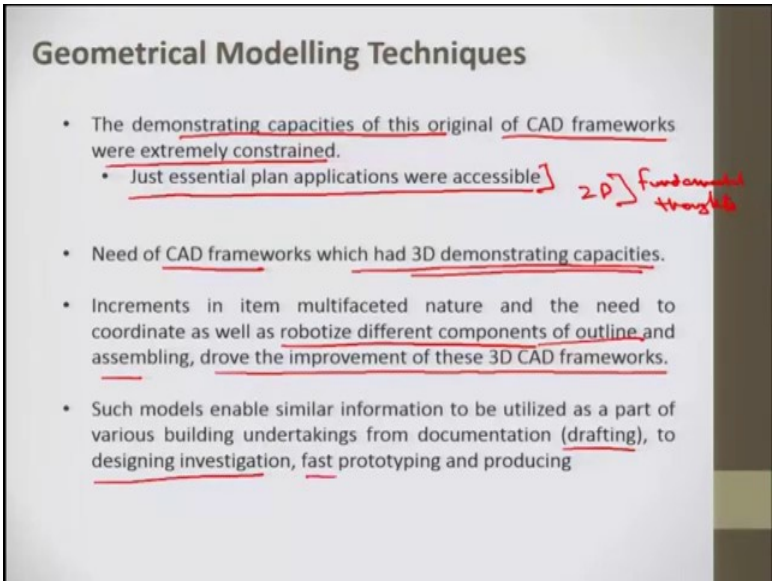
Prof. J. Ramkumar
Dr. Amandeep Singh Oberoi
Department of Mechanical & Design Program
Department of Industrial and Production Engineering
Indian Institute of Technology, Kanpur
National Institute of Technology, Jalandhar

Lecture - 25
Rapid Prototyping Modelling

So, let us continue our previous lecture here, next I will like to discuss here is Geometrical Modeling Techniques.

(Refer Slide Time: 00:22)

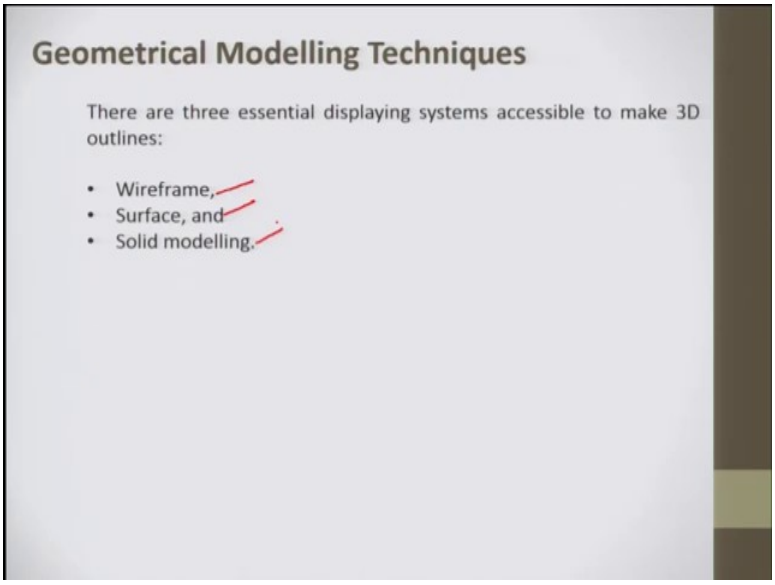


So, the demonstrating capacities of the original CAD frameworks were extremely constrained that is the 2D applications they had limited use only. So, just essential plan applications were accessible here and these applications were a long way from being fit for dealing with genuine mechanical plan issue. So, mechanical final mechanical plans could not be made out of these.

Need of CAD frameworks which had 3D demonstration capacities was there. So, the fundamental thoughts actualized in these frameworks in 2D frameworks the fundamental thoughts here, they were enhanced and used in the present age of 3D demonstrating capacities. So, increments in the item multifaceted nature and the need to coordinate as well robotize different components of outline and assembling, drove the improvement of

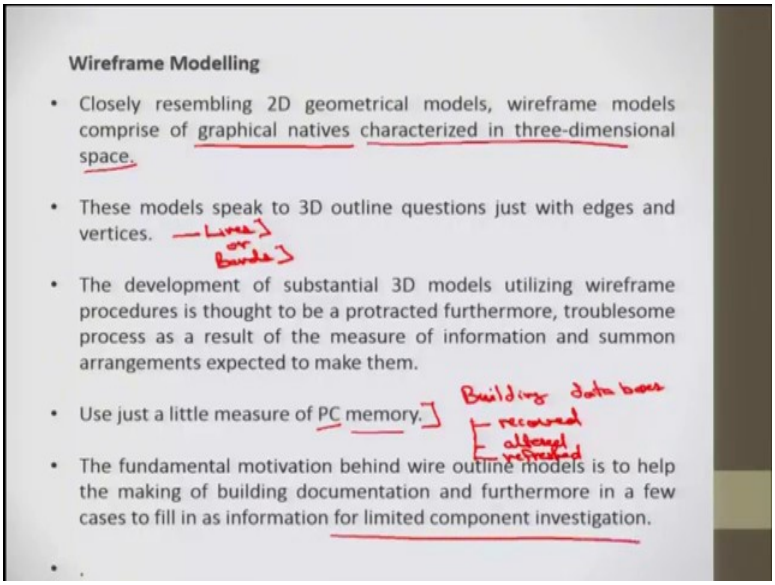
these CAD frameworks; So, such models enables similar information to be utilized as a part of various building undertakings from documentations that is drafting to designing investigation and fast prototyping and then production.

