiding horse, etcetera. So, everybody have the different physiology shape. And therefore, it is needed that particularly, something like a saddle should be able to customize to the particular user, which is there. So, not only the process is highly economical in terms of material saving, because you are just depositing.

Rather than, this a material build up process or a I would say, a surface machining process. Rather than the bulk process, which is subtractive in nature. So, this material is in a additive process. But, apart from that the main advantage of this process is that, you can highly customize, the parts of the features to the taste of the customer. And you can make very complex shapes, which otherwise is not doable with these different machining techniques, which are around. And in a way what happens is that, once your cad file is designed irrespective of whatever is the complication, which is involved. I just show you for example, what I mean by a complication.

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This is the crank share of an automotive. You can see the design and you can look in to the kind of complexity, which is involved in designing such processes. Typically, this is used in the automotive industry. And the way you generated is, using forming processes, but here you basically depositing and making a scaled prototype or a model. Through, which you can probably formulate the next step, which can be used for a DI manufacturing for that forming process to happen.

So, one advantage of this kind of a process is because of the complexity of the shapes, it can handle. It can be used as the intermediary for some of the primary manufacturing processes also. So, in the nut shell, what I am trying to say here is that, there are lot of advantages associated with the rapid prototyping. One of them is of course, the high level of customization. And other is ability to handle complex designs or parts.

Third is lot of material saving, because that it is a layered model. And there is no secondary material, which is wasted in the process. And then, this can formulate in the intermediate process for final primary manufacturing processes, like forming or casting, where probably you have to do the mold development or you have to do the DI making. So, some kind of a prototype is needed in order to envision and design, such a system.

So, having said that, the question comes, how this layered deposition model works. So, as I told you the first step is about, making a cad file, and sectioning the cad file in to slices or pieces. The slices could be close to about, whatever the resolution of the equipment gives in this particular case. And as I told you, this machine handles two different equipments, that is abs as well as PC. So, for the abs plastics, the minimum size of the slice, which is available here is 125 micron 0.005 of an inch. And the basic raw material, for this process comes as the roll.

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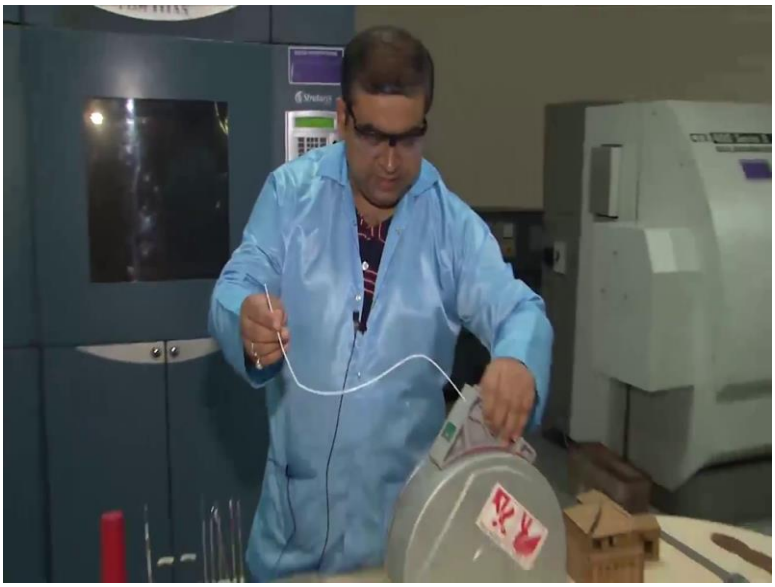

You can see, this is a wire roll. And this is what the basic raw material comes as. And this wire is fed from a very small nozzle, which actually is able to move in a x, y plane with the information that, it would have the coordinate positioned information, which we should have from the cad file. So, suppose if, now there is a sectioned layer of such a complex part, I showed you a part can be as complex as this.

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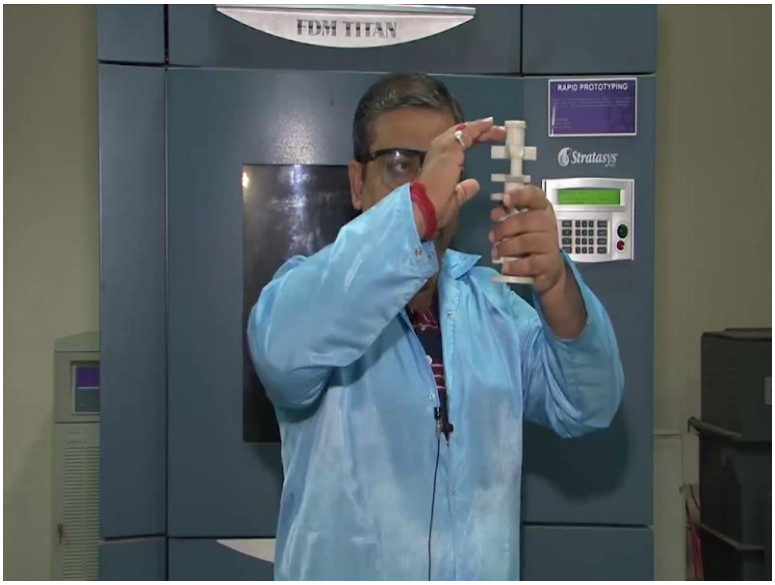

So, probably I have made a small section of this somewhere here. And I am actually seeing, what are the coordinates of that particular section in defining the tool path. So, the nozzle would actually move in that path and try to maneuver itself.

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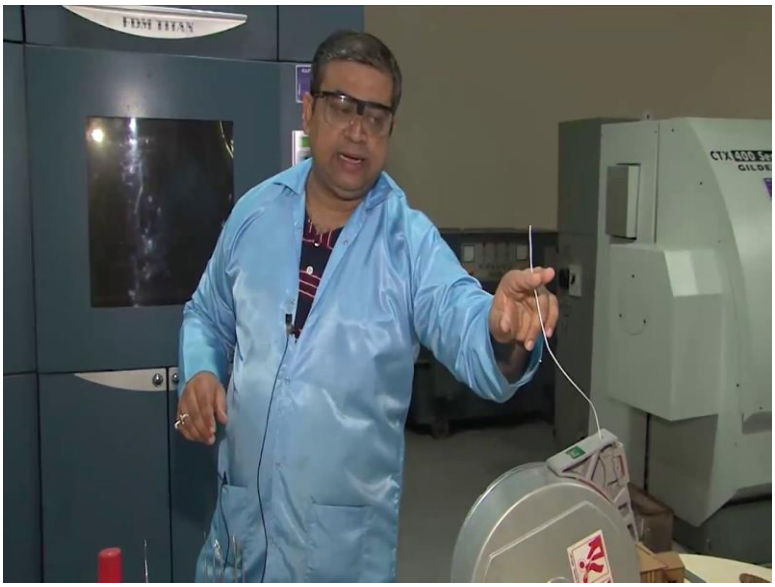

But the dispensing, this particular plastic here by heating it up to it is melting point. So,

the nozzle is typically heated at the 300 degree Celsius, at this case. So, that it melts the plastic. And then, the plastic flows across the nozzle. And it is going and walking across the tool path, which is generated into the overall feature size. And it is depositing that layer of 125 Microns.

So, once this layer is complete, it is ride up then the next layer is deposited. And so, next layer the information will again come from the cad file on the basis of the next slice, which the cad has originated on the basic file of the design or the drawing. So, here is very interesting technique. Let us look at the machine little bit. Let us actually open the system up.

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So, as you can see here, there are two parts basically of the machine. One is the controller part and also the material feeding part. The rolls are now, currently in position and they are fed in the system. And the controller, here is actually indicating several different aspects like, what is the support material? What is the model?

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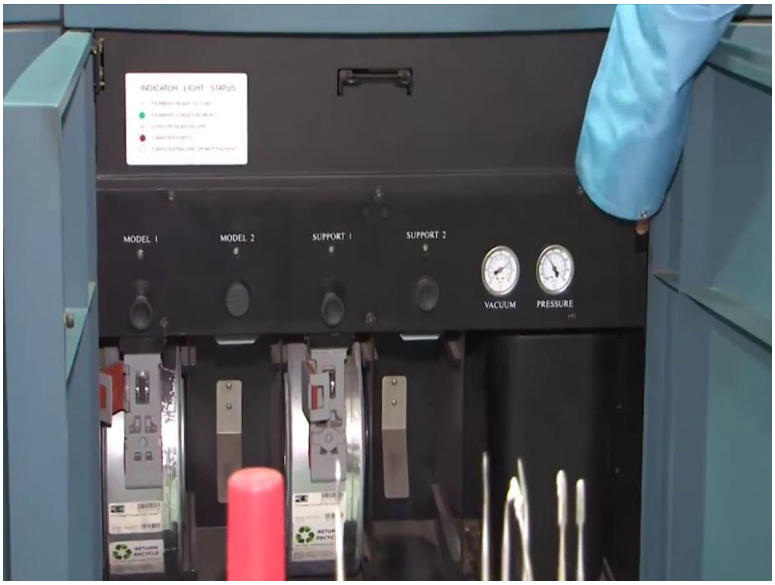

And then, there is a vacuum pressure and other pressure, which are indicated. There is a small toggle switch here, at the corner here.

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Opening, which would generate the toggle switch, would be operational here as I showed you or when the machine, initializes itself. So, there are several processes which are

happening here, after the controller has been switched on. And one of them is basically to auto home or order of position of the dispenser unit on nozzle, in the x, y, z plain. And also it does a several checks and the balances at the beginning, so that the machine can be completely initialized, for the next run.

