Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Manufacturing Process Technology – Part- 2

Module- 47
Additive Manufacturing Processes

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Hello and welcome to this manufacturing process technology part 2, Module 47.

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We were talking and discussing about the rolling process and we actually try to figure out what is the neutral angel in the last step where we created the p/2k value before and after.

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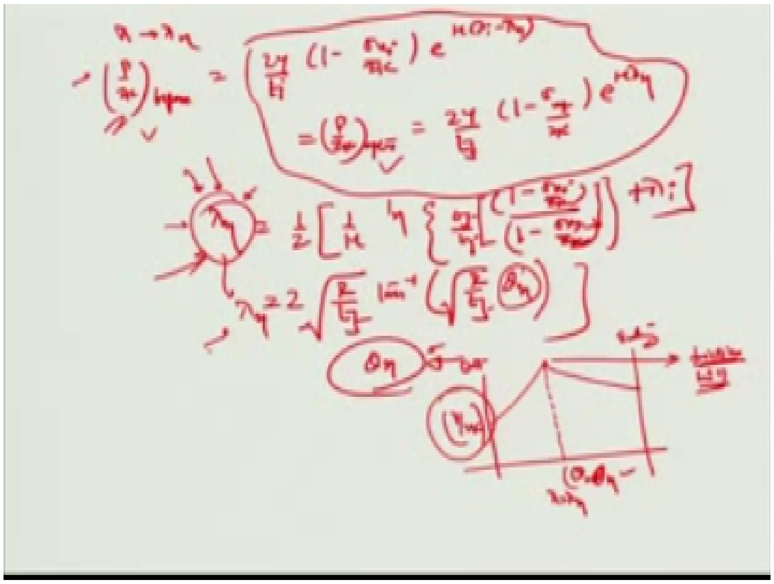

And in this manner we were able to find out a common λ m through which you could actually find out what is going to be the neutral angle θm for the rolling process ,so having said that if we wanted to plot you know the p/ 2k that is the you know the pressure ratio you can say with respect to the yield criteria and that you plot with respect to θ you are basically so this is the exit side the roll may be this is the entry side so we are left with a plot something like this where you know the maximum value of this would happen to be at $\lambda = \lambda$n okay and $\theta = \theta$n so this the neutral point actually.

So the p/ 2k value really would peak around the neutral point where you can say that the before and after you know the neutral point whatever p/ 2k values are sort of equated at the neutral point, so that there is a continuity of the of the pressure related to this value so this held right here is also known as the friction held which is very commonly use terminology in case of a rolling processes, which corresponds to an angle $\theta = \theta$n neutral angle which has been calculated earlier by this expression before.

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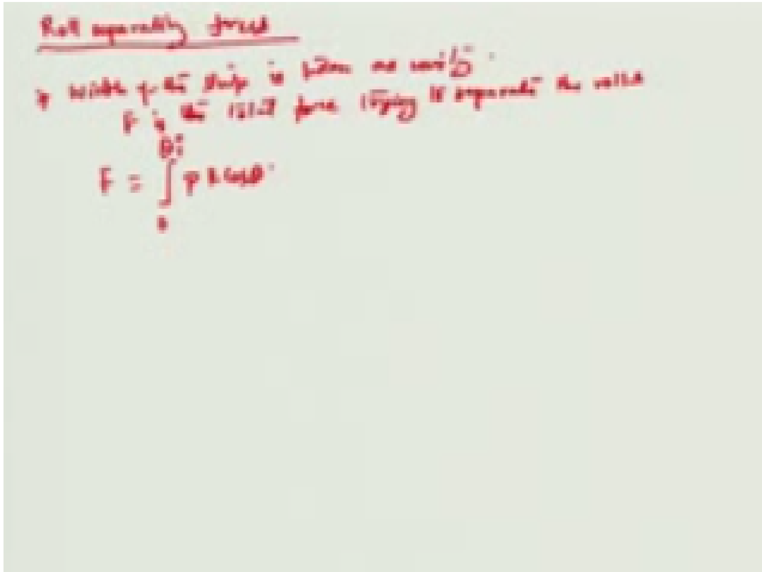

So let us now determine the other parameters related to rolling process one of them is the roll separating forces and for doing this we again assume similar in a similar manner the width of the step to be unity so width of the strip that is being rolled is taken as unity and the total force f trying to separate the rolls that you know comes here can be really be obtained so let us say f is the total force trying to separate the rolls.

So you know f is basically equal to 0 to the value θi the whole you know angle that basically the roll covers over the sheet at point t = 0 okay, of the total force here which is actually equal to the you know if assume the width to be unity the pressure which is their form the roll times of R cos θ if you look at the way again let us go back yeah.