(Refer Slide Time: 01:49)



So, there are 3 kinds major kinds of models wireframe model, surface model and solid models.

(Refer Slide Time: 01:59)



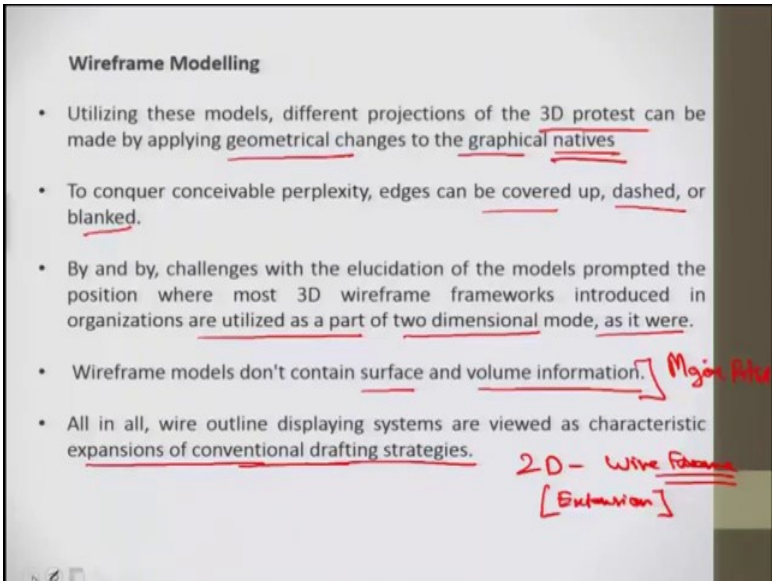
So, what are wireframe models? Closely resembling to the 2D modeling 2D geometrical models, the wireframe models comprise of graphical natives characterized in 3D

dimensional space. The wireframe is the frame that is for example, this pen is there the frame of this pen would look like made of wires so, this is wire frame modelling.

So, these models speak to 3D outlined questions with just edges and vertices. The edges can be lines or bands. The development of substantial 3D model utilizing wireframe procedure is thought to be as a protracted, furthermore, troublesome processes as a result of the measure of information and summon arrangements expected to make them. Just a little measure of process computer memory is utilized here, this helps in building databases because wireframe models utilize very less memory. So, the information here stored in a PC memory. So, this information can be recovered, altered and may be refreshed.

So, the fundamental motivation behind the wire outline model is to help the making of building documentation and furthermore in a few cases to fill in as information for limited component investigation.

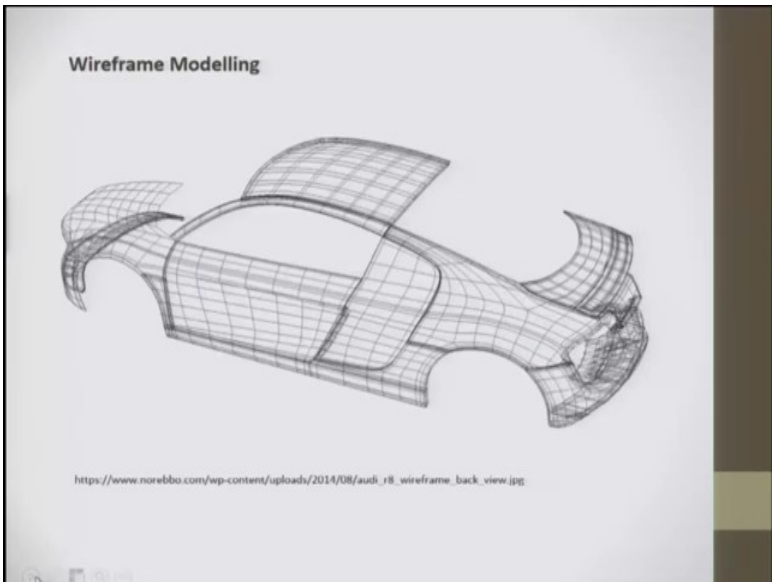
(Refer Slide Time: 03:35)



So, utilizing these models different projections of 3D protest can be made by applying geometrical changes to the graphical natives, which were previously there. To conquer the conceivable perplexity, edges can be covered up, dashed, or blanked. By and by, a challenges with the elucidation of the models prompted the position where most 3D wireframe frameworks introduced in the organization are utilized as a part of 2 dimensional modes, as it were before.