So, we have to wait for a little bit until, the cursor here comes to unlock door. And at that point of time, we can actually open the door. You see the light has been on inside the chamber, where the rapid prototyping can actually happen. So, the first stage of this machine would be related to setting up of this machine. And we will go back on the computer and try to make a cad package. And try to mesh it in a particular manner with all these specifications, where a file machinable file can be created for this system.

And then, this file would be transported in a soft manner into this system. And the machine path etcetera, would be pre defined. So, all what we need to do is to transport that file and set this machine on and forget about it. So, that the part can get manufactured inside this oven of the part containment with there in the machine. So, you want to now do this auto home.

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So, you just need to enter for doing this command and you can actually, see now. Inside

if you have a look at it, the stage is going up. And there is a position of the nozzle with respect to the stage that is happening, within this particular machine. So, that you can have a home position for the work piece with respect to the nozzle, within the machine system.

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So, it is still homing x, y gently and the z stage. So, if this process will take a little more time.

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You can also actually see right on the top, here is the dispensing nozzle, which is come up. And it is now, it is trying to position in the x y direction. Once this is defined by the work piece and then, it will all about the way that nozzle will be dispensed. Then, the correct tool path would be mapped as per the cad slice, which would come inch by or you know few hundred microns by few hundred microns, as you construct the part the final part.

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Though, the controller here as you are seen for the r p of the machine, after homing of the x y z as happened. Stage has happened shows a lot of options like build job, operator control, model status, maintenance, so on and so forth. Each of this has certain meaning. And I will describe these along the way I do the machining process. However, once we want to just actually, first clear the stage with existing whatever is lying inside from the last run.

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And then, basically try to prepare the stage for this particular run. So, what we are wanted to do is, to sort of go into this operator control, which is the second option here which in can use the cursor key to go. And then, enter on this operator control which takes me in to another menu, sub menu which say unlock door, load, unload so and so forth. So, I am going to again enter because, there is an unlock door option which is there.

And then, it goes to another sub menu, where again there is a symbol unlock door here. And I am going to actually a sought of, start this and this. Enters or this actually is able to open the door. We cannot leave the temperature on for the long time because, this actually is the sheet the miler sheet, which was from the last run.

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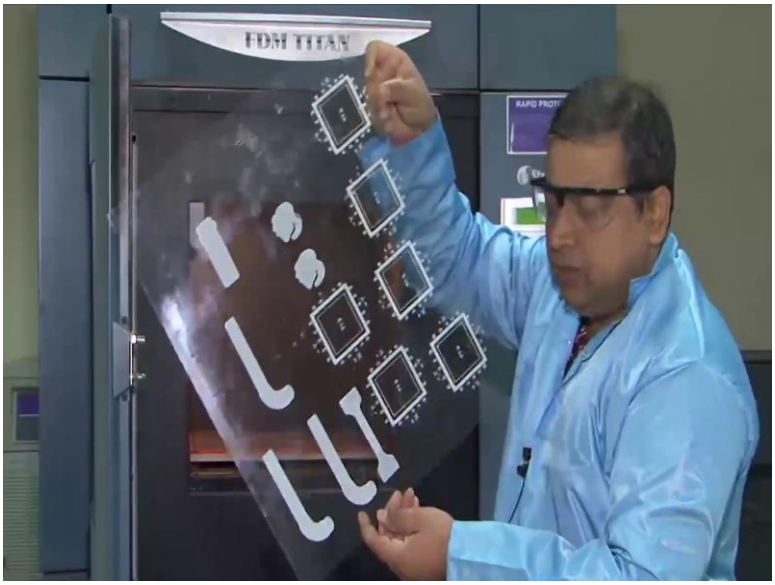

I am going to remove this miler sheet and put our sheet here. So, that this becomes the new run, actually of the process. The oven is actually getting heated up here, at above 119 degree Celsius. So, it is a little risky to actually at this stage, touch the sample surface. But, you have to just ensure that the sheet, that you are posting is actually at the very corner of this particular thing. And there is a guide there, which actually ensures that it is at the corner. Once it is done, you can close the door back.

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So, that now you things are replaced. And the next step that we want is to actually go back to the cad software, in the computer station, and we able to process a particular file. So, that we can transport the files here, in a soft manner and start the initialized machining system. So, basically now as I told you in the last step, we demonstrated the machine.

We said that, it is really about the cad file and how we can slice it into different pieces, which ultimately would define how the tool moves or the tool path would be defined in that manner. So, here in this particular work station, we would like to actually slice a cad drawing into pieces that is, number 1. Number 2, there is a huge issue that supposing this the part, we want to manufacture is in r p.

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Now, we will have to somehow suspend it in a manner, using a supports, so that the whole part can be fabricate. Also doing that, the question is that how the support should be kept in a mediumistic manner, where later on there can be cleaped, there can be parting line for which the lone object can be separated from the support. And the support actually is the most hollow part, with as less material as possible.

In comparison to the probably, the object which is more solid in nature. So, therefore there has to be a provision associating with the machine, where how to handle the part by keeping it at a certain intimation or by keeping it parallel to the ground with some kind of an angle. So, that the whole part can be getting created. And also about, what are the dimensions and how the cad file which has been designed earlier, has to be transported those I should be sort of....

So, today we are going to do the same. So, with our f d m titan machine that I showed in the last illustration, there are two different software's which come with the system. Mark them, it is called as inside version of 9.1, which is actually used to define the layering and also define the tool path. So, one issue is how to slice it into particular section and other issue of course is, how to define the tool path.

So, both of these will be done in this manner. And then, there is another software which is called the control center 9.1 version, which actually further illustrates how the object has to be placed in the overall miler sheet, that has been shown in the last step. And if there are parallel objects play that, how many objects would be there which add a single go of the machine would be able to build up the job, etcetera.

And you have to optimize the layout in the manner. So, that as many independent components that can be developed together, that would typically give the yield of the process. So, if the components are higher in that manner, the yield is also higher. So, that layout of the final placement of the jobs in the x, y, z state is given by, the second software control center. So, we will do this later, the first version of the inside where we import and scan and try to section and so. So, let us look at how we handle it. This is the main screen of the software.

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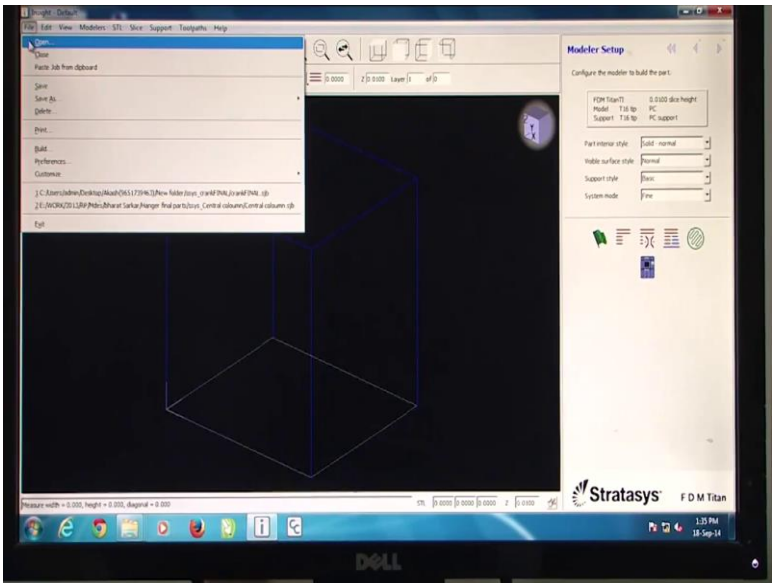

So, we actually go to the file menu. And in the file menu, we actually can open up a file. So, here what I have done here is the interest of time. I have actually made a cad file earlier or borrowed it from some source. And typically, the cad data has to be set as dot STL format, for enablement of this insight version 9.1 software to be able to needed. So, therefore, STL file has to somehow opened, using the inside software.

You open, we go into this desktop and then there is a folder, which is there to a drop down menu. And then, there is a crank final position. And there is a small part, which is there you will see, which you want build using the system.

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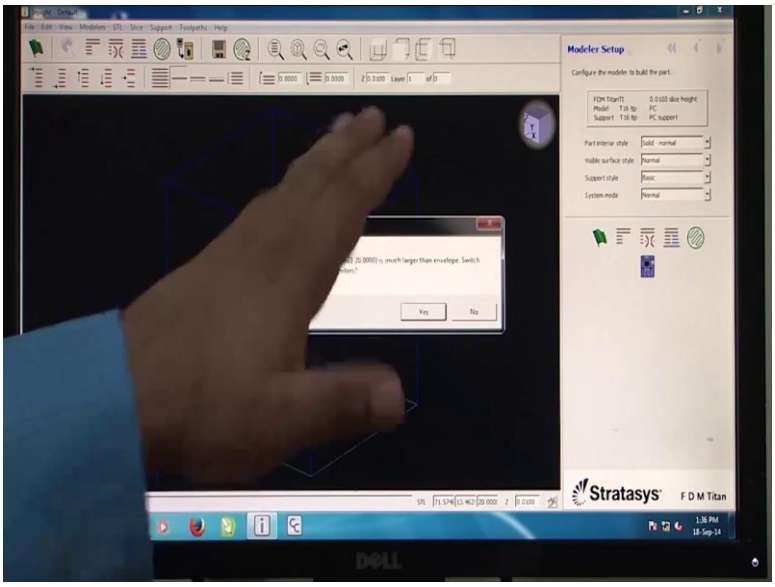

So, we open this file and transport this back to the scale. So, it is not scale. We have to scale it, because there is a typical consignment volume which would be defined by the bed size of the stage. I think, I had mentioned it earlier. That the bed size in the case of f d m titan about, close to 16 inches times of 12 inches times of 14 inches. So, that is about the size of the biggest part that can be accommodated, within this particular system. And I also defined, that the minimum layer size that the system is able to revolve is about 125 microns.