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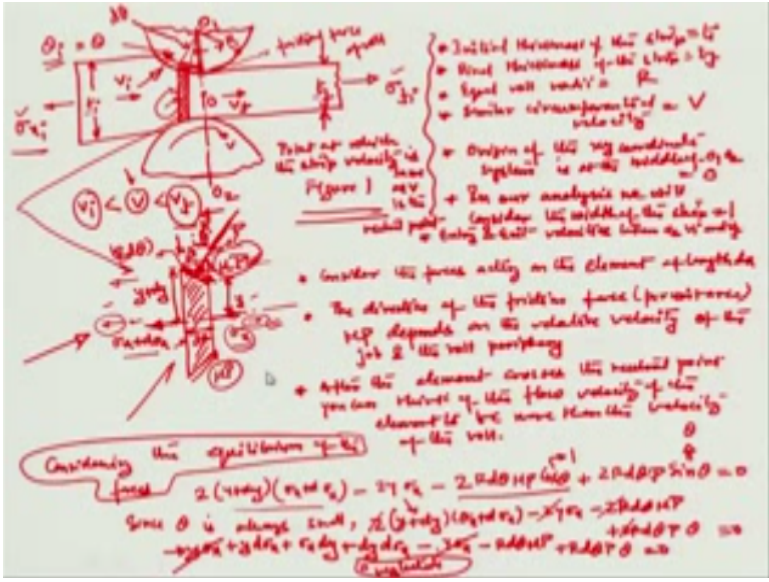

So if you look at basically this earlier figure right here you know that this is the direction of the roll pressure P and it is a triangle θ with respect to the horizontal so we are talking about this separating roll force which is a component of this p which actually is imparted by the sheet on the roll, so that roll try to separate out because of the rolling process.

So can they are held in place by their dear rings, so it is actually some kind of a bearing roll that we are talking about. So this is p cos of θ times of the area of this particular sheet which is actually nothing but the total radios of the roll you know d θ so this Rd θ is the length of this particular element that we are talking about times 1 which is see the width of this particular value and gives the area, so pressure times of Rd θ is the total amount of force and the component of this force in this direction is f cos θ okay. So that is how you consider this particular you know expression and that is how you generate this roll force.

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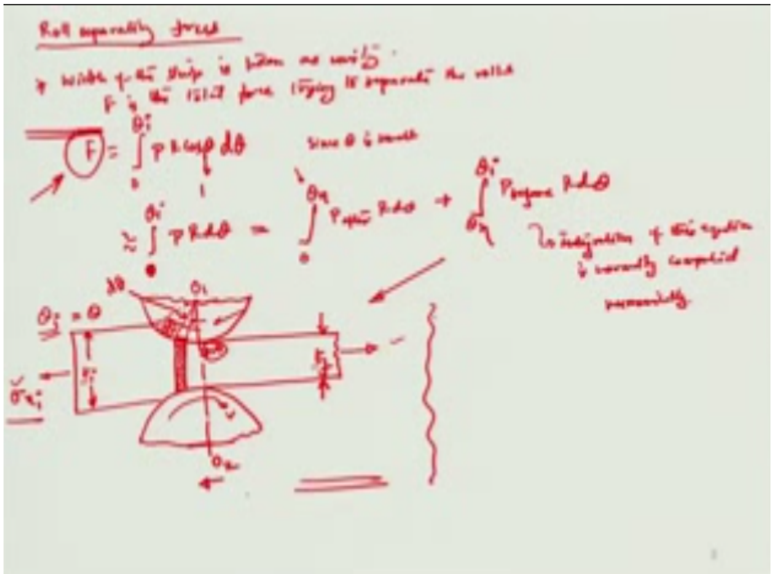

As I was illustrating here in this example as pR cos θ d(θ) so having said that now if you have this as the vertical force which is trying to separate the rolls because of the incretion of the sheet medal and if we again assume these θ value to be small so since θ is the small we can have the cos sort of converge to 1 cos of θ converge to 1 and we are left with approximately an expression 0 to θ_i of pressure p times of R d θ to be = to this force f.

But mind you there is a problem or a catch here and the problem is that you know if we are taking about the hole angle 0 to θ_i this really needs to be divided into 2 different angels 0 to θ_n which is the neutral angle where the friction force is assumed to be enabler for the rolling process to happen and after the neutral angle the friction force becomes a disabler okay so we have 0 to θ_n p let us say after because this is really the point you know if you look at the way that θ was assumed.

The θ was assumed from the neutral point on words so this basically is again illustrating the hole rolling process and as you see here the angle θ actually starts from this last point of contact all the way to this particular point here and θ_i in fact is from θ = 0 at this end all the way to θ_i okay so θ towards the initial this thing initial sort of point of contact of the roll with respect to the work surface.