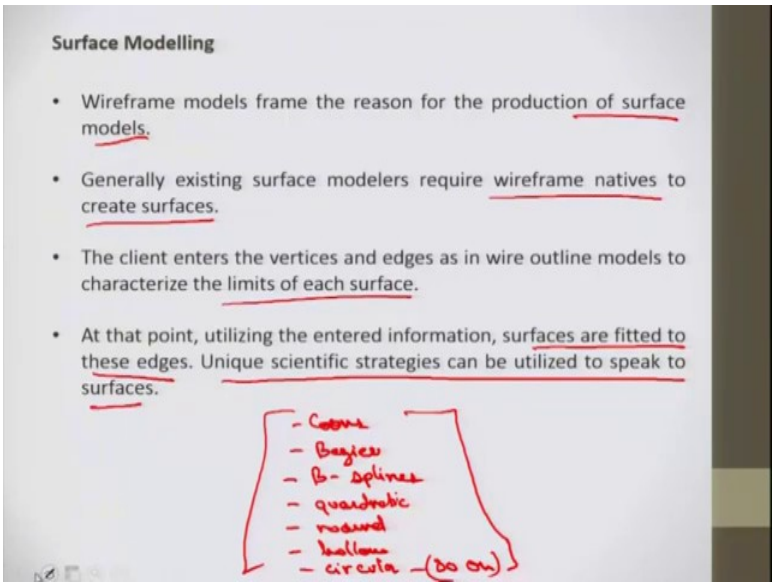
The wireframe models do not contain surface and volume information. So, this is a major pitfall here. All in all, wire outline displaying systems are viewed as characteristics expansion of conventional drafting strategies only, that is from 2D to wireframe. This is just an extension and no extensive information is available in wireframe models that can be used directly in our computer aided manufacturing. So, this is a kind of a wireframe model of a car body.

(Refer Slide Time: 04:50)



So, this looks like surface of the or the outer body of the car is made up of wires. So, these models these days we can use is when you use any software like solid works Katya NX or any like surface modeling software also so, these wireframe models are made by itself.

(Refer Slide Time: 05:14)



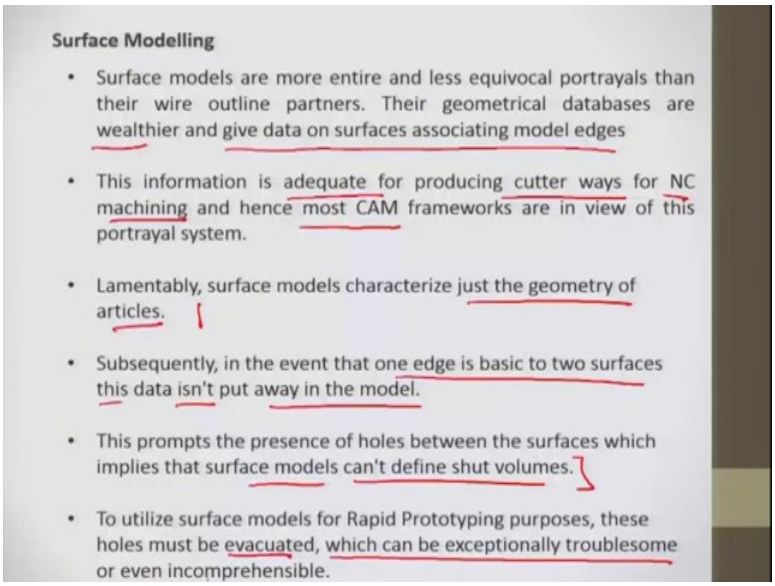
So, next is Surface Modeling, wireframe models frame the reason for the production of surface models, because in wireframe models these wireframes are there, but we do not have information in between what is there in this surface so, surface models were required.

So, generally existing surface modulus required wireframe natives to create surfaces so, these wire frame natives were required to create the surface. The client enters the vertices and edges in wire outline models to characterize the limits of each surface. So, this wireframe models are nothing, but the limit of my surface the upper limit, lower limit here and these are the limits here. So, here we would have the surface. So, maybe if I say the limit of the of the body also, the wireframe are providing this thing.

So, at this point, utilizing the entered information, surfaces are fitted to these edges. Unique scientific strategies can be utilized to speak to surfaces, for instance freestyle surfaces can be spoken to utilizing one of the accompanying geometrical portrayal systems. The surface which are just freestyle here the non-geometrical curves can be used for example, non geometrical curves are coons, Bezier curves, then B-splines curves, then quadratic, round, hollow, may be circular and so, on.

So, this free style surfaces can be broken into these known curves.

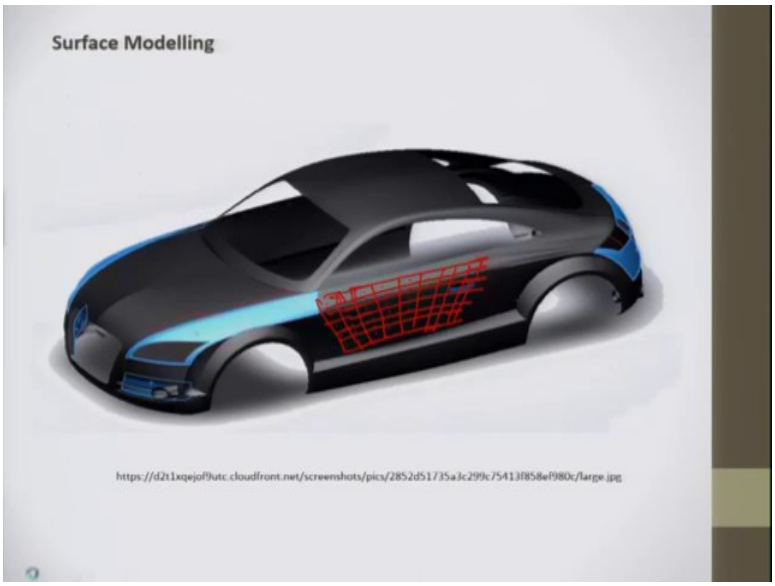
(Refer Slide Time: 07:23)



