Product Design and Manufacturing
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Lecture - 26
Rapid Prototyping Processes (Part 1 of 2)

Good morning, welcome back to the course product design and manufacturing we are in the final weeks of this course so, I am taking rapid prototyping in this module. So, till now about rapid prototyping I have discussed that what is rapid prototyping, why it is rapid, what I what is a prototype, how rapid prototyping is related to additive manufacturing, how it is related to concurrent engineering and the various kinds of prototypes prototype shapes. Then we have discussed about a general procedure of rapid prototyping.

Now, I will like to discuss certain processes rapid prototyping processes. So, I am Doctor Amandeep Singh, in this lecture we will discuss rapid prototyping processes.

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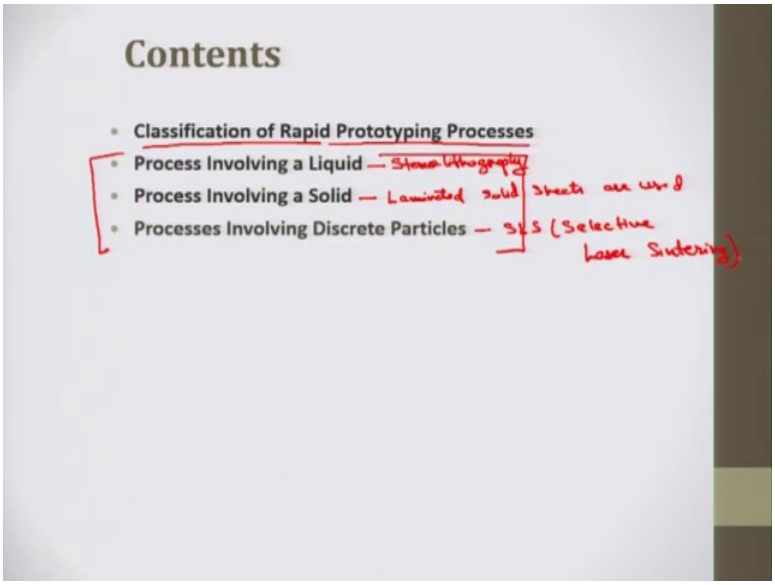

First, I will talk about the classification of rapid prototyping processes then we will discuss various kinds of prototype processes involving a liquid, processes involving a solid and processes involving discrete particles. In liquid the major or the common

process, very a popular process is Stereo Lithography and processes involving solid laminated solid sheets are used here. For processing involving discrete particles one of the very popular process is SLS that is Selective Laser Sintering. Well (Refer Time: 02:10) will not keep our scope of discussion limited to these processes only, we will also try to cover the other processes which are there in market.

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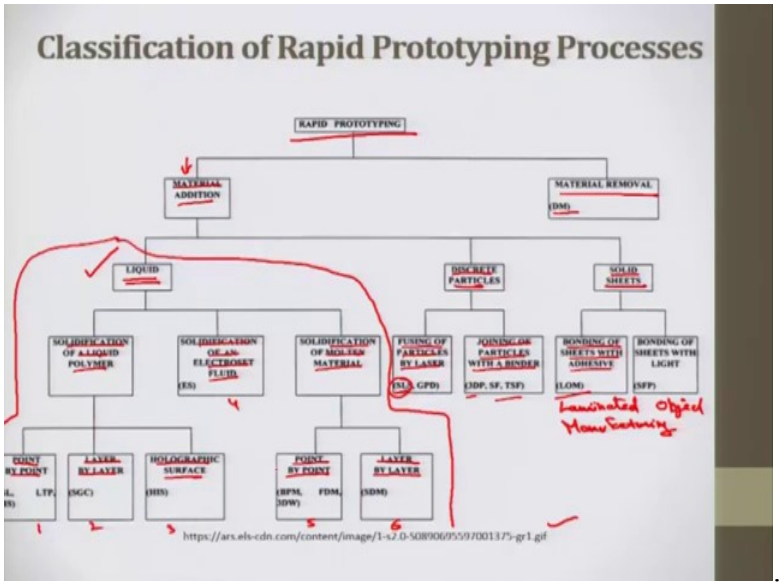

So, I will start with my classification thing, rapid prototyping can be classified into 2 ways first material addition and material removal. Actually these 3 are the materials, I would have to mention liquid, solid and discrete particles are the kinds of materials. So, here liquid discrete particles and solid sheets these 3 kinds of materials are used and we can see the most of the processes which are there use liquid material.

So, this liquid material is mostly the resin that solidifies after a bonding material mixed with it or it solidifies by using UV rays or laser heat so, these are specific liquid material processes here. Then we have processes which I have use discrete particles, in specifically we have fusing of particles by laser, here the most popular process is selective laser sintering. Then also we have in discrete particles joining of particles with a binder, discrete particles are there in a powder form when these are mixed with the binders after some times the materials get solidifies.

So, this is 3D printing and other processes are there. Then we have solid sheets, solid sheets bonding of sheets with adhesive, we have this process LOM that is laminated

object manufacturing. In liquid material, raw material specifically the solidification of a liquid polymer is one classification another way is solidification of an electro set fluid, then solidification of a molten material. Molten material solidifies just when temperature comes down to it is melting point, in solidification of liquid polymer what we do once we heating a material then it is cured means it solidifies, point by point processes are there, layer by layer processes are there, the holographic processes are there.

And this in this also point by point processes are there and layer by layer processes are there. So, what we can see here is that out of these 6 processes 1, 2, 3, 4, 5 and 6 all these 6 processes include the solidification of a sap through electromagnetic radiation. Tree develop the part utilizing point to point or layer by layer, while at the tree harden the whole layers of surface is without the movements delay.