So when are talking about neutral point really so there are 2 issues 1 is from θ = 0 to θ neutral point where the friction force is playing the, roll of a disabler and beyond the neutral point all the way to θ_i where the friction plans force is playing the, roll is a enabler so having said that now let us look at this equation we can modify this is 0 to θ_n p after times of Rd θ + integral of θ_n to θ_i okay.

And then you have p before which is actually enabler in this case times of Rd θ so that is how you have the force or obtain the total force of the rolls because of the hole forming process, so normally the integration of this is a in this equation is a computational afire so integration of this equation, is normally computed numerically and therefore numerically it gives quite a good reasonable estimate of a the total force phased by the by the rolls. So the other issue is of course the driving torque and the power.

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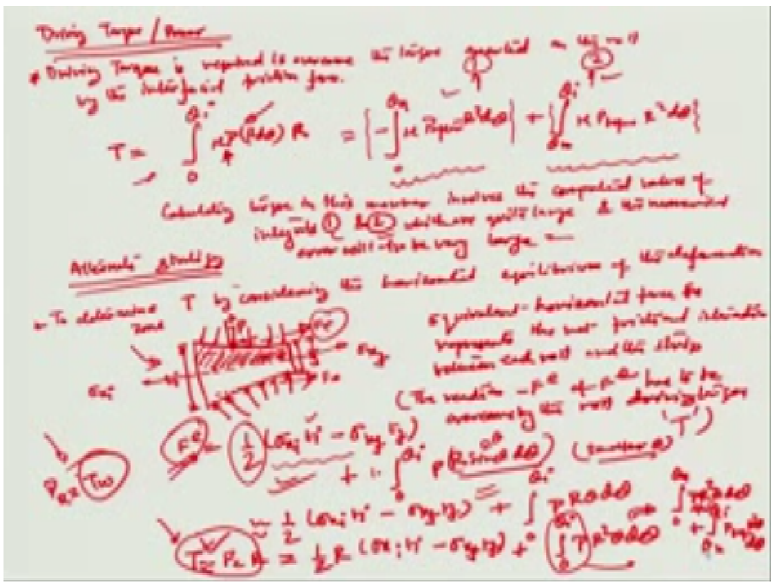

So let us look at part as well the driving force of the driving torque and the power that is needed for rolling operation obviously we initially can think of that the driving force or the driving torque in this particular case is required to overcome the torque exerted on the roles torque exerted on the roll by very interfacial friction force and you can say the friction force to be EP okay, so therefore the total spark can be represented as from 0 to θ_i times of the zone UP times of the Rdθ which is actually = width of that element 1.

If it is unit width in the were directions so you have Rθ times of 1 Rdθ times 1 times of if it is a torque in the torque is really rate because of frictional force which is initial to the roll surface at the center of the role so multiply that with the spark radius r in this particular case.

And we can easily because you know this p value would change it is properties before after the neutral point so again we are left with estimating this with – of 0 to θnj because this actually is visible up after times of $R^2d\theta$ + again θn to θi when the friction force to comes in, so this is post it spark μp before $R^2d\theta$ so it should be noted that the friction would resist after the neutral point the rolling action and before the neutral point it will enable or a to the rolling action, so because of using this method.

The result would really come as a difference of two very large quantities then there will be a lot of numerical error of, if wanted to numerically calculate these two integrals there would be very, very large quantities and then it going to be a significant, numerical errors in this methods so calculating torque although it is logically current but calculating torque in this manner may have involves, the computed values of the integral1 and 2 mentioned about this is integral 1 okay this right this as integral 1.

And this is integral 2 so involve the computed values of integrals 1 and 2 and therefore both of them are sort of you know cancelling each other there is going to be a large error okay, so which are quite large the numerical error will also be very large so let us look at some kind of an alternate strategy by not really directly calculating what is going to happen by the friction on the rolls but to sort of consider the horizontal equilibrium of the deformation is shown of the strip to calculate.

The spark with probably more accuracy than such a large numerical error which is involved in the last step here, so in this case we would like to determine T by considering the horizontal equilibrium of the deformation zone, and this is shown right here so you have now many forces which come into play this is let say the whole volume of the strip where on one side the thickness changes to some t final value.

And other side it is starts expressing to the roll at thickness T initial and you having sparks on both sides, one of them is σ_{xi} and other is σ_{xf} okay and similarly you also roll pressures all along the way so the pressure of the rolls, are actually perpendicular at every level you know and corresponding to the premature of the sheets which are been pressed, and so it will result in some kind of equivalent horizontal force f^e.