Surface models are more entire and less equivocal portrays than their wires outline partners. Their geometrical databases are wealthier and give data on surface associating model edges. This information is adequate for producing cutter ways for NC machining and hence most of the computer aided manufacturing frameworks are in view of this portrayal system. Lamentably, surface models characterize just the geometry articles, not much details. Subsequently, in the event of that one edges basic to 2 surfaces this data is not put away in the model, if one edges just an intersection of surfaces here.

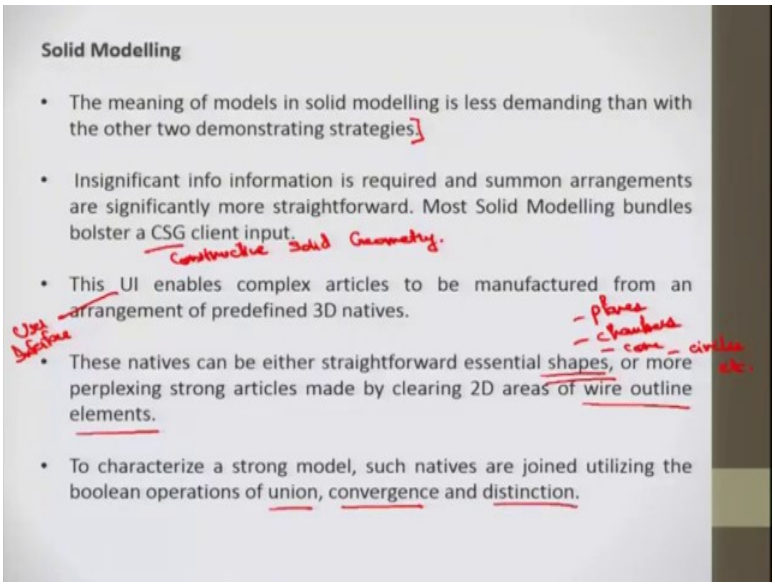
This prompts that the presence of the holes between the surfaces which implies that the surface models can not define shut volumes so, this is a drawback here. To utilize surface models for Rapid Prototyping purposes, these holes must be evacuated, which can be exceptionally troublesome or even incomprehensible.

(Refer Slide Time: 08:36)



This is an example of a surface model of a car. So, the wireframe model is then the surfaces are filled this was a wireframe model. So, these surfaces are filled so, each of the element here is filled here.

(Refer Slide Time: 09:04)

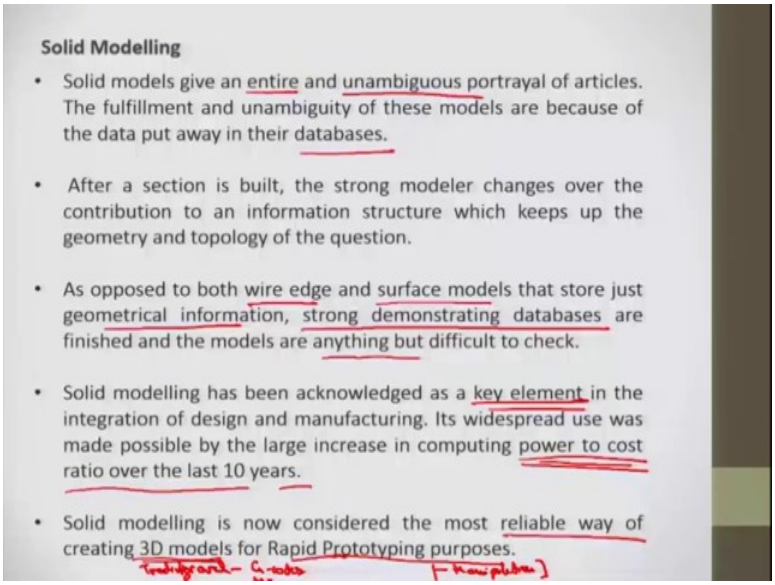


Next comes the final thing the most significant thing in solid in a Rapid Prototyping that is Solid Modeling. The meaning of models in solid modeling is less demanding than with other to demonstrating strategies. Insignificant information is required and summon arrangements are significantly more straightforward. Most solid modeling bundles

bolster a CSG client input, CSG is Constructive Solid Geometry. The user interface here usual is written in user interface enables the complex articles to be manufactured from an arrangement of predefined 3D natives. These natives can be either straightforward essential shapes, or more perplexing strong articles made by clearing 2D areas 2D areas of wire outlying elements.