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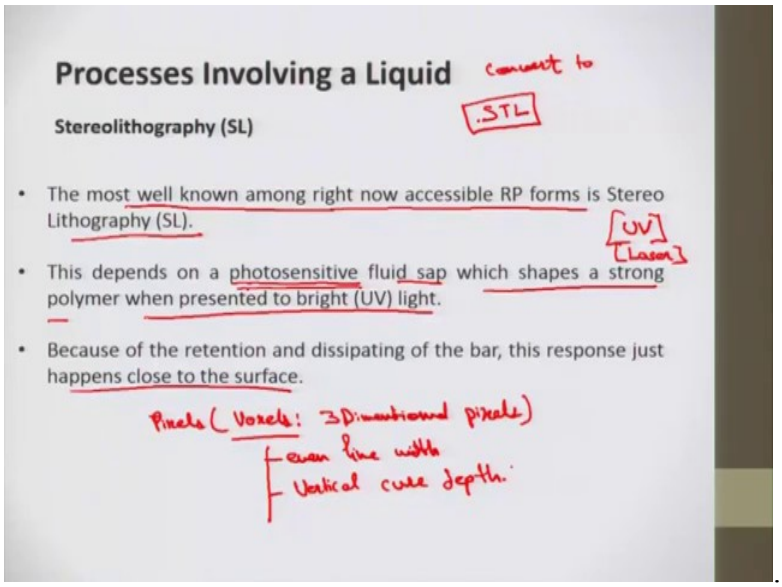

So, the first process I left to discuss here is Stereo Lithography, the most well-known process among the right now accessible rapid prototyping forms is Stereo Lithographic process. So, as we have discussed that STL format even in the rapid prototyping general procedure it is said that convert the file to STL convert to STL, because this is the most popular process.

So, in this process depends upon the photosensitive fluid sap because the fluid is to be cured using some photosensitive way maybe UV light or in this case mostly UV light is used, some other cases laser light can also be used.

So, photosensitive fluid is required which shapes a strong polymer when presented to bright UV light because of the retention and dissipating of the bar this response just happens close to the surface. So, in this case this produce some pixels or better to qualities voxels, voxels are actually 3D pixels 3 dimensional pixels. So, these voxels are described by their even line width and vertical cure even line width and vertical cure depth.

So, we will see how this process works.

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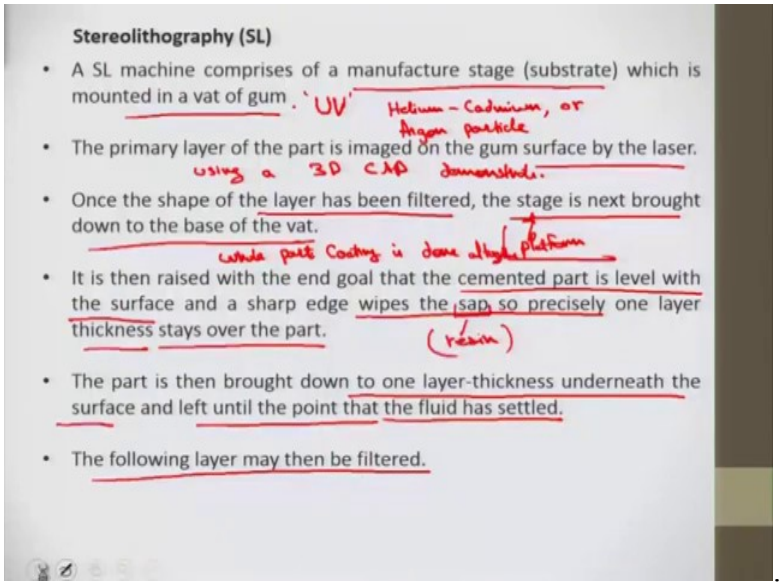

So, it is typical Stereo Lithography machine comprises of a manufacturing stage that is substrate which is mounted on a vat of a gum. The primary layer of the part is imaged on the gum surface by laser. So, so in this a vat of gum is there also a UV source is there mostly helium, cadmium or argon particle laser are used. So, this is imaged on the gum surface the primary layer is imaged on the gum surface by the laser, this is done using a CAD, 3D CAD base using a 3D CAD demonstrate I would say.

Now, once the shape of the layer has been filtered the stage is next brought down to the base of the vat, this stage is actually the platform. Now, this in this case it is to be kept of the mind that the end goal here is to coat the part all together the part is coating I would put here coating is done all together, that is whole part coating. So, it is then raised with the end goal that the cemented part is level with the surface and a sharp edge wipes the sap so precisely that one-layer thickness stay over the part.

So, when I say sap here I specifically mean the resin that is my liquid. The part is then brought down to one-layer thickness underneath the surface and left until the point that the fluid has settled. Now, the following layer then may be filtered.

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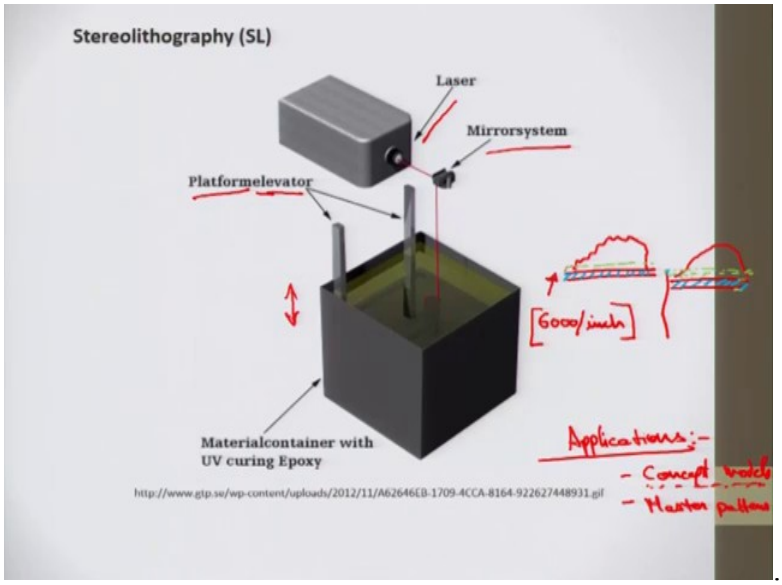

Now, let us see the apparatus here so, this is an apparatus, here we have a laser and the mirror system, the platform elevator is here. Now the mirror system is diverging my laser focusing my laser to the point where it is required and the laser is the source that is that would help to cure the resin and the platform can be elevated or may be brought down.