So, having set this, the part appears to be inches. And so, it cannot be accommodated with in this. And they are asking to convert this s t l to millimeter, just for the sake of demonstration we are going to do that this time, because it is going to be a micro part. Also it is going to illustration that, how the micro systems can be fabricated using this particular method.

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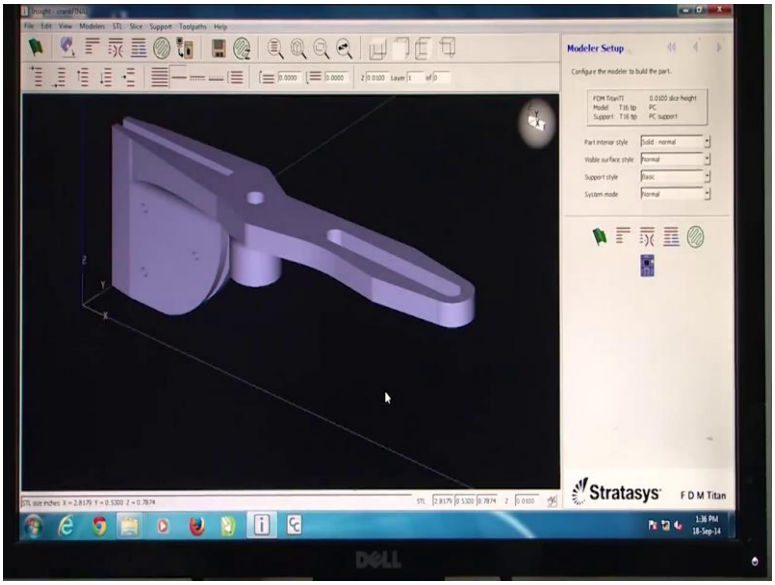

So, we are going to select this model. And the model automatically is now translated an opened in the inside version 9.1 software. Now here, there is a there are different aspects which we need to consider for varying the different dimensions. So, this is not very convenient way of locating the object because, naturally it we built the part like this, tendency of the object is fall down or something like that.

So, we want to actually locate into the manner, so there is more convenient. And we can then very easily separate from the remaining portion. And so, I am going to actually made the front portion of the part here as the bottom. So, I am going to actually now see, what is the bottom, take this up. And then, take this cursor all the way to this portion. So, this come to bottom on the part topples. So, now you can see the part as toppled.

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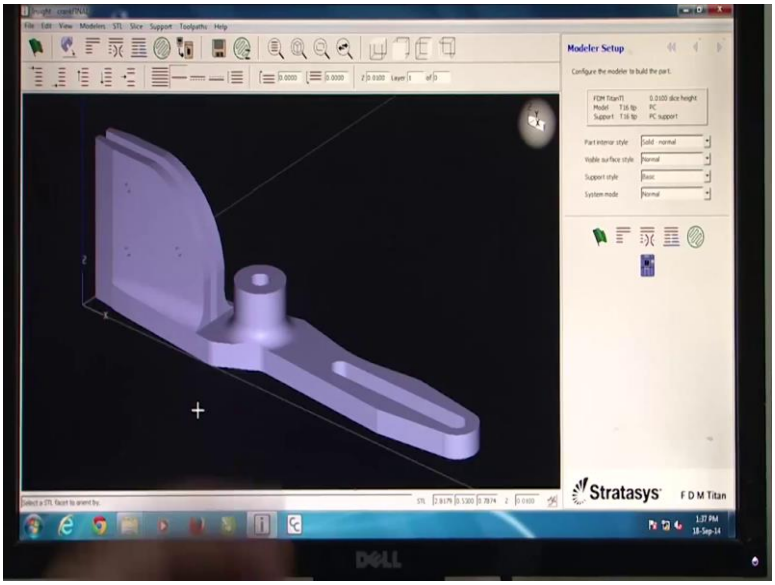

And it is lie down on a flat surface, which is actually more appropriate for the purpose of doing r p or rapid prototype. So, now there are the questions of, what is the slice height etcetera like for which, I would like to set up the system.

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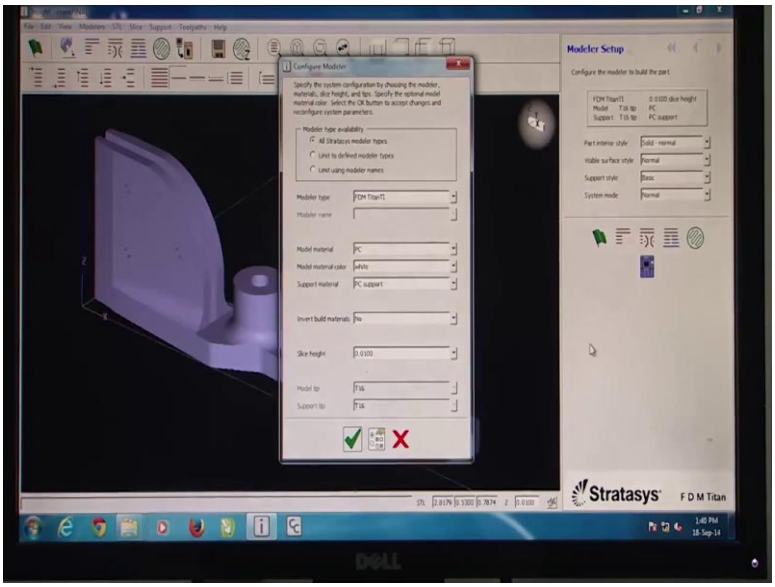

So, for slicing it, the first thing we need to control here is the, actually to do the machine

setup. And you basically try to configure the modular here in a manner. So, that you can define what is the layer thickness, etcetera. And what is the nozzle, that you have to choose. We have to remember that, there are about four nozzles in this system, which has been delivered or specified by the manufacturer.

And they are classified as a four different types starting from T 10, T 12, T 16 and T 20. Each of them has a different diameter, because ultimately if you slice, side has to be more. Naturally, the dispensing rate also has to be more for the tool, to actually be able to carve the object out. So, if the nozzle is slightly higher in diameter in that case, the dispensing would be faster. And therefore, it can go to a higher layer thickens.

So, it all is defined by the layer thickness, that how the nozzles selection etcetera would take place. Typically, there are two different materials as I told you earlier, that this equipment can handle. One is poly carbonate and another is abs plastic. So, when you talking about abs, there are different layer thicknesses ever which are available. And there are, you know all the nozzles including T 10, 12, 16 and 20, all the grades of the nozzles are being used in that category.

In the case of polycarbonate system, is little less flexible. So, there are only two layer thicknesses, which are able to get catered. And one of them is about, 0.01 of an inch and another is about 0.07 of an inch. And there are only two different nozzle sizes, which has to be use. So, in this particular dropdown menu, you can see there are different aspects given here. The first is called the modeler type.

So, let us actually see there are different machines, which the manufacturer has. So, typically ours is the FDM Titan T 1. So, we have to do this as a selection. Incidentally this is also set as default selection in the software. So, you need not worry about it. You can keep that as the default value, which the software takes. The different materials again, so in this case it is polycarbonate. But, there are abs materials.

There are, you know variety of different even polycarbonates, which are available. In this case, we want to choose a simple Poly Carbonate PC. So, this demarcated by PC. So, about to take this up, number model. Automatically the model material color at defined

as white, in this case. And then, the question of support material comes.

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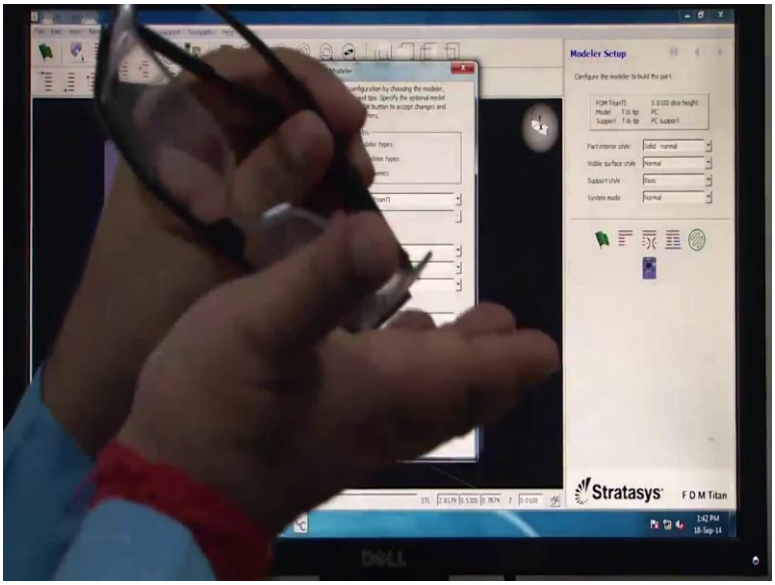

So, as I told you that, if there is a complex shape like this and you want a position it over a certain surface, you have to give a support to get it standing. So, most of it is in air. And you can actually build up by using layer by layer fabrication approach. And this support is very critical because, this is a wasted material. Later on, you have to remove this material. And the material would be removed, as it is a parting line and it is coming out of that.