So, these essential shapes what can be this shapes? This can be planes, or a chambers, then cones, circles etcetera a. To characterize a strong model, such natives are joined utilizing the Boolean operations of union, convergence and distinction.

(Refer Slide Time: 10:49)

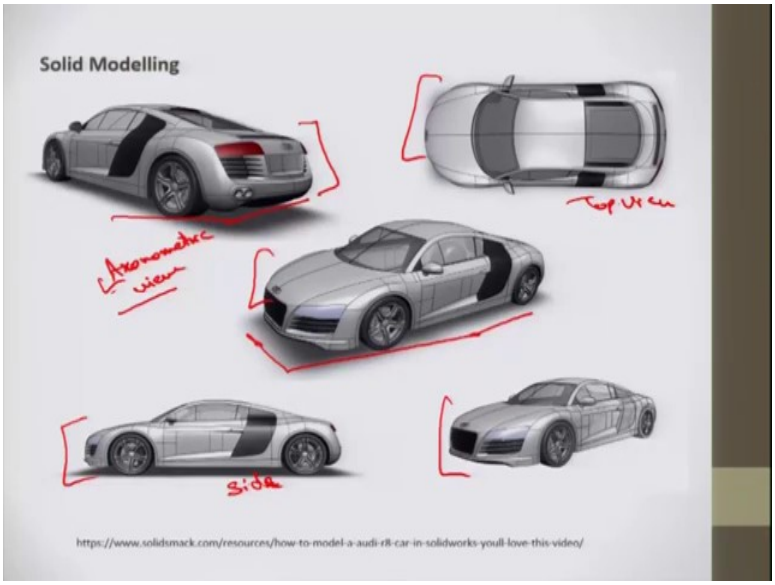


So, solid model gives an entire and unambiguous portrayal of articles, the fulfillment and unambiguity of these models are because of the data put away in their databases. After a section is built, the strong modular changes over the contribution to an information structure which keeps up the geometry and topology of the equation. As opposed to both wire edge and surface models that store just geometrical information, strong demonstrating databases are finished and the models are anything but difficult to check.

Solid modeling has been acknowledged as a key element in the integration of design and manufacturing. It is widespread use was made possible by the large increase in computing power to cost ratio over last 10 years. So, this was one of the consideration, what is the power? That is the power to cost ratio here. So, a solid modeling is now considered the most reliable way of creating 3D models for Rapid Prototyping, in case of

Rapid Prototyping these Rapid Prototyping machines just manipulate the data the 3D models that are generated. This is a kind of a solid models.

(Refer Slide Time: 12:05)



So, this is a model solid model for a car. So, this is side view, this is top view and other are the axonometric views. Axonometric views here, axonometric views maybe this looks like a diametric view, isometric view so, this is a kind of a solid model. The machines which are used to manufacture these 3D models manipulate the data before manufacturing so, as they can use that.

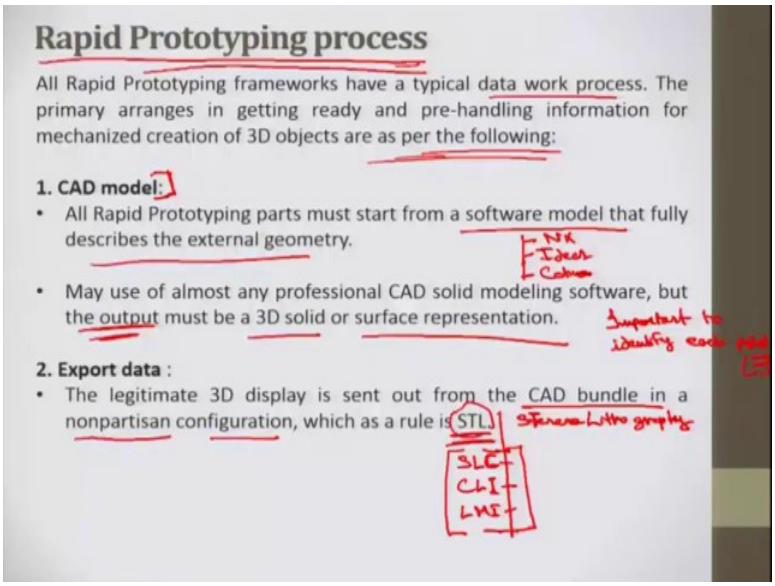
So, 3D models even in traditional manufacturing these 3D models are converted to in traditional these are converted to the G course traditional, it is G codes, G and M codes that is in CNC manufacturing and Rapid Prototyping it is data manipulation.

(Refer Slide Time: 13:20)

So, if I talk about this car, could this body outer body be made in one go? A could a single print made this? If I say yes it can be done by certain process lies the laser sintering process might do this thing. But if I talk about the wheels, these are different components, this is a different component and these different parts can be made separately and then assembled. If you just need to have the surface look, the shape look, the shape feel, then this can be manufactured in a single go.

But if we need to see the how different parts would assembled? A how would what would be the intrication? What were the implication in assembling the parts? Then different parts different components are manufactured using Rapid Prototyping techniques and they are then assembled together.