So, what is happening if I say this is my platform and this is the part that is to be made. So, what happens? First, the platform is at this height and one-layer thickness one-layer thickness is first cured. Now, in the second step the platform is brought down on this is my I will put another color here, this blue color is my platform.

After curing the platform is brought down by one layer now, this much part is ready that is this is this part is cured and another layer of resin is putted. Similarly, this process continue till the whole part is fabricated here. In this case the typical layer thickness is 6000 per inch so, the access resin is removed after each step here excess resin is moved and the part which is solidified here is then coated with another layer of resin here. So, this is how are Stereo Lithographic process works.

So, this has applications in producing the concept models we will take another session regarding the applications of rapid prototyping processes. But, to broadly say the concept models that is to know the shape, size, field of the model these models are generated of the product that is wanted and some master patterns these are major applications. It has a wide range of applications in medical, aerospace, automobile, aviation and multiple other sectors.

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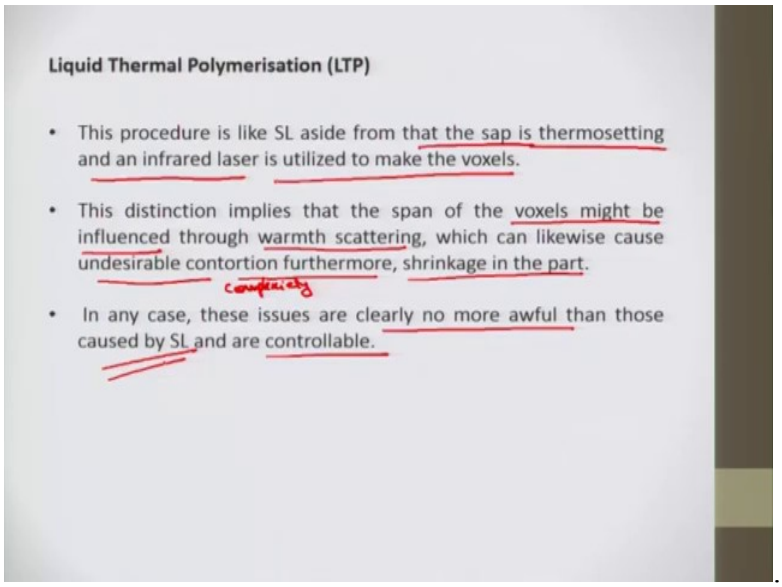

So, next process is Liquid Thermal Polymerization. Now, what is liquid thermal polymerization? This procedure is very much similar to Stereo Lithography aside from that the sap that is the resin is the thermo setting and an infrared laser is utilized to make the voxels here. So, this distinction implies that the span of the voxels might be influenced through warmth scattering because of the laser, which can likewise cause undesirable contortions furthermore shrinkage in the part.

So, these complexities involved here and in any case; however, these issues are not much awful, but much controllable in comparison to those there in Stereo Lithography.

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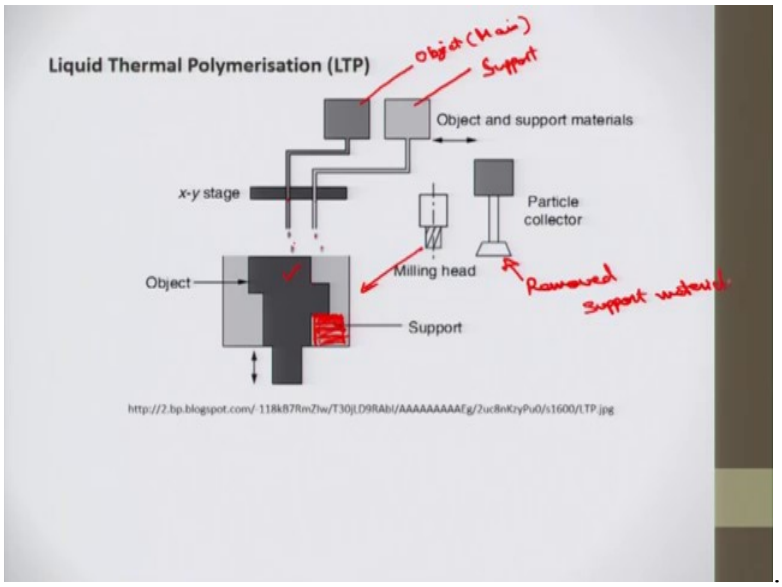

So, this is specific liquid thermal polymerization process, in this liquid droplet us are coming down in and their 2 nozzles here one is are object material object or main material, another is support material. So, what happens once this object is produced using this object material the support material is just to provide the support for example, this part could not be constructed, this height could not be attained unless we have this support here this much support here. After this must support only this object could be put here.

Now, the extra material would be removed using this milling head and the particle collector would collect the removed support material here.