Which can be represented by a cross section of this dotted line with respect to the profile here on both the sides and so this fe values the one which is created by the friction between the roll and the sheet and disable to push forward the sheet from the filling the gaps in the roll, okay so I will said that the equivalent horizontal force f^e represents the a net frictional interaction between each roll and the step so therefore the you know reaction – f^e of this force f^e has to be overcome by the roll driving dark T.

So that is the consideration in this case and then therefore calculating f^e is much of a simpler job then you know calculating the numerical value of this integral and trying to create the met spark out of it, so let us actually a see in this particular force system here write here, how to calculate this fe so the force f^e can really be determined by into the let say the let force in the direction from initial to final which is actually given by half times and remember the section has a unit worth.

Coming out of the plane of the vapor here plane of the screen here so here ½ σ_{xi} times of Ti – of σxf times of ef is going to really give the total forces on this element because of the torque and you have to remember why this ½ factor here is because when we are talking about this particular element we all mean by the coordinate frame is to look at the thickness which is actually you know why basically Tf /2.
And similarly this Ti/2 on both sides so we are following the same coordinate here, so that is one and then you have a frictional force here and the frictional force here again will be given by again twice 0 to θi the roll pressure P times of R sin θ times of d θ obviously the width is unity so R d θ times of unity is the area and you can think of a that the pressure P which is actually at a certain angle here.

Let us say this is the pressure P at a certain angle θ here so we are talking about a component of this P which is trying to sort of push the sheet out from the smaller thickness to the higher thickness side okay. So in this case the component of the roll pressure is really not aiding the rolling process, so it is only this FE force which is responsible for the mid force towards the right, okay.

So these forces are towards the right here which could cause the sheet to move forward and therefore it has to essentially overcome the difference between distress area product of the left and the right and also the component of the role pressure on the surface of this particular element that we are talking about which is R d θ, okay. So you can probably at smaller θ estimate this to be approximately ½ times of σ xi Ti – σ xf Tf +.

So basically I am sorry I just made a small error here this is only about one side of this force FE because we are talking about only the upper half here just you know look at it in this manner that we are talking about Y = Ti/2 or Tf/2 so the amount of roll pressure in the component of the roll pressure is only because of one of the rolls on the top side and therefore is actually one into not two into okay.

So we just modify this here where I think + 0 to θi times of P times of R and you have you know you can mention or we can substitute approximately sin θ as θ because of smaller θ, so we are actually sort of assuming here smaller values of θ so we have PR θ times of d θ is the final formulation and obviously if this is the total amount of frictional force we talked that this force will exert on the center of the roll would actually be the FER product.

Or force time radiation product or force various product and this torque is approximately estimated as ½ R times of again you know σ xi times of Ti – σ xf times of Tf is obviously reasons + integral of 0 to θi PR^2 θ d θ and you have top remember then again that when we are talking about the roll we have to solve or divide this into again 2 parts 1 is 0 to θm, PR^2 θ d θ + you know θ n2 θi and this is for P after and this is P before, okay.

P before R^2 θ d θ so that is how we calculate actually the torque value rather than creating a direct you know roll of friction here you basically try to find out what is the force that is needed for pushing the element and that is assumed to be if there are no other losses which are there of the energy then it is assumed to be the same as the force that is needed for pushing the element forward or the force of the roll friction force of the roll.

So there is no loss between these two forces and they are equal and opposite to each other so therefore that is an alternate strategy to calculate what is going to be the torque value, so power as you know in this particular case is given by torque ω so if I had a certain value of torque and if I a knew that the rolls are rotating at a certain ω so inert RPM we should be able to give you give a good estimate of what is going to be the rolling power.

So we have now made a case where we have tried to mechanistically observe the rolling process very closely we have try to make a force balance to which we could predict what is going to be the roll pressure what is going to be the friction force what is also going to the driving torque and the power which is needed for a driving the roll okay or executing the rolling process and then also try to determine what is going to be the roll separating force.

So typically all the different forming examples be you know forging of a block or forging of a circular disk or may be even the extrusion or you know drawing or deep drawing or bending processes they have to be modeled sort of in that manner so that you know you can have sort of a mechanistic first principle based modeling of the various factors like what is the power that is needed to execute the process or what are the kind of forces that are subjected or there are being subjected onto the material by the either the roll or the you know the die in case of forging so on so forth.

So I am not going to go into the modeling of any other aspect at this time because we are already at the towards the end of the lecture but what I am going to do is to sort of give you some brief sort of schematic illustrations about the various metal forming processes which are there and then may be torque a little bit about additive manufacturing enclose this topic of contraction process technology part II.

However we have made sure that there are online notes available for the different processes like forging of a block or forging of let us say a circular block or a rectangular block or even related to extrusion so if you have any kind of queries or questions the modeling is typically made in the same manner as has been given here mechanistically so you can actually feel free to interact through the online portal.