(Refer Slide Time: 14:20)



And next is the general process for Rapid Prototyping. So, all Rapid Prototyping frameworks have a typical data work process. The primary arranges in getting ready and pre-handling information for mechanized creation of 3D objects as per the following steps. So, first is having a CAD model.

So, all Rapid Prototyping parts must start from a software model that fully describes the entire geometry, the software can be any CAD software, any CAD software I would say this can be NX ideas (Refer Time: 15:02) solid works and so, on. And may use almost any of the professional solid modeling software, but the output must be a 3D solid or surface representation here.

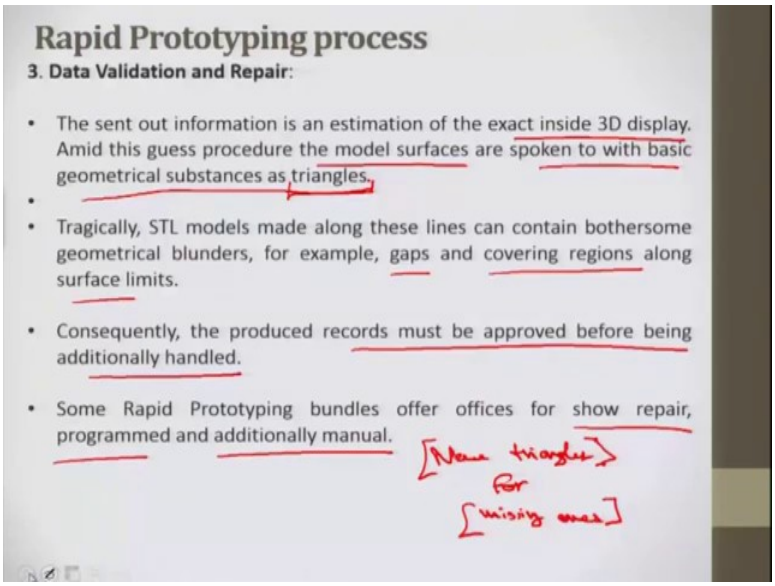
A good 3D CAD that is computer aided design identify each point in the 3D space whether it lies inside or outside the protest surface. That is important to in the output in the output it is important to identify each point, it where it lies? Inside or outside the portal surface whether; it has to be a like a kind of a negative surface or positive surface.

So, Export data is the next step once that CAD model is ready then the data is exported. The exporting data is converting the data into STL format, STL is Stereo Lithography format. So, this is the general format Stereo Lithography which is the accepted the most of the CAD bundles except this one. So, this legitimate 3D display is sent out from the CAD bundle in a nonpartisan configuration, which is as rule in general rule STL format. Some CAD bundles permit the size of the produce record to be controlled by expanding

or lessening the model determination, the size can be controlled; other formats can also be this STL is Stereo Lithography.

So, there are other formats like SLC, CLI and LMI, for instance this CLI is a common layer interface, LMI is layer manufacturing interface. So, it can be stored in these format cells also depending upon the requirement of the machines, but most of the machines these days support STL format.

(Refer Slide Time: 17:39)



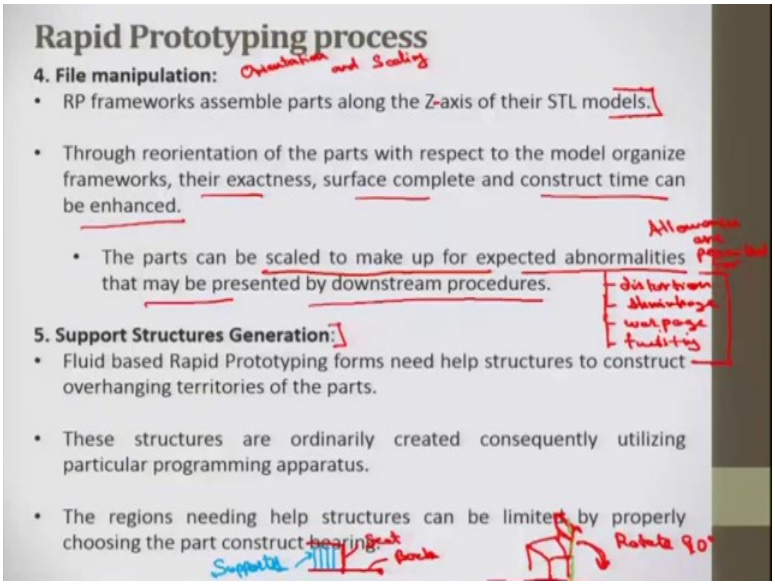
So, next step is data validation and repair, the sent out information is an estimation of the exact inside 3D display, that is we need to produce. Amid this guess procedure of the model surfaces are spoken to with basic geometrical substances as triangles. So, these all data points are brought to be made up of triangles here.

Tragically, STL models made along these lines can contain bothersome geometrical blunders sometime, for example, gaps and covering range along surface limits. So, consequently, the produced records must be approved before being additionally handle. Some Rapid Prototyping bundles offer offices for show repair, programmed and additionally manual.

These bundles incorporate programming apparatuses that assesses the STL models and decide if any triangles are absent, if there should arise an occurrence of blunders the holes in a models are loaded with new triangles here, new triangles for missing ones

sometimes. We will try to take an example in the fore coming sections to see how practically these things are done. So, then is once the data validation of repair is here.