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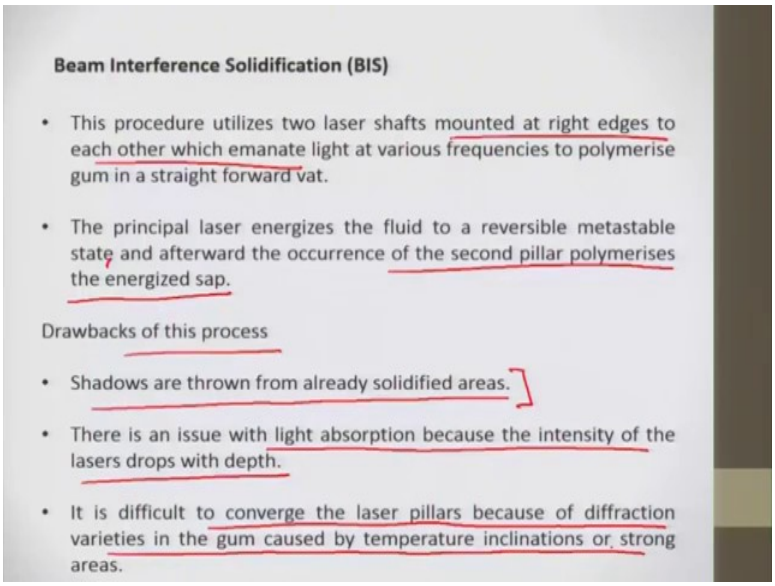

Now, next is Beam Interference Solidifications, this procedure utilizes 2 laser shafts mounted at right edges to each other which emanate light at various frequencies to polymerize gum in a straight forward to vat. The principal laser energizes the fluid to a reversible metastable state and afterward the occurrence of the second pillar polymerizes energized resin here.

The drawbacks of this processor the shadows are thrown from already solidified here is the principle laser has already solidified the resin here. And there is an issue with the light absorption because the intensity of the laser drops with depth. It is also difficult to converge the laser pillars because of diffraction varieties in the gum caused by temperature inclinations or strong areas.

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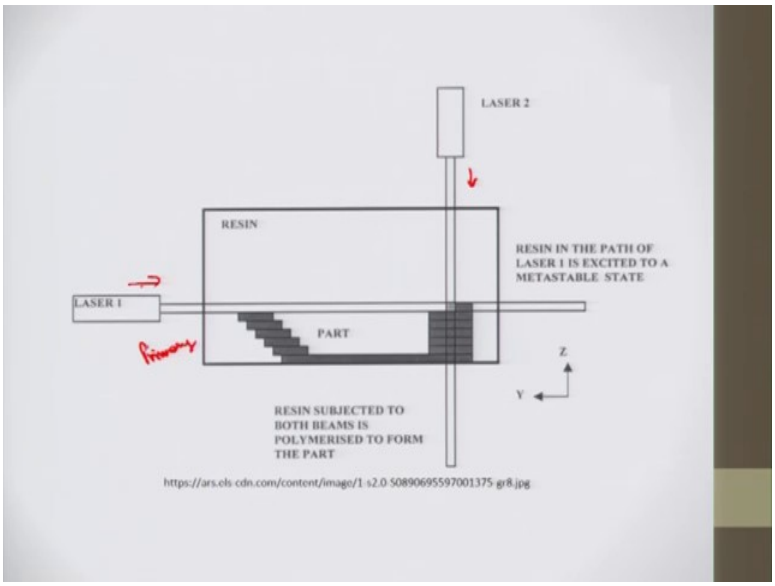

So, this is the kind of our beam interference solidification 2 lasers are at right angles, one is the primary laser another one is the secondary laser.

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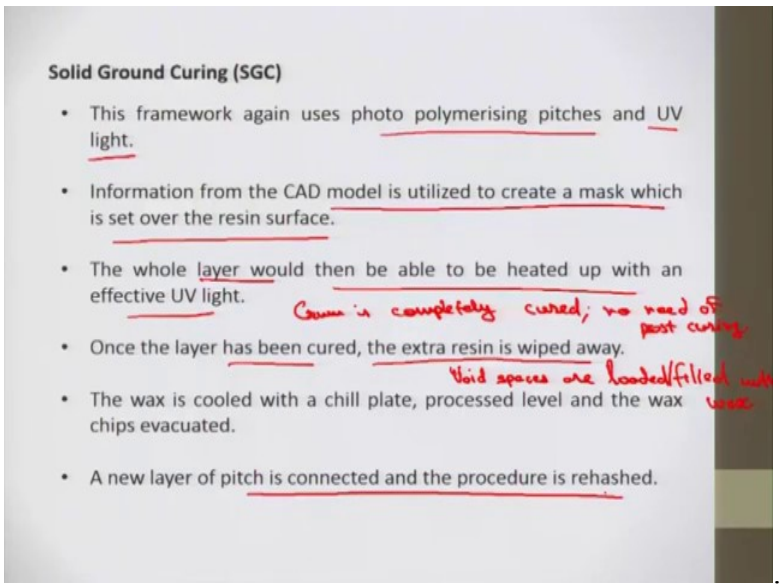

Now, next is Solid Ground Curing, this framework again uses photo polymerizing pitches and ultraviolet light. The information from the CAD model is utilized to create a mask which is set over the resin surface here. So, the whole layer would then be able to be heated up with an effective UV light, once the layer has been cured the extra resin is wiped away. Now, because the whole layer be heated up with the ultraviolet light this

implies that the gum is completely cured and no post curing is required, the gum is completely cured here no need of post curing.

So, the laser when the laser has cured the extra resin is wiped away and any species if there are like wild species here are then coated with or filled with wax are loaded or filled with wax. The wax is cooled with a chill plate processed level using milling and the wax chips are an evacuated. The new layer of pitch is connected or applied and the procedure is rehashed.