And we will try to answer all your queries or take up all the ovaries so let us now look into the different processes.

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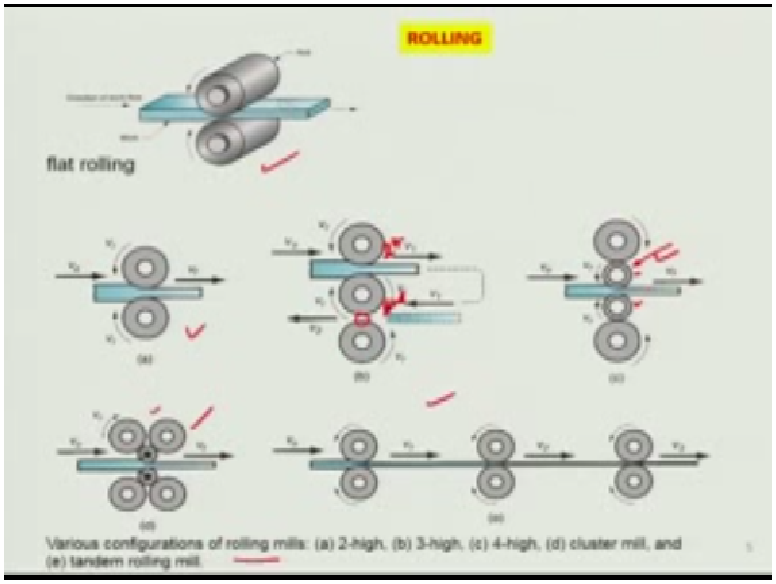

Which are available so we have already done the rolling process so rolling can be done various configurations rolling mills you can have a two high rolling mills as we have seen here a three high where again as you can see that you know there are set of 3 rolls which are spaced by different distances so you have the first pass somewhere here and the second pass where the metal is sort of reefed back okay.

From the first gap into the second gap right here or we also have again rolling done with different argumentation like fore high rolls or cluster rolls or cluster mills or tandem rolling mill so typically the roll of the fore high or the cluster mills is to provide the support or the added support which is needed for rolling of hard materials particularly, so you provide a backup support for the main roll which is creating the actual definition process of harder material.

You have two different configurations for that one is four high or another is a cluster meld configuration that you can see and in tandems means that you are having a success for reducing pass as you are going between different roles at feed velocity so that you can have a thinner second emerge from a thicker section by just in tandem or rolling sequentially between different role gaps or roll separations. So that is about rolling we have other process of significant.

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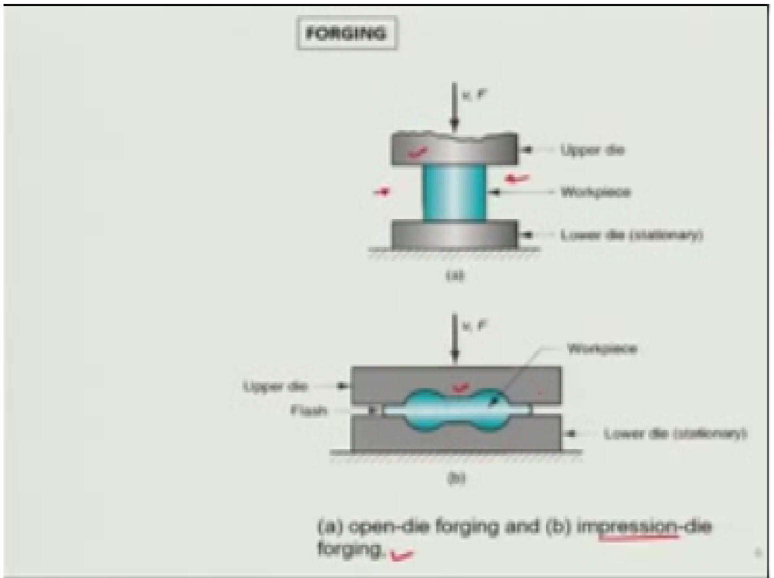

Like forging where either can have a open type forging case and there is a very nice illustration in the notes as well where we talk about how frictional force related to the die here and the expanding metal would vary there would really a point where the deformation would be at the same velocity as the or the force of the formation of the stress total principle stress would be the same value as the frictional force occur between the dies and the work piece.

Similarly you have again impression die forgoing where there is so where you have some kind of an impression or a cavity being created in the die and basically the shape gets formed because of the you know negative shape gets formed on the metal element because of the cavity which is shaped in to the forging die.