(Refer Slide Time: 19:13)



Then is file manipulation, here manipulation means orientation and scaling now, Rapid Prototyping frameworks assembles part along the Z axis of their STL model and sometimes to produce the parts, to manufacture the parts the orientation has to be made different. So, as them to say we have to see what is the support that is required, what are the hollow surfaces and what are the positive and negative surfaces.

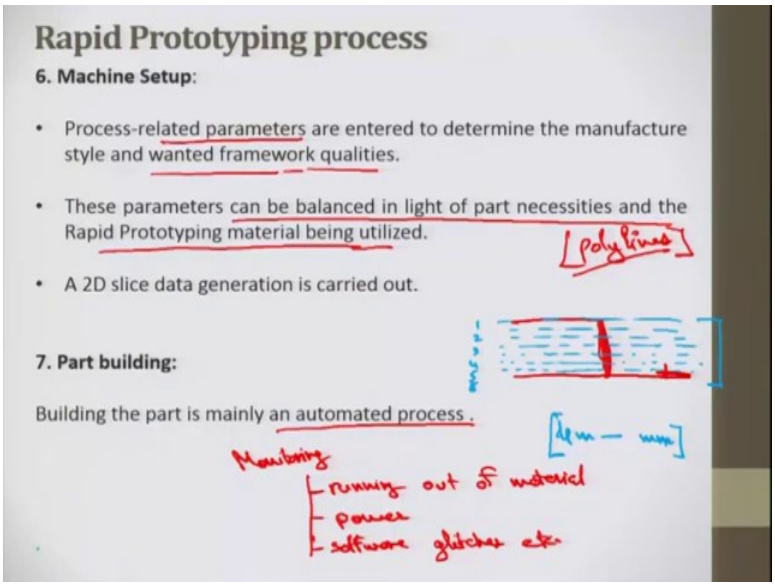
So, according to that orientation best orientation is set so as minimum time is consumed. So, through reorientation of the parts with respect to the model organized frameworks, their exactness, surface complete and construct time can be enhanced. These parts can be scaled also to make up for expected abnormalities that may be presented by downstream procedures. Some abnormalities might occur for example, distortion is there, then shrinkage, then war page, then twisting. So, this data is scaled or I would even say here or I could say here is that alliances are kept alliances are permitted for these abnormalities or so, that these defects do not comes into play.

A few Rapid Prototyping frameworks enable a few sections to be settled in the framework chamber so, as to be manufacture as the same time. Then next step is supports structures generation so, if I need to manufacture for example, if I need to manufacture a chair using the prototyping technique, we need to have this supports

structure. One thing is first thing is orientation, could we or should we manufacture the chair with this orientation only? Or could we rotate it rotate 90 degrees? Or keep use this part that is the back part as our base and then manufacture, and even if you manufacturing with this part we will have require support for example, it is I would like I would put here side view, this is my chair, this is my leg, this is my back.

When I have rotated this one rotated this one and put it here, this is the chair and this is my so, this is my seat, this is my back. So, even if I manufacture it in this way so, we would need supports here. So, when we will go through the types of manufacturing processes we will see that there are two kinds of materials that are in certain liquid processes one is build material, second is the support material. Build material is one that is that can bear load that will stay there, support material is done one that would be then removed after the final product is there.

(Refer Slide Time: 23:21)



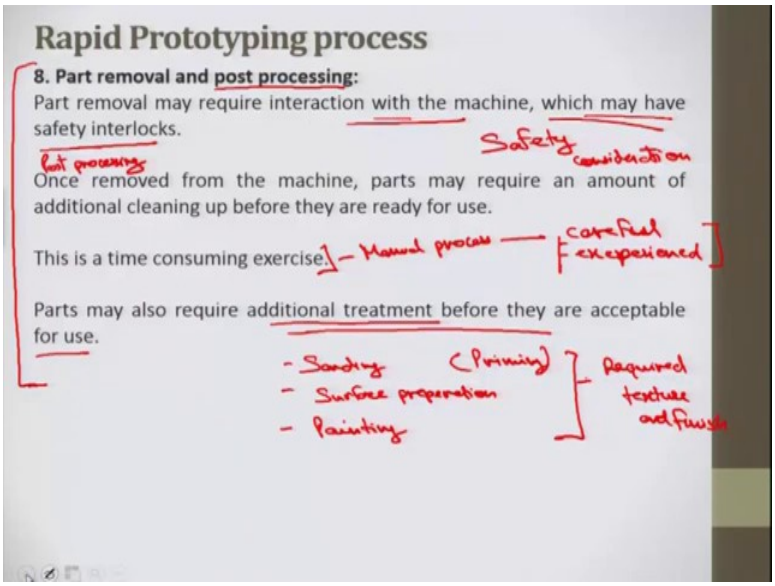
So, the product is produced in a cuboid and the non required unwanted supports are then removed. Then is machine setup, process related parameters are entered to determine the manufacture style and wanted framework qualities, the certain parameters for each process we will discuss those. These parameters can be balanced in light of part necessities and Rapid Prototyping material that is being utilized. So, a 2D slice data generation is carried out, 2D slice means because Rapid Prototyping is layer if I talk

about this chair manufacturing only this face this was my chair, this is my seat. So, these are 2D slice data is generated to have different slices of my 3D model.