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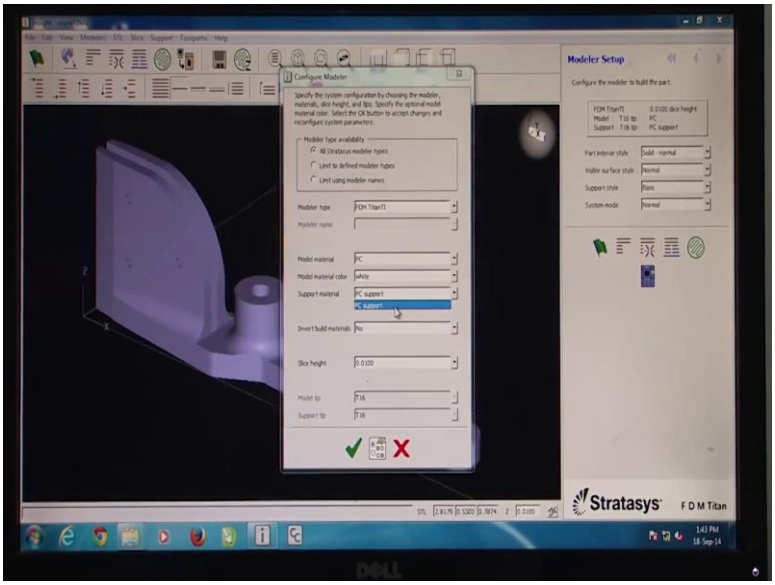

So, here in this particular case you can see the support material being defined by all the polycarbonate. So, the action that has been setup in the software is, that is PC part. Typically, the support will also be of the PC. So, the PC support is defined here. Although, you can change it probably by going into the, you know the set up of the software. But, at this time you want the material to be same, selecting PC support.

Then, if you want to really invert a build material, you do not want to do the inbuilt material option ((Refer Time: 20:58)). So, the inner built of material option actually is, particularly when there are more than one material is to be selected. And unfortunately, our machine is not capable of handling this option or selection of multiple materials.

When particularly, we want to deposit something, which is like, you know a layer by layer of two different polymeric structures or may be three different polymeric structures, the option of the invert would become more handling. There is a slice side option, which is kept here. Now, you can see there are two different slice sides.

One is 0.007 of an inch and another is 0.01 of an inch, which make this about goes to about 2, about 250 microns. And we want to select the thicker slice side was the interest of time, we want to complete this fabrication process earlier. So, we are going to bill this

slice 250 micron by 250 micron. One layer would be 250 micron. And that is how the whole slicing would be done in the inside package. So, it is essentially a slicer package of a cad file that, we are talking about.

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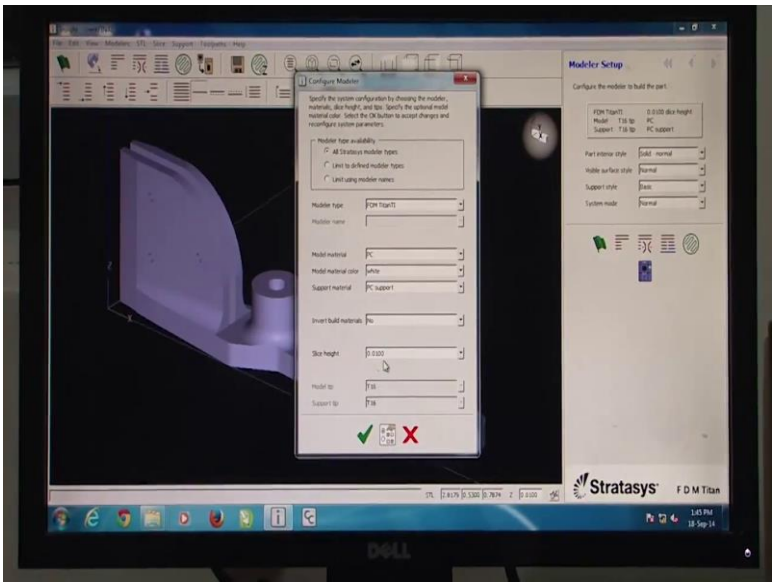

And automatically you see that, if you select this 0.01 option, automatically T 16 nozzle is selected. It means that, this would be able to handle and dispense that 200 degree microns layers. So, T 16 is probably a slightly thicker in diameter nozzle, which is existing in this particular case. If you had selected 0.007 as given earlier here, then you will automatically see that T 12 is being selected automatically.

That means, the lower size r f s nozzle is selected in that particular case. So, it is very obvious. That, you know the software is quite friendly. And it will amenably work in a manner. So, that it actually you know, tailors all these systems. Finally, we make it by pressing on this right button here.

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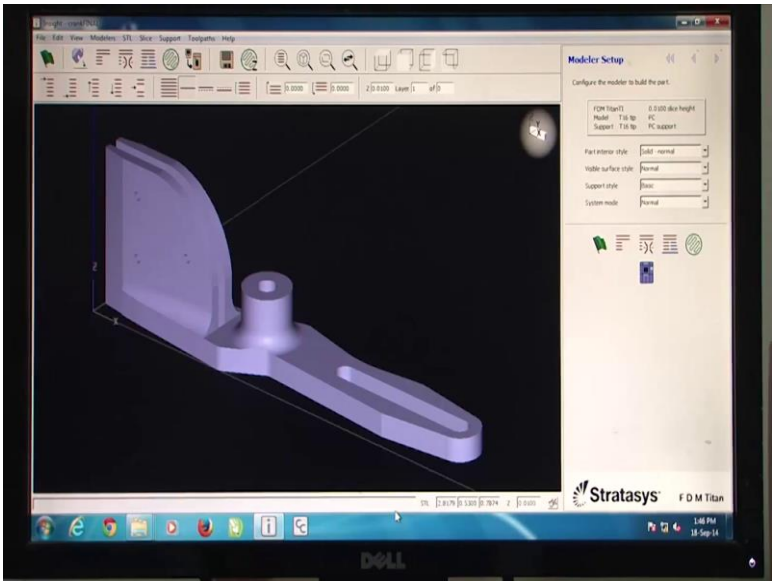

So, now you can see the text box which comes here on the top, is mentioning FDM Titan T 1 slice side of 0.01 model of T 16 tip to be used, a polycarbonate part and polycarbonate support. All these options have come here with chose, that the machine has now accepted. We various different options associated with this system. Now, the question of slicing comes into pictures. And I would just slide to illustrate a little more of, how the component is placed.

So, and the styling how the styling would be happening? So, you have different options here on the right side of this particular systems, you can see there is a part interior style. And if I just click down this drop down menu, there are three different options namely solid normal, sparse and sparse double dons. So, once it means essentially, there are two different options this machine has. One is that, it has a honeycomb layout structure, which is sort of lesser density structure.

And then, there is a flat fluid structures which is there. So, that the tool moving like a honeycomb manner and tool may also moving like a layer by layer. And the solid normal would mean, that we want the bulk to be equally dense. And it may be depositing, layer by layer or maybe even the tool path, even if it is like a honeycomb like structures would be so close to each other, that they would be consider to be only one whole.

So, this is a denser form which is available. There are different other options, which are there namely sparse, which would mean that this is typically sparse when you talk about supports and etcetera, where very less amount of material is deposited. And the gap between the material are very high. So, it is like a packet of card board, a corrugated card board, where there is a honeycomb kind structure.

And then, there are two layers which are giving the toughness of the strengths to the whole sheet. So, support can easily be done in that manner, because support is not to be used for any future application. The support is only a temporary sort of dismountable structure, which is only because you want to support the object to its ways to build it.

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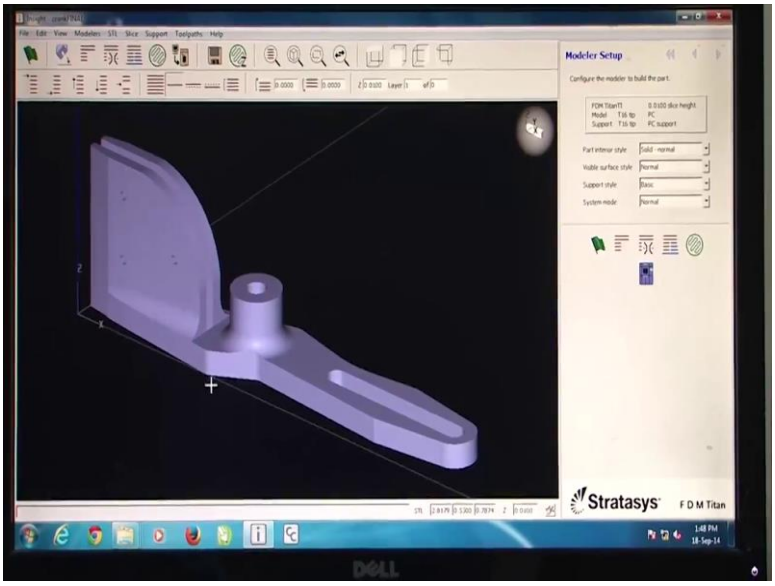

So, you can actually in this particular case, select the solid normal. Because, it is a real part, it is a cran. I was selecting the denser. And then, you have a visible surface style. So, there are two different. One is normal and another is enhanced. So, we will select the enhance option here, which meaning that the surface would be quite integrated. And the surface would have very good topology. There is a support style again. The support style can be just a basic support or a smart support. So, let me just illustrate, what it means a little bit.

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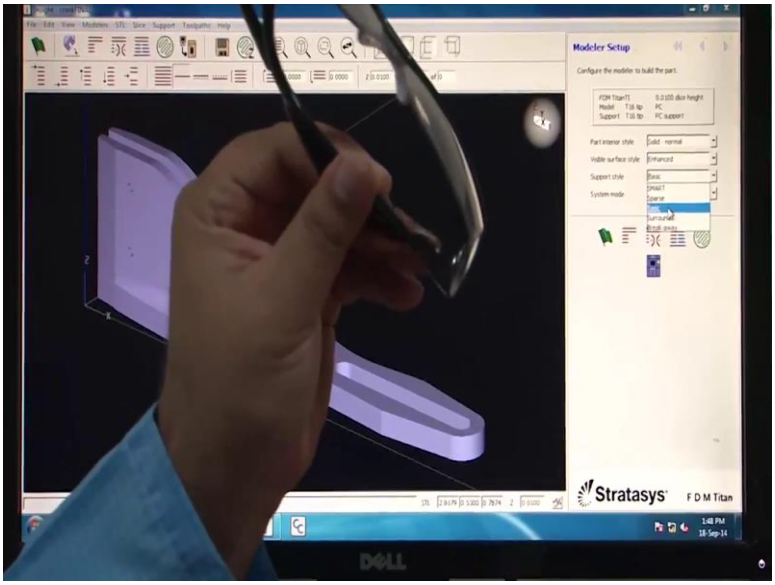

Supposing, there is a object like this and you want to place it at a certain angle. In order for the r p system to build it layer by layer. When it does it, there is a question of support which comes under picture. So, one support can be just simply orthogonally, placed like this. And other support can be at a certain angle, which is able to still support the weight of this guy, because you will have to calculate when the c g of this person, of the c g of this particular object is within the peripheral, this support.