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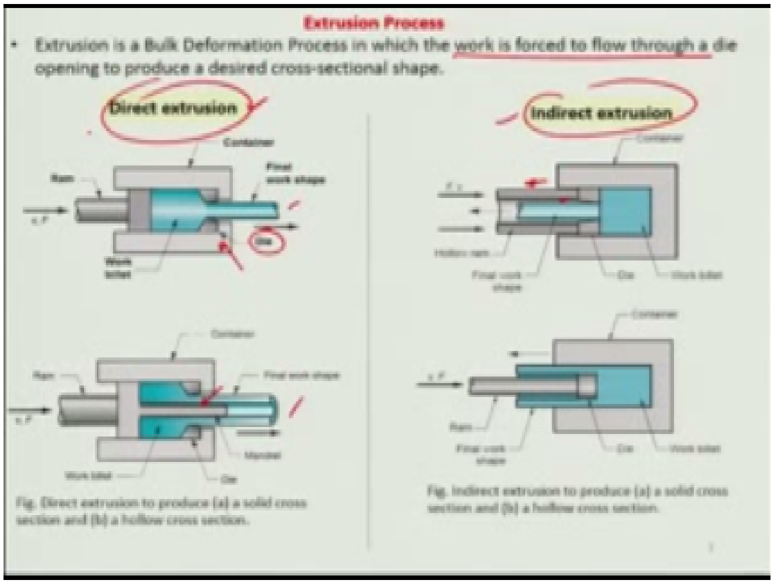

There are other processes particularly exclusion it is a bulk deformation process and which the work is force to flow through a die opening you know you can produce the desire cross section shapes there are different kind of exclusions for example direct exclusion here or indirect as you are seeing here in this direct exclusion case there is a direct forming being incorporated by pressing a billet work billet from a small RFS which is available in this particular die to generate the final work shape you can do a solid shape or a hallow shape based on it there is a reason additional mandrill to create this hallow.

Similarly in a indirect exclusion process is you can see here you basically trying to flow the meddle in the reverse direction through the gapes or the you know the sort of in this case it is the gape formulated by a solid cross section or if there is a hollow cross section also a similar kind of back flow of the metal can happen because of the ramming action done in a direction from left to right.

So this is again in a indirect manner you are doing the same metal forming process like what was happening earlier by just direct fitting of work billet.

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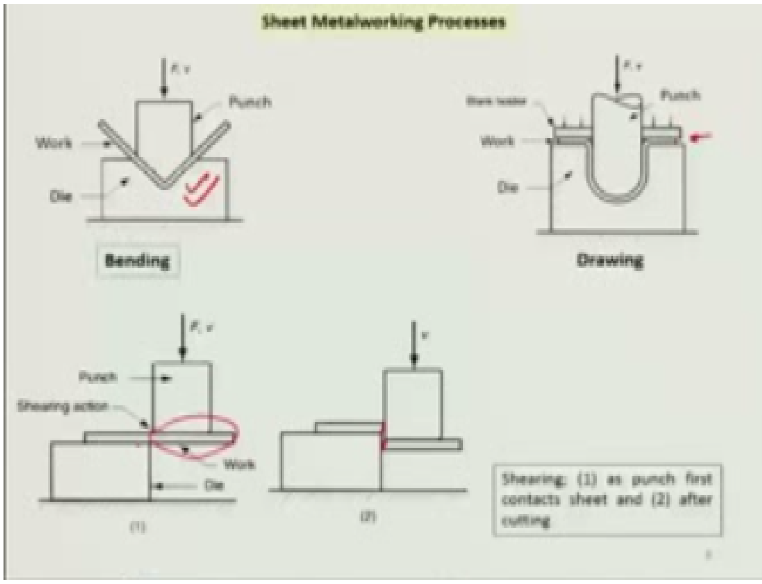

We also have various other sheet metal working processes like bending where there is a punch which is used to basically bend thin sheets okay, you can also draw thin sheets as is illustrated here there is a die cavity and the punch and die cavity in this I am able to create a sort of you know drawn shape of the cavity there is also a shearing action which happens in two states where one there is punch which comes and strikes on the work piece here and then there is a cleaving off which happens at this particular inter phase and that is the second part of the process after cutting where the remaining part of the shear to component of the shear sheet is taken away from the zone of shearing.

So that is how some of these operations are schematically shown the idea here is why we are discussing this is that in the same manner as we did rolling you have make it the strike models available for each of these processes and this kind of concludes from outside the whole metal forming domain we also wanted to do a small module and introductory module to additive manufacturing for which I will just have a few slides as a ending for this manufacturing process technology part 2.

So let us look in to additive manufacturing.