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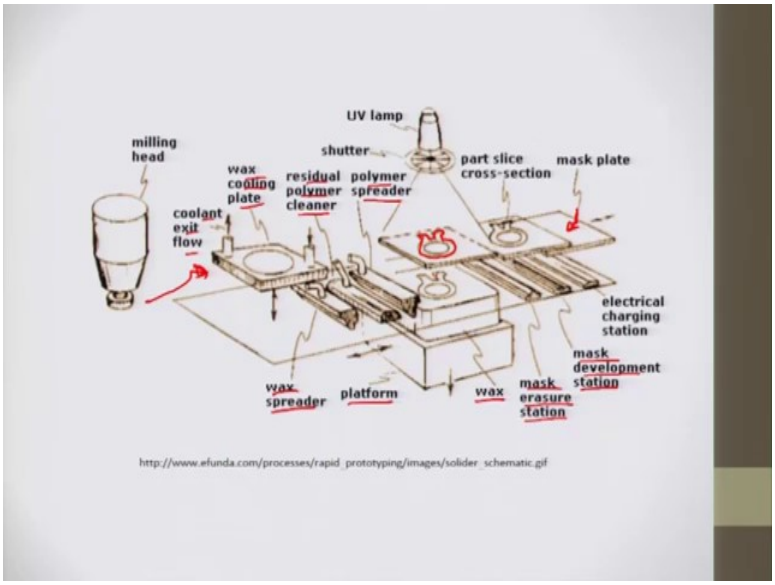

So, in this case specifically what we have a UV lamp and this is a mask, the UV light is passing through this mask and the only this portion from which light could pass through this portion would solidify this only this portion would be cured and other portion would not. Then the part slice cross section it is done another mask is put in for these successive layers.

So, what we have here is UV lamp, the shutter that shuts on and off the UV light, the polymer spreader here which spreads the polymer, the residual polymer cleaner, then wax cooling plate here, the coolant exit flow. And here the milling could also be used to remove the solidified part whichever is unwanted here. Then mask plate is being induced here step by step, then electrical charges station is there, mask development station is there, mask erasure station is there, wax is there, platform wax spreader is there.

So, the basic principle is that the UV light is passing through a mask to produce this specific shape here.

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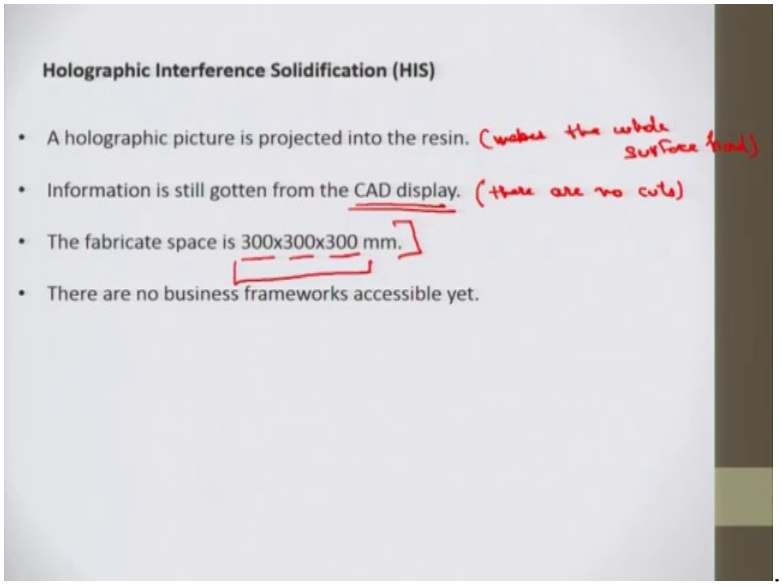

This shape is 2D slices, now next is Holographic Interference Solidification. A holographic picture is projected into the resin in this case, this may make the whole surface hard. In this case also the information is got through the CAD model, the CAD display.

Now, despite the fact that there are no cuts please keep into mind, there are no cuts in this case. The fabricate space is in general this much, but these are the machine properties, sometimes the bigger or smaller machines can also be used, there are no business frameworks accessible yet in this case.

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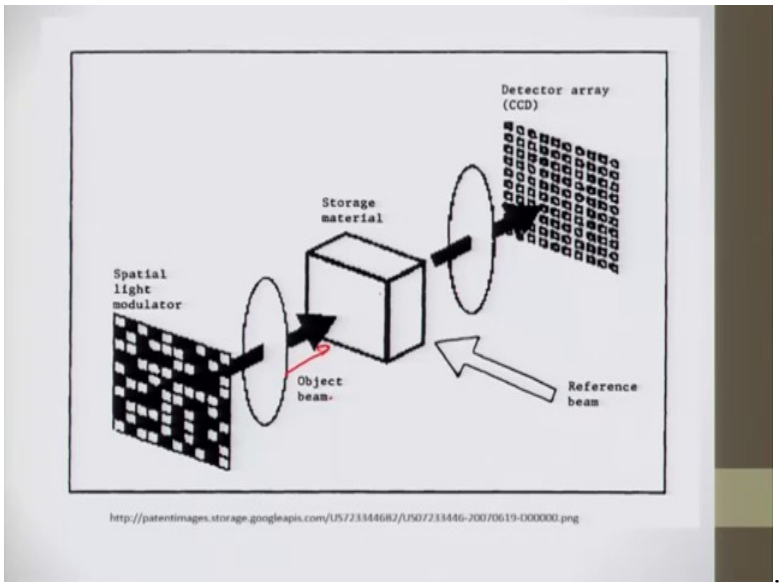

So, this is a specific kind of holographic interference solidification method. The spatial light modulator is there and the light is passed this is the storage material object beam is there, a reference beam is there and detector array is there.