So, if supposing the c g is within that support then, it will not topple. And that is the basic ideas and you do not want to part to be toppled, do while it is being made. So, you can scelitonise the support material in a manner. So, that it can do this job, by at a certain angle also. So, this is called a smart support, which will actually saves the material. So, one option could be you just give a thick grill like this in a perpendicular manner.

And other can be, to go like this make a certain base size and then, from their go at an angle and be able to support it. So, that the overall c g is still within that basement area. So, this is the way that the support is designed. I think you probably understand philosophically, how the support I would be able to manage. And the idea is, the support should be minimalistic as possible.

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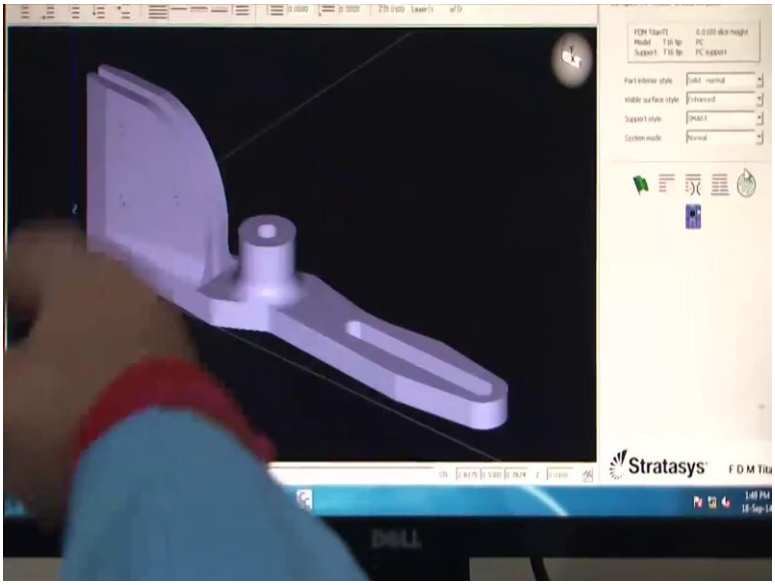

So, in this case we will do the smart support. So, we will actually select the smart option here. So, the automatically the software will calculate. That the support will not much of the material waste. And then of course, you have a system own, which again is you know find a system and normal. So, we select the fine option. Because, the system has to do a good job and making the integrated surface quality of this part, by depositions. And we are kind of done at this level, by setting up all the parameters for the slicing.

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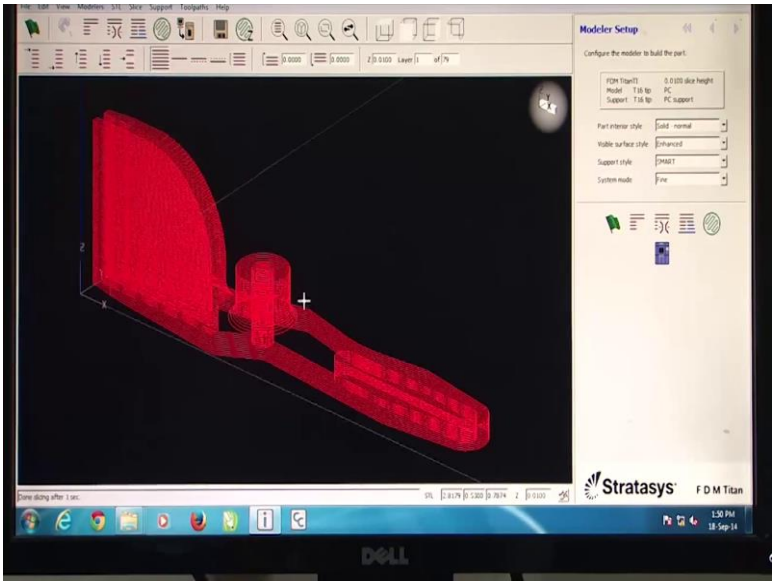

So, let us look at how the slicing happens. So, if I press this options right here, you can see that the system slice is available. You can actually go up. And you know, you can see each individual slice being made in the software. So, each slice has now a thickness of about 250 microns. That is the beauty of this whole process.

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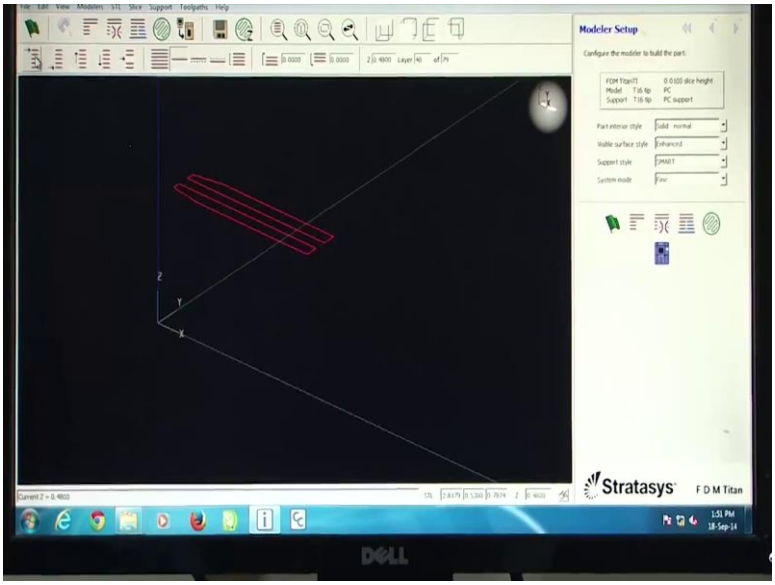

And what I would also like to illustrate here is that, once this slicing is made you can actually also look at the independent slices by this options, here on the left corner where you can go from the top end. And then, with the page up page down option you can actually keep on varying this. And see, what are the various layers which you have to deposit? And in fact, this also mentioned what is the tool path to deposit that layer. And finally, you will see that the whole surface is being constructed based on that.

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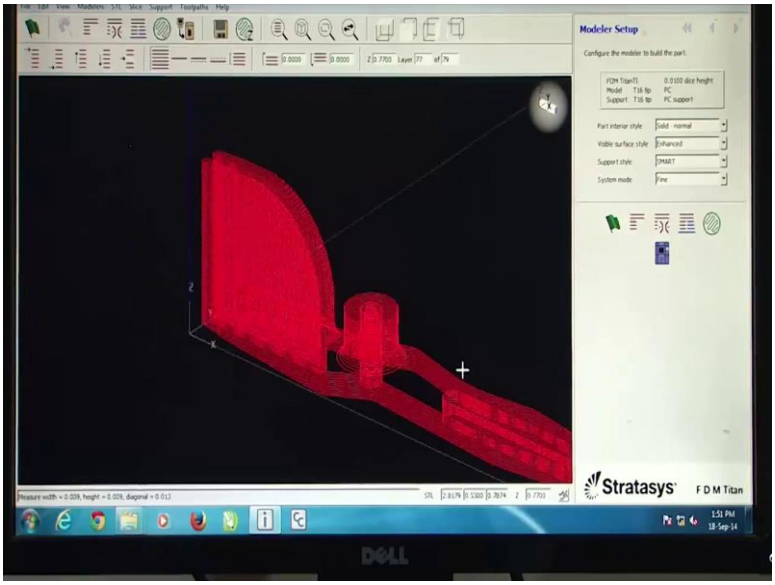

And then, you can also do it simultaneously from that top surface as well. And you can go up by doing the page up, in a similar manner. And that is how typically you get all the support. So, here again coming back to the same options, I can just there is a option here with all slices shown together, in a patch which will resisted wag the whole sample of the piece, in the system. And so therefore, this is how tentatively you can look at the slice clot.

So, once the slice clot is done and the question of defining the tool path, comes into picture. So, the other option now we have once we have actually, we have done the slicing, we have to create a support system here. There are certain all etcetera, which I not able to see, because of the intense slicing. But, you can see there are certain holes etcetera, which has to be created.

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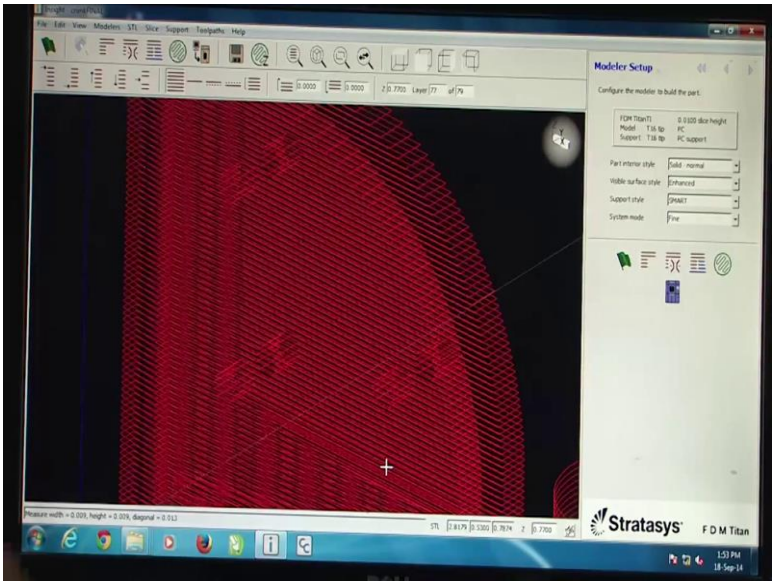

And therefore, there has to be a support within that, where typically the density would varies etcetera. That can be easy cleavage. So, that the support can be later on taken off to create that whole in that, particular dense structure. So, having said that, let us actually go to this. The other option here with say support. So, create support for the current job. So, I am going to just press click on this.