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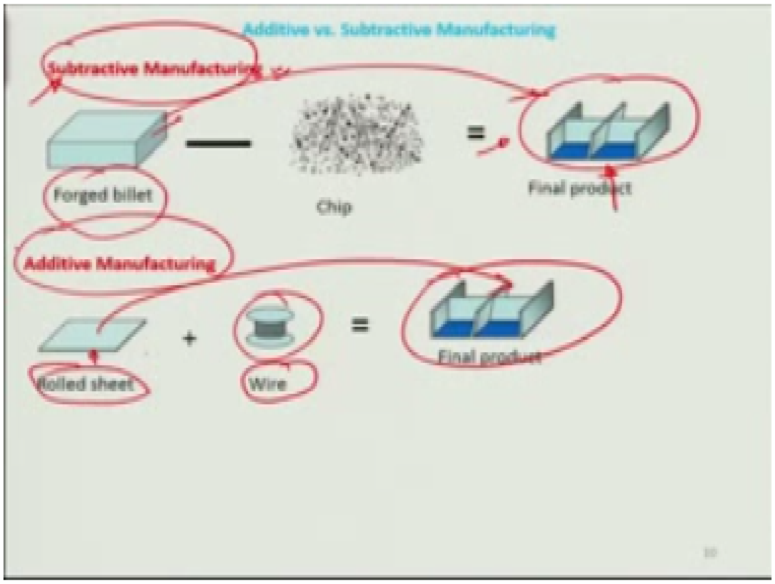

So you have various conceptually different techniques of manufacturing one is subtractive manufacturing where really it is about you know starting from a bigger shape or a size and then trying to chip of this, so that there is a material removal and you know because of the removal you obtain the shape of the final product and that is typically call subtractive manufacturing because you are taking half material from the billet in order to converted in to a hallow cavity shape like this which is being indicated here in the final product.

However in the additive manufacturing it is actually just building upon rather than subtracting so you have small base rolled sheet which is to built up on and for building up you are using a wire and you are trying to melt the wire and deposit it locally on the top of this roll shade so that from this initial shade you can have a final product. So here there is really no chipping action or subtractive process but additive built up and the buildup is done by a wire which is typically heated and fed whatever shaped and sizes need to be realize the spooler of this wire which actually feeds the wire and its scoots the wire kind of moves.

And create this section by section deposition so that you can have the final product. So this is really the basic difference between what you have done earlier in machining and what you would be doing now at the manufacturing.

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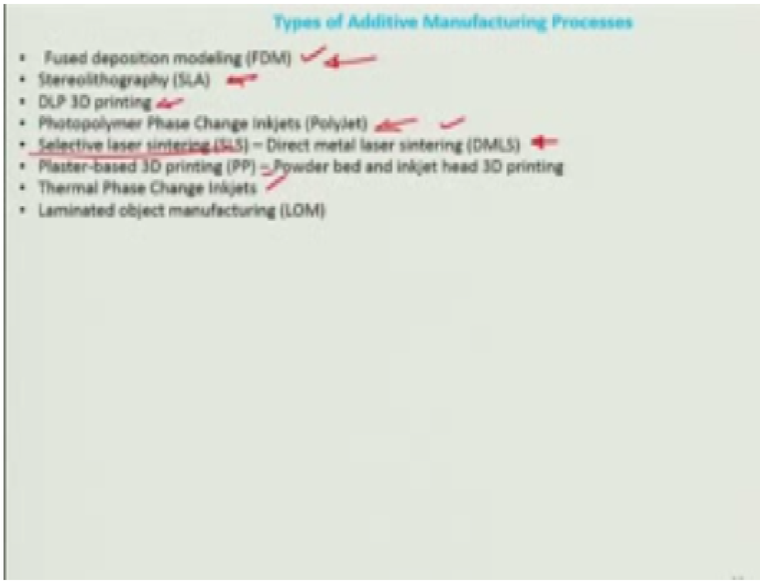

The many different kinds of additive manufacturing process for example you have the very famous FDM or fusion deposition modeling which actually I illustrated also and there is a video on lecture 8 for D* which has been recently uploaded for seeing that how from a soft drawing you could convert you know using the FDM process in to a complex part. There are other processes like sterioliythography then this digital light projective base 3D printing again photo polymer phase changing jets poly jets kind of redo manufacturing you have selective lasers centering which is a process which is used not only for polymers but also for other classes of materials like metals you have direct metal laser sintering as well.

Then you are many others like plaster based 3D printing or thermal phase change injects or the laminated object manufacturing etc, so we are going to look in to few process here which will give you some basic idea about these redo manufacturing processes.