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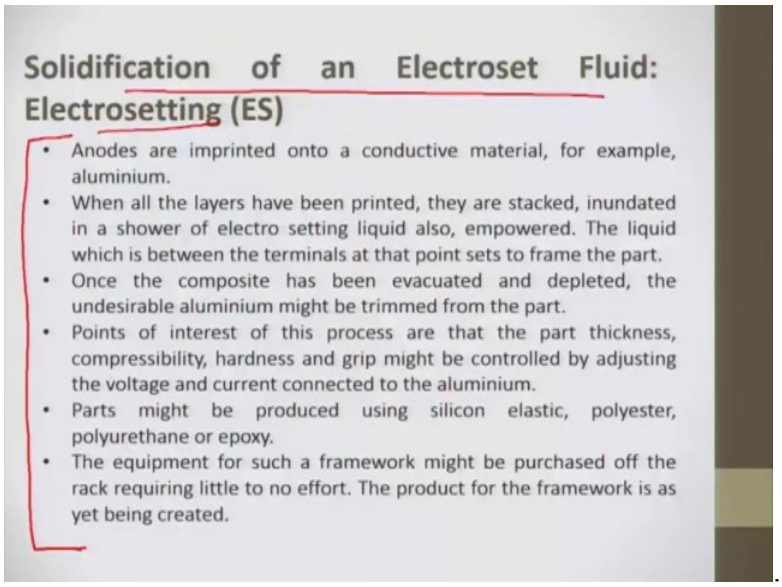

So, there are certain other processes like Solidification of an Electroset Fluid, which is known as Electrosetting. I will not discuss all these processes, but provide you these with these notes, but I would like to discuss a few very popular processes.

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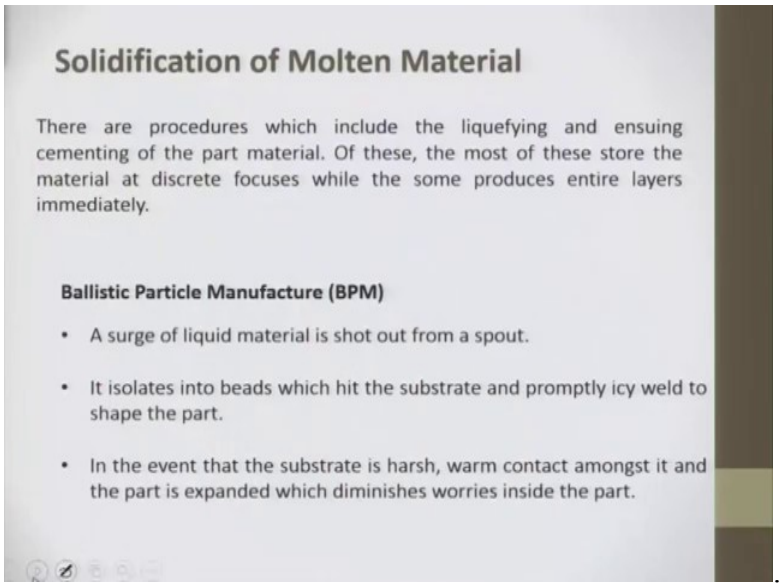

Solidification of molten metal is second qualification here, there are procedures which include the liquefying and ensuring cementing of the part material of these are most of these store the material at discrete focuses, while some produces entire layers immediately.

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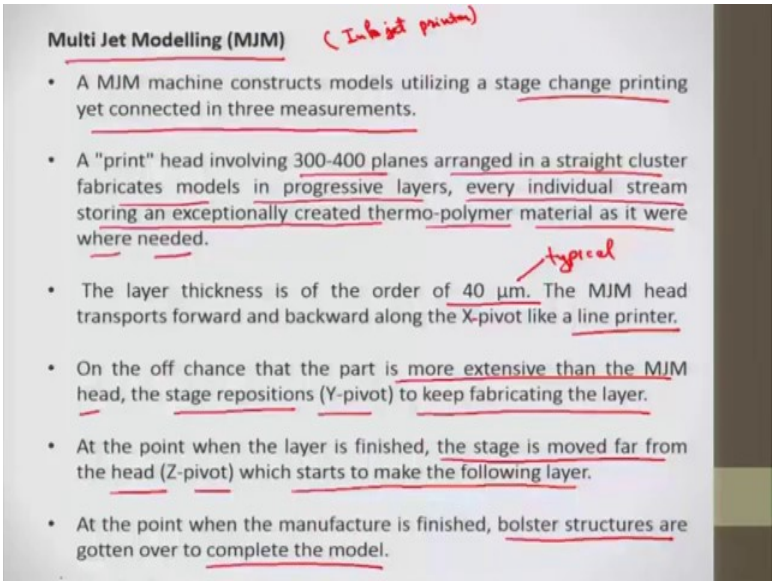

So, they certain techniques for this one ballistic particle manufacture is there, then we have multi jet modeling. Now, multi jet modelling works very much similar to our Inkjet

printer. A most of you might have seen how does inkjet printer work so, it has certain planes arranged in a state cluster and it does the printing.

So, this is the same way it this process produce a 3D part. Now, in multi jet modelling machine constructs model utilizing a stage change printing yet connected in 3 measurements like on in inkjet printer here. The print had involving 300 to 400 planes arranged in a straight cluster fabricates models in a progressive layer, every individual stream storing an exceptionally created thermo polymer material as it were where needed.

The layer thickness is of the order of 40 micrometers, this is the typical value. Now the multi jet modelling had transpose forward and backward along with X axis like a line printer. So, it just transfers the material like an Inkjet printer and the stage is moving this stage is moving it is just transferring the material in the strain. So, on the off chance that the part is more extensive than the multi jet head, the stage repositions where at is Y axis may also be used here.

Now, at the point when the layer is finished the stage is then moved far from the Z axis which starts to make the following layer the next layer here. At the point where the manufacture is finished, the bolster structures are gotten over to complete the model.