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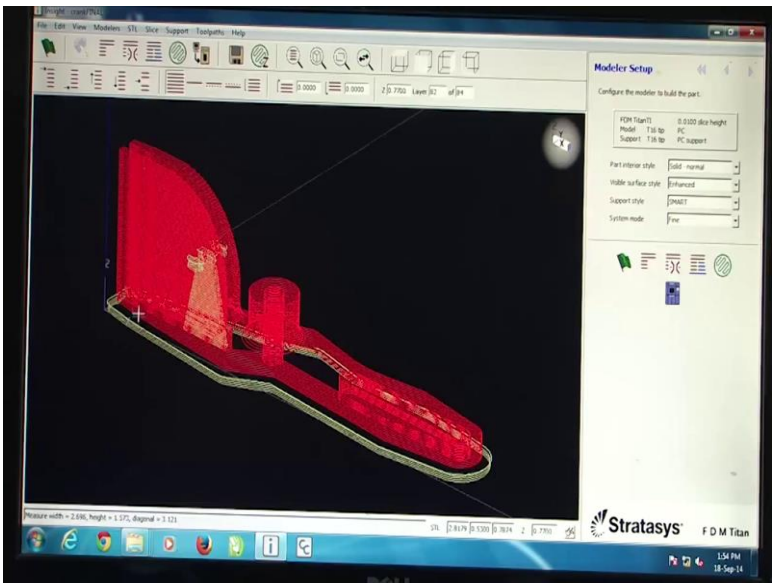

And now, the software is going to creates supports here. So, here you can see that there are yellow lines which are actually reflecting, what are the support media which is there. There are the supports, which are made here. Supports, which are made on the periphery of the objects, something like this. So, you have build up the supports here. And then finally, we want to actually find out that within once of section, what is the tool path which is get incurable.

And the tool path is reflected by this green symbol, which is actually reflecting the zigzag portion of the tool path, within such a domain. And I want to create the auto total path. So, the software actually now tries to compute and create a layer by layer, tool path. So, that you can easily look at by going to the various layers, how the tool path baring.

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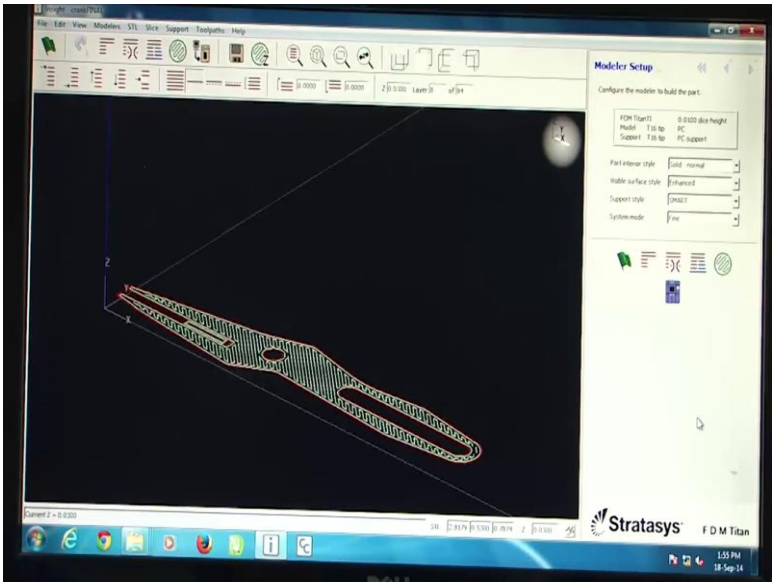

And you can see there are, how the different layers are been, the green actually represent the tool path. So, you can see that how the different layers are having a certain tool path define with the nozzle, would actually do the dispensing action. And typically, that is how the whole system is based on.

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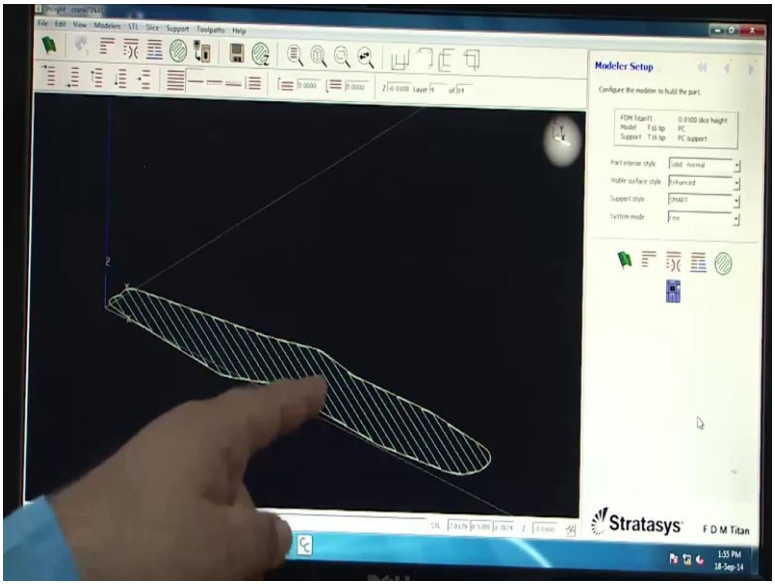

So, this is typically the support structure as you can see, it is much lesser in terms of the density of the material because, it would be like a honeycomb kind of a structure. The distance between the two dispensing points, would be much more in that. Because, this is something which is in any event going to sacrificially remove and the material has to be as lower dense, has possible. So, that we can make lesser loses, then is possible.

So, therefore this is how actually the whole system is made. So, let me just recall what all steps we did it. We opened a cad file in the dot strial available in the dot strial format. Then, we tried to size it down to the volume of the box, which is 16 times of 14 times of 16 inches cube in our system at FDM Titan. After doing this fitment of the component within the volume of the box, we did various options to it.

First of all, we try to define the materials which is want to be defined the slice height and the tip size. These things we have selected, once that we selected, then we are kind of ready with the next step which is the slicing options. So, we go to the slicer command or slicer menu. And then, slice it into the 250 microns. You can see that slice clot coming out, by going to the logo here in the top of corner, which says from top to bottom.

We can actually look at various slices. See, if they are interfering with each other is there

any problem in the slice, etcetera. And normally, there is no such problem because, the software is a highly error free slicer, which has been developed. And then, you can also give the various material texturing or patterning by mentioning. Whether, it is a solid normal or whether it is a sparse or sparse double dense kind of a layout.

Which automatically means that you know, you may vary the densities of various zones, making it corrugate in some places and uncorrugated, if you need. Here, in this case we wanted the whole model to be made out of a solid block with uniform strength also. So, we have chosen the solid marble. We also talk about the visible surface style and also the finish with which the machine would be deposit. And also give a support style, which would save of the material.

Remember, we did the smutch style in this case which would allow the material to the minimalistic, for doing the supporting action of the component so on. So, all these things are defined. We then, try to see the or give the support structure of the material. And once this support structure is also define, then we do the tool path. So, once the tool path is planned as you saw, that the material had a denser tool path than the support structure, which means the support walls much less materials. Just only intend them to support the material of, which would parted away later in a no useful material. Once this is done the file is complete, we can save this file.

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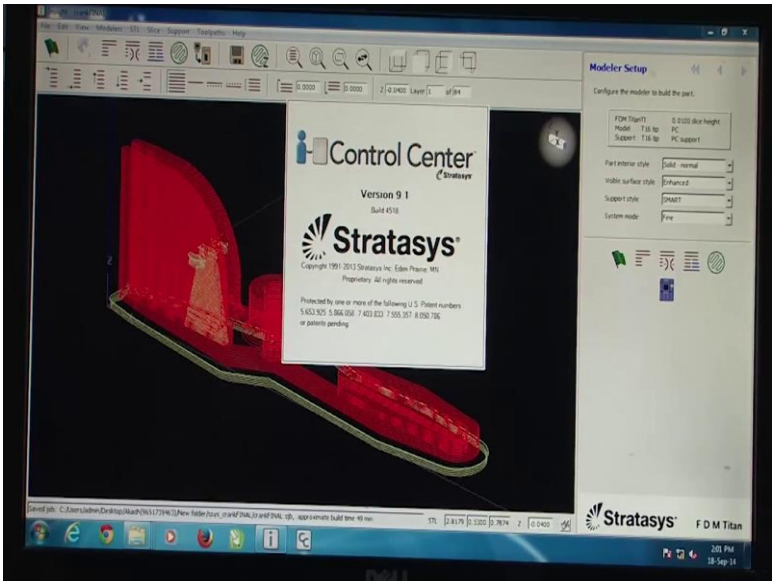

Looking at the complete illustration here, I am save it. I am going to the save option here. So, when we save the current job, it will automatically we saved of at the same place. Thus, this is a new folder, the same location. Thus, beneath the file that was initially extracted as a dot s t l file. And so therefore, you just save this here. Of course, there is some over righting existing job in the same name. We have to just do that over righting here. So, that the job is now save as a dot c m b file, which would be later on able to get extracted by the other version of the software, which I actually told you at the beginning is this control center.