So, I can say I have divided into 1, 2, 3, 4, 5 and 6 layers; however, the size of the layer starts from a few micrometers to a few millimeters only. So, the STL document here is cut to create progressive cross-sectional layer. In each cross-segment poly lines are utilized, poly lines are utilized to in exact the outside and inside limits of the Rapid Prototyping models. These poly lines limits can be balanced by a specific incentive to adjust for process mistakes. The cut information can be created, disconnected for the whole model or online one cross section area at one amid part fabricating.

Then comes the part building, building of the part is mainly an autonomous process here. So, the only thing that is to be done here is monitoring. So, and the machine can carry this process without any supervision, a little monitoring of the machine is required at this time to ensure that no errors have taken place like errors might be running out of material, power off, power off, then maybe software glitches etcetera. Next is part removal and post processing, once the Rapid Prototyping machine has completed the build the parts must be removed.

(Refer Slide Time: 26:31)



Then the part removal may require interaction with machine, which may have safety interlocks. This is to ensure for example, the that the operating temperature is sufficiently

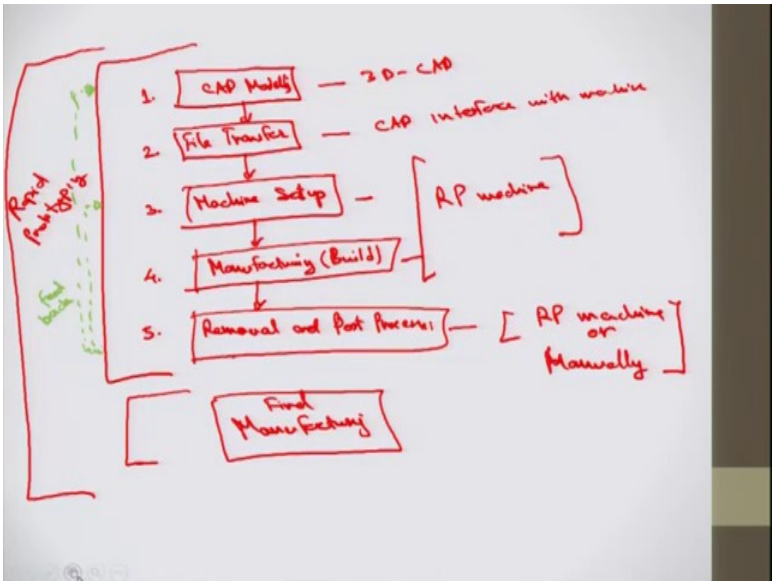
low and there is no actively moving parts, file part removal these things are to be taken into consideration.

So, that is safety concerns are important here. Once removal from the machine the parts may require an amount of additional cleaning up before they are ready for use, this is actually post processing. Parts may be weak at this stage or they may have some supporting features that must be removed. So, removing of supports is kind of a post processing process, this is a time-consuming exercise or this is a manual process mostly. And careful and experience and careful and experienced manipulation has to be carried out here.

Now, parts may also require additional treatment before they are acceptable for use, this is our last step. So, before bringing the part to the final user to the end user, additional treatment might be required, it is generally required here. Now the parts are ready to be used here, but additional treatment for example, they may require some sending, then surface preparation, then maybe painting I could even call this priming. So, this is there to give a to give it a required texture and finish.

So, these treatments are laborious and lengthy if the finishing requirements are very demanding. So, this is our Rapid Prototyping process so, these were 8 steps which we have discussed so, if I tried make a flowchart here.

(Refer Slide Time: 29:25)



I can divide this into 5 major steps. So, first step is CAD modeling here, second step here is export data and third step is data validation repair. I will try to bring these into one, second step is file transfer that is file transfer to the machine.

Then the third step I would put here is machine setup, machine setup, then is manufacturing able manufacturing (Refer Time: 30:17) build the part, then fifth one is removal and post processing. So, this is the flow chart so, in this case this is done by our 3D CAD package, this file transfer is done by our CAD interface with the machine interface. Then machine setup, manufacturing both these things are done by our RP machine only and this is sometimes done by RP machine Rapid Prototyping machine or by a I would say manually.

So, this is a Rapid Prototyping. Further when we do final manufacturing ere and if it is also done with the additive process we can call it additive manufacturing. If it is not additive manufacture process then again it is production here, but the feedback is taken from here only when the prototype is ready here prototype is ready the feedback is taken from the fifth step to the first step. But, sometimes the CAD model is all good and feedback is given to only machine setup only.

So, this is my feedback and this is done before manufacturing. So, this was the general procedure for Rapid Prototyping. So, we will discuss about Rapid Prototyping machines and Rapid Prototyping technologies in the next lecture. And we also see for certain applications of this one also we will try to take you to the Rapid Prototyping lab that is 3D manufacturing lab in or IIT Kanpur mechanical department specifically design department here. So, we will see we will see practically how these things are done so, let us meet in the next lecture.

Thank you.