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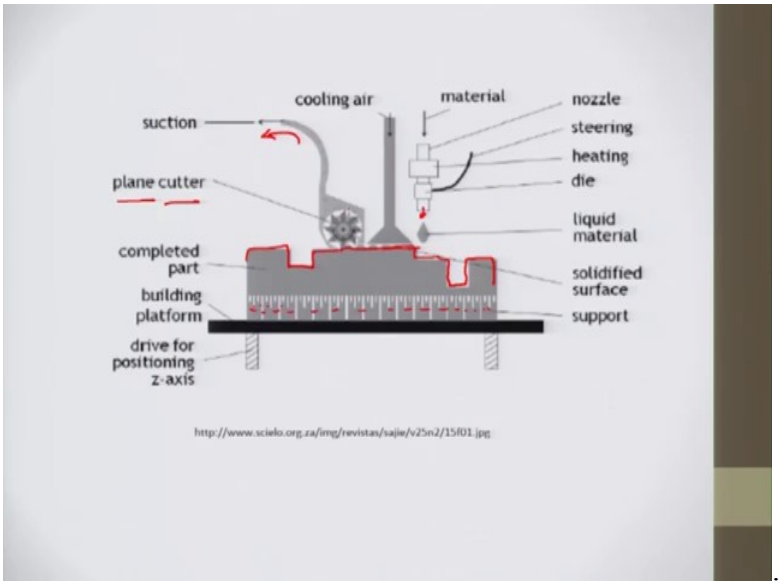

So, this is a kind of multi jet modelling machine in which we have this platform this is Z axis, Z axis is only mood once the layer is complete and this is the cooling air here is provided material is provided why this nozzle here. And steering is there to move this one and heating is also done for heat the material to deposit it one here.

Then die is there also to let the material pass through, the liquid material is there, solidified surfaces there, then these supports are there to support the object material here. Then building platform completed part this is the part that is being produced here, this material is being deposited here, the cooling air is cooling the part. The undesired portion here is cut through a plane cutter and the material is sucked by this suction pump here.

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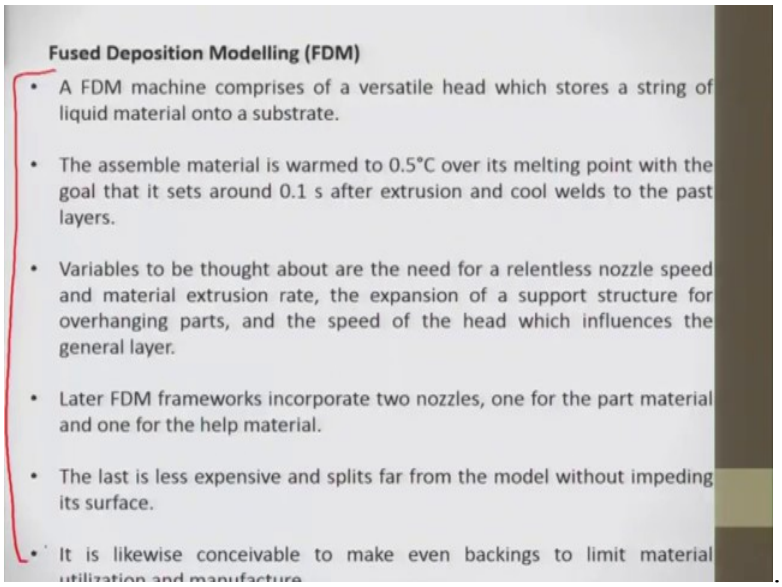

A next is Fused Deposition Modelling, this one also comprises of a versatile head which stores a string of liquid material onto substrate. So, please go through this as well.

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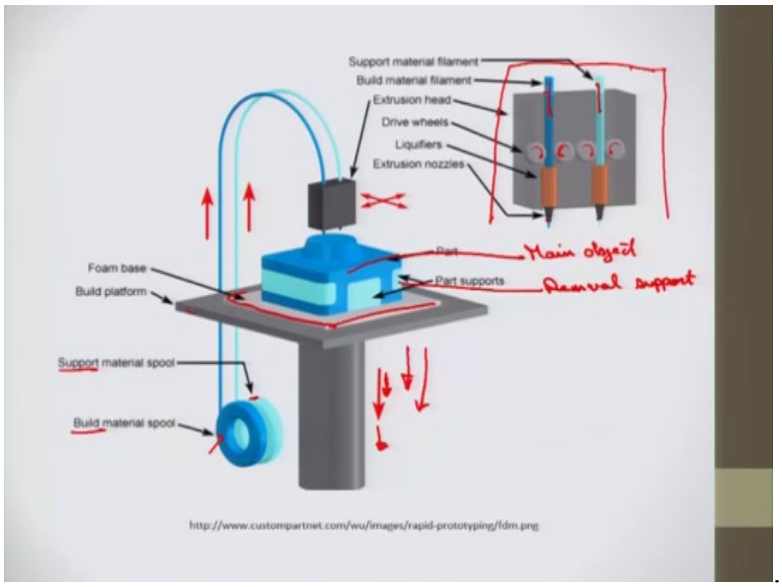

In this case what we have? We have this spool of the build material and this support material this is support and build material. Build material is my main object and this is just removable, the light blue color is here is removable support. So, these pools are provided here and these extrusion noses are there that are supplying the material to my platform here, it is my workplace. Then foam base is always there and the build platform can move up and down here, while fabricating build platform moves down layer by layer.

So, in this case in the nozzle head we have support material filament these are filaments, dark blue is my build material, light blue is my support material. So, drive wheels are there that push the materials through within the nozzle, liquefiers are there that liquefies the material here, which is then solidified further.