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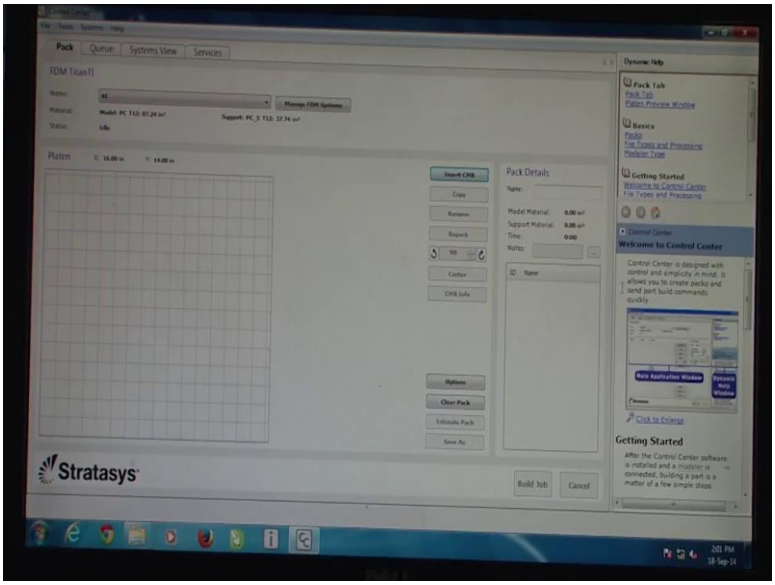

And this control center in the software, which would now fired particularly the job, all the way to the tool. So, before starting this also I would just like to sort of do some settings in the internet protocol, because of this a machine here the computer is connected to the FDN Titan, through a certain land protocol.

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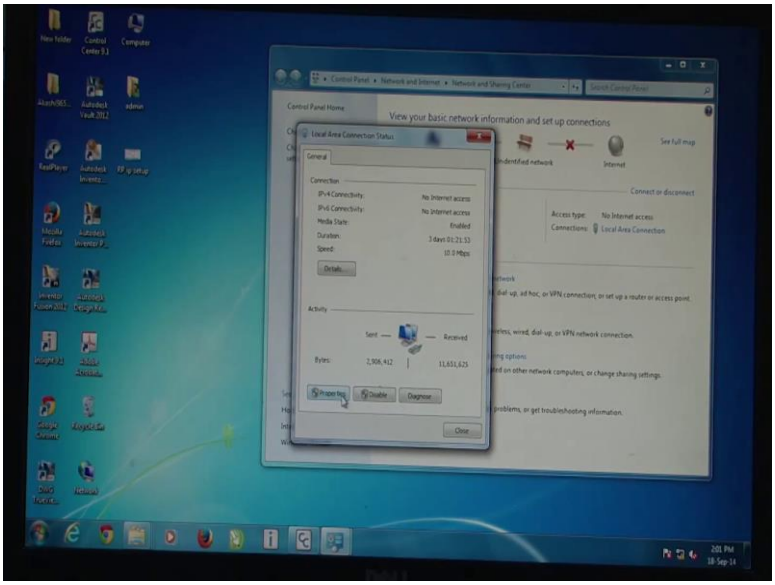

And this land protocol has to be initiated for this particular PC. So, what I am going to do is, to actually go all the way to the network connections here.

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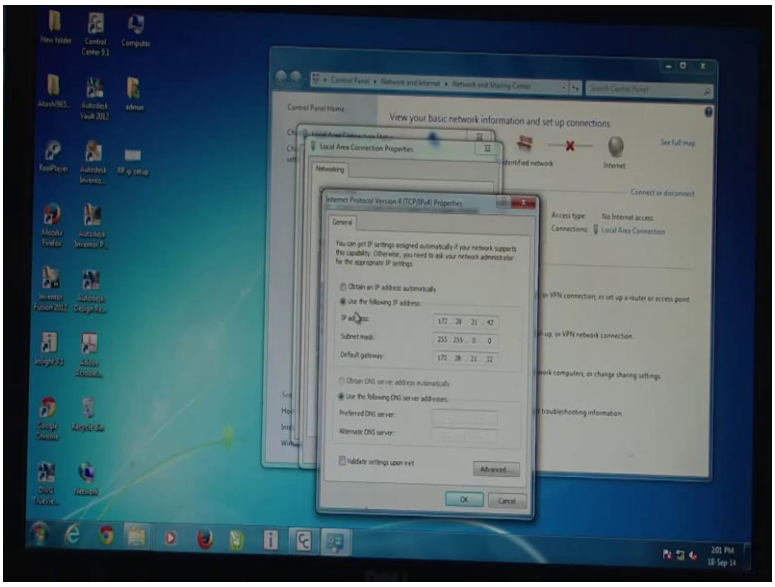

Open the network. Open network sharing center and then go all the way to the local area connection network here. And then, enable or disable certain properties. So, what I am going to do is to go into the properties here. And select this internet protocol version 4 by virtue of which, it is being search. So, we see the properties here. You can see the machine is free set in the IP address 172.28.21.42. This is the IP address at the machine. So, this protocol has to be initially defined.

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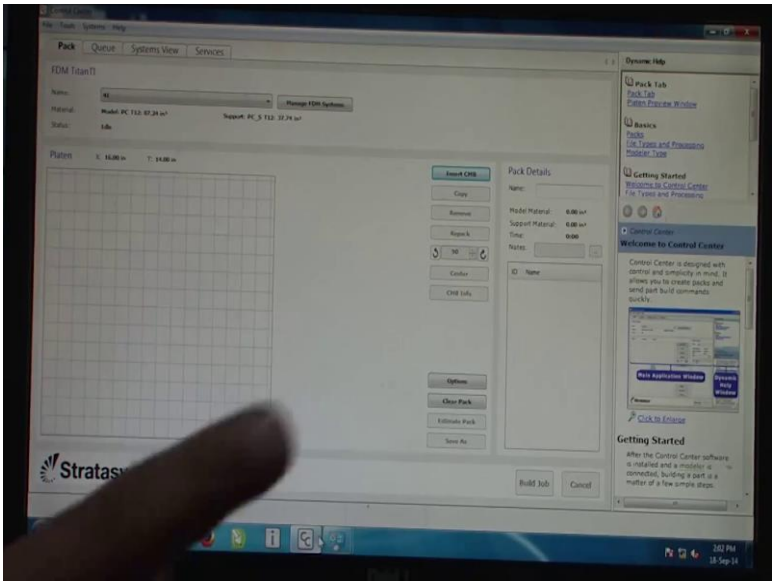

So, that you can whatever you do in this CC, the Control Centre here, would automatically we operated online or it may be send online to the FDN Titan.

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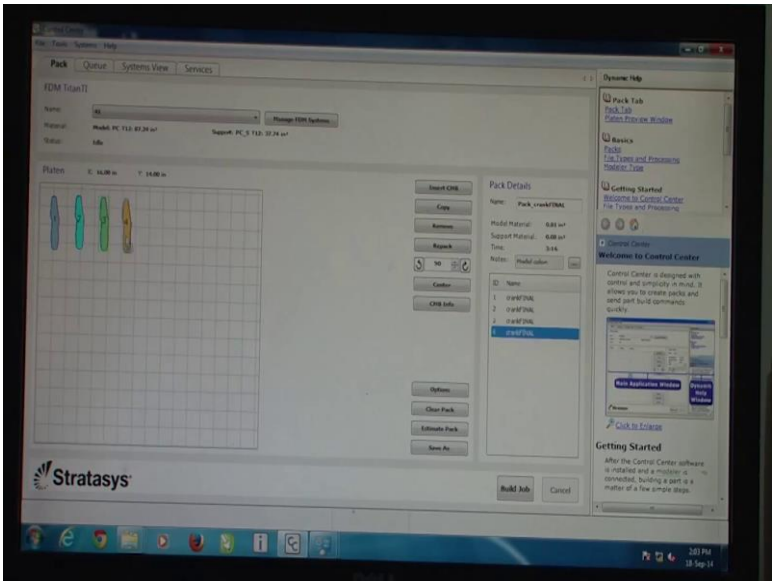

Once we do or once we through all this process, will again go back to the machine. And see how this job, which now what get on the machine server or the machine controller

would be able to do the printing, the 3D printing in the machine itself. So, here again the system is very easy. We just insert the particular c m b file by opening the crank final, which had been I have done before. So, this is selecting this particular file.

So, when we open it now we can see, the crank final file has been is placed exactly at the center stage, have been FDN Titan. So, you may the side to make several versions of this copy or put different parts together or layout, you know in a condition manner. So, that you know, you have the whole area being exploited. Remember, every time the tool has to deposit. It has to go back to zero position or home position. So, it in a better idea to do parallel processing, by parallely printing many parts together.

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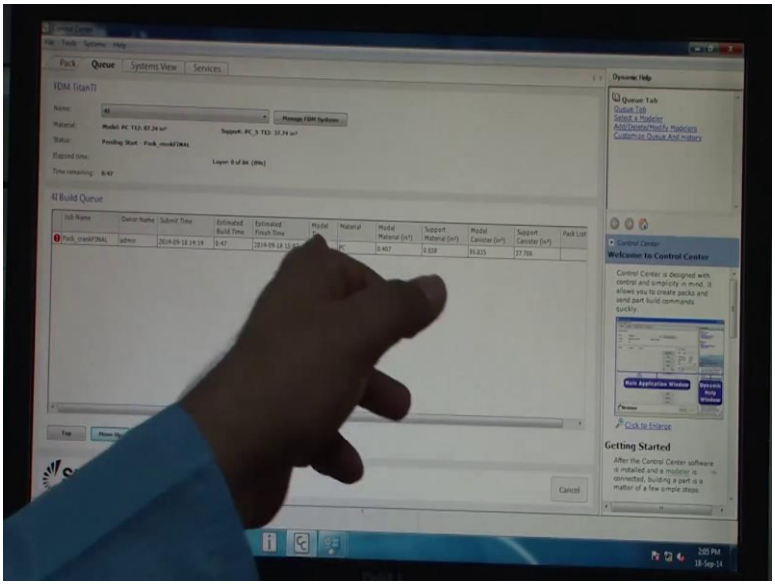

And so, here the idea is to be able to sort of. Take this, you know feature and make something there you can have multiple of these features together. So, we can actually make a copy of the same. So, we can make a copy. And we can say that, we want three copies. Initially the same thing would be copied like this. And then, you can place it one by one. You know, if you want to do that way. So, that you have many of such items.