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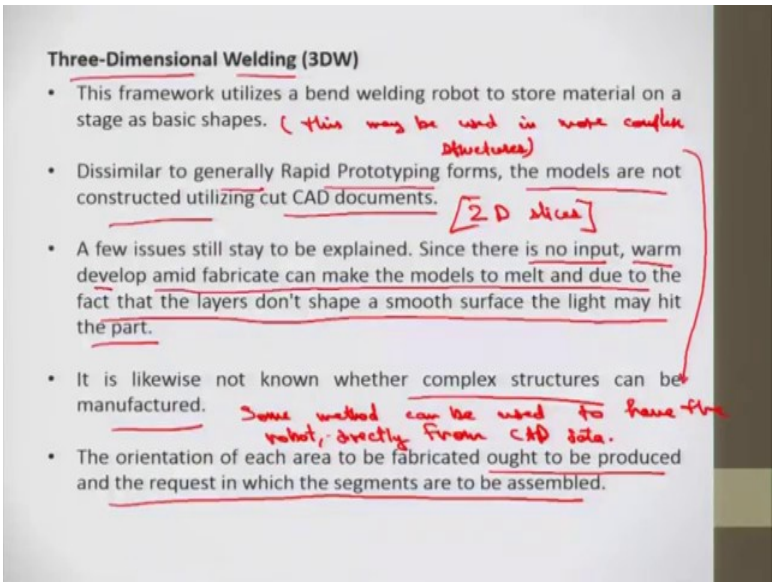

So, Three Dimensional Welding, three dimensional welding framework utilizes the bend welding robot to store material on a stage as basic shapes. This may be then incorporated with more complex structure.

Now, dissimilar to the general rapid prototyping forms, the models are not constructed using CAD documents because this is 3-dimensional welding and the CAD documents generally provides 2D slices. A model which is then converted into 2D slices after converting it to a steel format so, this does not use this. A few issues still stay to be explained here, since there is no input, warm develop amid fabricate can make the models to melt and due to the fact that the layers do not shape a smooth surface the light may hit the part. It is likewise not known whether the complex structure can be manufactured; the orientation of each area to be fabricated or to be produced and the requests in which the segments are to be assembled.

So, some strategy can be used here for complex structure, some strategy can be used, some method can be used to create the robot program straightforward can be used to have the robot, that is directly from CAD software or CAD data I would say. So, in this way complex parts can also be manufactured here.

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So, this is a typical 3D welding equipment here, in this case this probe can move this is robotic arm this probe can move and keep welding the material in X, Y and Z directions.

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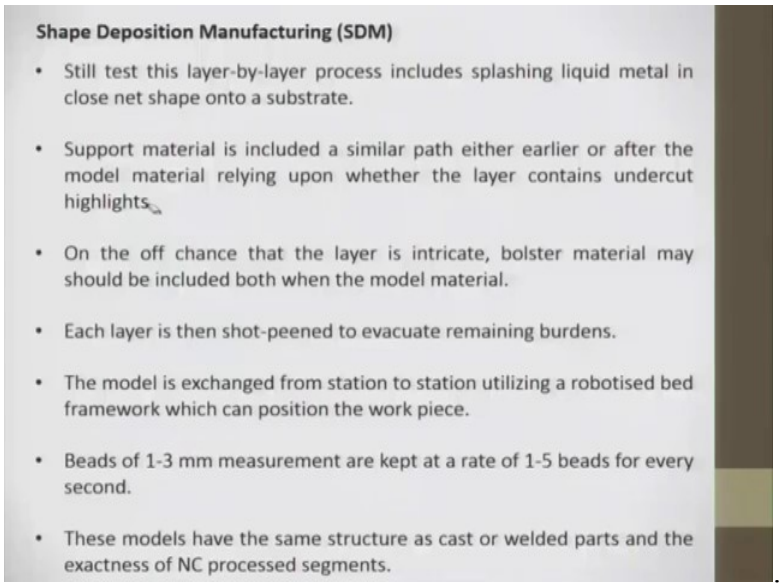

So, another method is Shape Deposition Manufacturing. So, please go through this method as well.

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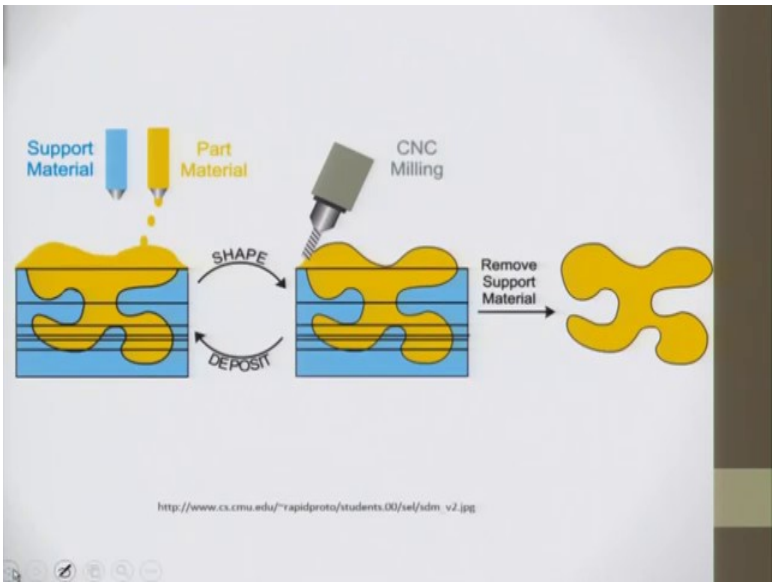

In this case what happens? The support material is provided here and layer by layer the part material and support material is there and support material is then removed using CNC milling that this figure very well explains how does this thing happens. So, in this case this shape deposition is there, the shape and deposit is being done alternatively.

So, with this we are left with one session on rapid prototyping, then this model will be complete. So, you are open to ask us any questions in this regard and let us meet in next lecture.

Thank you.