You do have multiple items in general. I mean all the parts may be, different parts also. You can place like this and make it arrange. So, the purpose of this control center really

is to make minimalistic effort of the part of the dispensing unit, there within the FDN Titan. So, that maximum printing can be done, in this stage all together. So, it makes it from a serial to parallel processes essentially. So, once this is done I would just like to sort of remove.

You know, some of the things that I had just made. I just want to print only one, for the sake of clarity. And you can actually rotated inverted. You can actually, you know select this particular part here. And you can rotate to any particular direction. I would just like to prefer the orthogonal direction here and I interested in the printing. So, that the tool path is save, for quite some time, every time the position back to that.

So, once this is done I think I would just like to built the job. And there is a built job menu, which is here. So, the moment I click it, the job is now almost ready. And you can see probably that, the job is in the cube already. So, you can see that there is the pack slash crank final admin, which is the actually been started at 15 02 hours on. Today's date, there is 18 9 2014.

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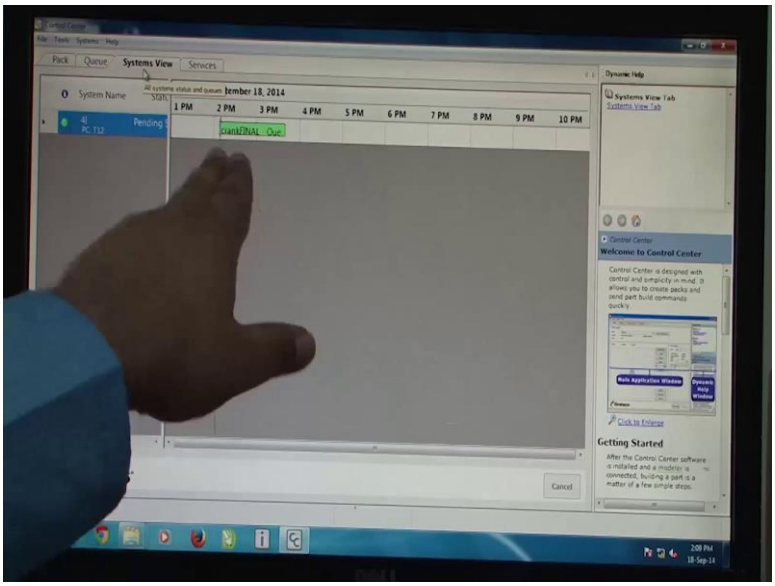

And the estimated built time is given you to be about 47 minutes. Also, what is important for us to look is that, what is the machine loading at this time. So, you already saw the

material confainment. I am going to illustrate this again. That there are, this material canisters which is the initial raw materials those wires, which you have to feeding. So, there is actually the calculation done by the machine itself, which talks about how much amount of material is left here, which is about 86 inches cube, in the model canister.

And the support canisters are the material about 37 inches cube. And the amount of model and the support materials which are needed are also mentioned here, as 0.407 inches to and 0.038 cube. So, typically you have to understand that these two, which are needed, should be over than the material, which is available. So, once this condition is met I think, we are all set to do the machining operation which we will see in the next illustration.

So, here now you know you can also in the software, up to looking at the cube you can look at the systems view, which gives an idea of the time. You know, this going to take about 47 minutes. So, at the position here really show the stop time, looks about 2 10 right now, in the day. So, you can actually guide this. So, it is going to start at 2 10 and completed about, towards to some ware beyond 3. You know something like that.

Now, because there is going to be a heating time, there is going to be a cooling time, the actual printing time is about 47 minute, whether it is going to be a free processing time, which is needed for the controller to be certain. So, that the total time duration that the whole job would taken is near about 4 to 340. So, it is an hour from which the job would be finished. All the details can be describe on this particular systems, has very helpful for the user. So, that you can actually process and plan, how much time you know the machine will operate and when it needs to be done. So, once this is done I think, I would just simply close this particular software.

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And we are now, machine able to go to the work station. So, basically now you know I just like demonster, what happens? The controller of the machine. The sliced part has already come. And it has been cube online to this machine here. If I would just look into the controller, this screen write here says build job. So, there is an option called built job, down here a sort of keys were there are different controls, which are available.

If you want escape from a certain command, you just press this escape button. If you want to go into the command, we just press the enter button. And then, you can actually go up and down with these cursor arrows. And then, needful would be done in terms of parameter setting later on. So, we just enter the build job menu.

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So, once we do that, we can see that we are talking about build next job. And then, they are saying crank final. So, this is the job which has been queued to the machine. I am going to build this job now. And the movement I press the menu key here, you will see that first, the stage would go all the way to the initial position.

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And also there would be a setting of the dispenser nozzle to one corner, which is the home position for the nozzle, from where the printing would start to take place. ((Refer Time: 40:58)). So, I would need to just do this built next job is e crank final.

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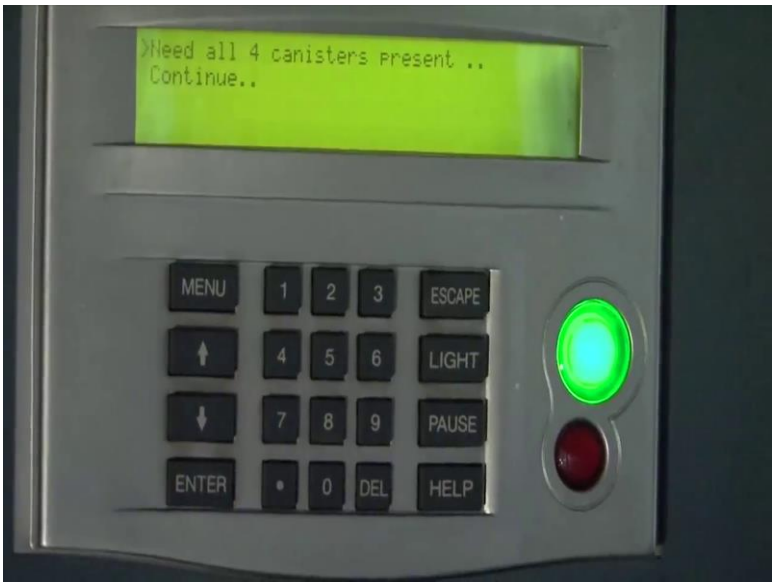

The moment I enter it, now you now they are need all four canisters present. So, I you know the job can be done by two canisters. Because, as you saw that the PC support material as well as the normal PC, which was there was having volume voice much larger volume in comparison the need, which was there develop this particular job. So, I just go to the continue option here and this by pass this ((Refer Time: 41:25)).

So, now you can see that inside the machine cabinet, you have the water positioning of the dispenser tip. And then, slowly the stage is coming up all the way to the point, when the initial dispensing will start. One thing, which is very clear here is that, the tip is gone to its home position. And we had also defined our job in that particular pocket only. So, that there is not much motion of the dispenser to be made, with respect to the state. So, once it is all setup, there is a option here which says demo bounding box.

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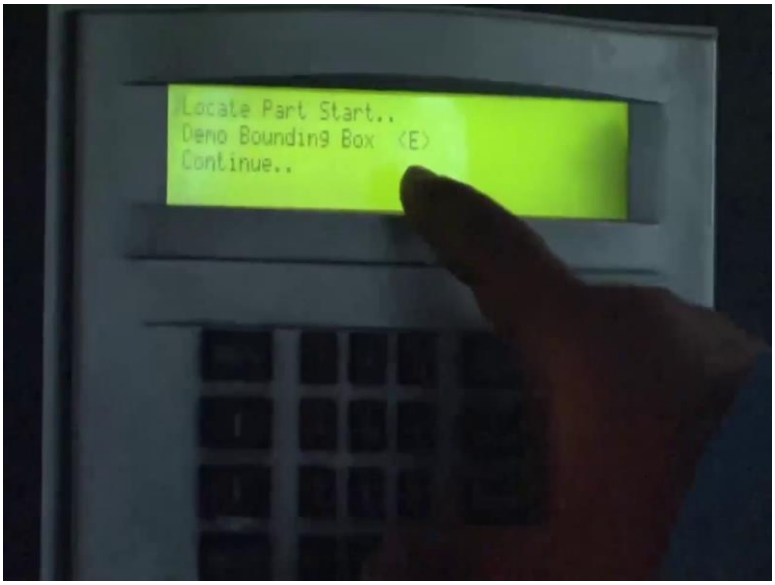

So, if you go back to this particular controller here, you see there is an option which says demo bounding box. All it means is that, when I am going to press this demo bounding box, ((Refer Time: 42:06)) It will show the domain within which the printing has to be done on the surface of the 3D printer. So, I am going to just select this particular operation here, do the enter... And you can see that there is domain tool path has gone inside.

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So, the domain which the tool path has gone inside the movement I enter, demo on the.. You can see that there is a square domain which the tool the dispenser is going. This is the kind of domain, where the work piece printing work should be actually done. So, now I just continue it. So, go to the next option and continuing and enter it. And now, the whole auto calibration activity in the machine would be in automatic mode. And the whole printing would start happening, were there would be a dispensing and writing of the particular shape on a slice by slice, on the miler transference film.