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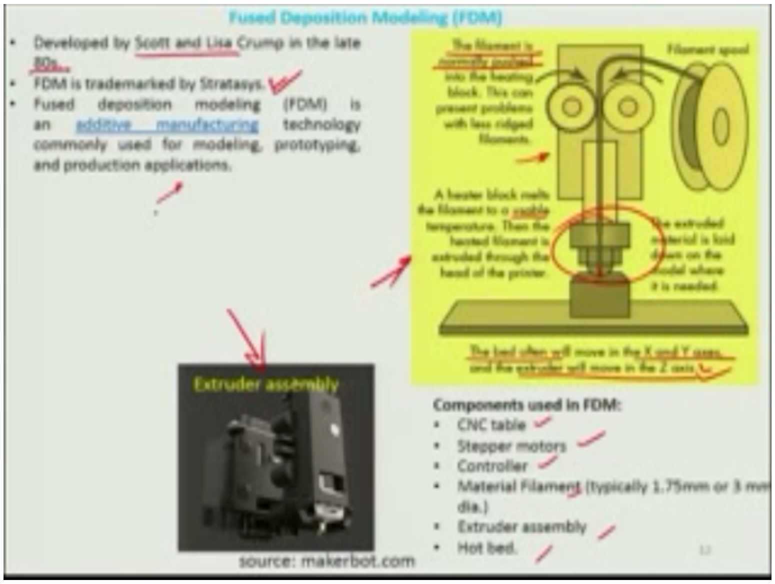

So let us know first understand what is the fusion deposition modeling so this process was developed in the 80's by Scoter and Lisa Crump and you know it is basically trade mark the company call statuses which actually provides a technology and this technology is based on various events which happen across this drawing here you can see there is a Philomena of a plastic wire which is normally being pushed in to a heating block here and this heat block is something like excluder which actually melts at the material in to a sort of a using out jelly okay and this only happens when the metals goes in to its so the material to its class conjunction temperature through which when I comes in to a usable flow state and then what happens is that you know you can often move the bed in the x and y axis and the excluder in the z axis.

So that you have a layer by layer depositor, and so the inter phase that this machine as is really through a powerful cad package which kind of takes any shape and cuts in to various sections and one section is actually equal to the thickness that is being deposited at one run or one particular you know layering as given by this device. So it is really dependent on the resolution of the whole system is to how this is Z axis movement can be realized from once at to the other.

So this idea shows an exadurationally by makert.com and you know there are different components in the FDM system like CNC table stepper motors controller and material filament in the extruder assembly and hot bed which is to typically used for realizing any such fusion because of the modeling in fact we have a details video that I have given for this using machine called FDM.

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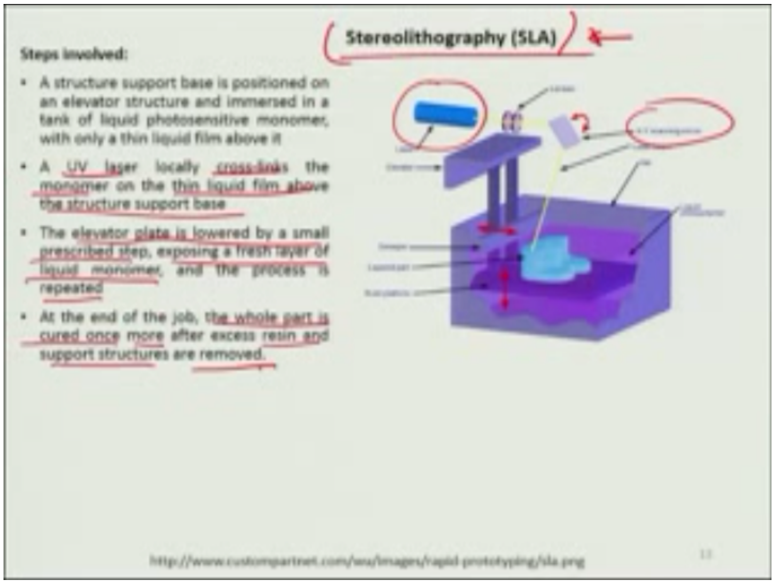

Again manufactured by strategies and sell by so please have a look at it, it is actually lecture 48 or module 48 on this particular course the other every interesting method that is available for a manufacturing which is SLA stereo lithography method where in the idea is that again now you have a resist okay it is sort of sensitive polymer and then you heat or when you basically try to clear this polymer with laser beam in a section by section or you can actually have the result flow vacuum flow between the moving plate okay.

And the section of thickness that has already may incorporated exposes at different heights at different depths so that the whole structure can be build up I think I had given a bigger illustration of stereo lithography while looking at we micro systems fabrication processes it is basically process why is exactly the same the only thing is that we are utilization of laser here and basically again a motion of x and y scanning mirror which would try to write down the different sections okay Across the SLA

So the UV light or UV laser is basically cross linking the monomer on the thin liquid from above this structure support base and the elevator plate is lowered by small prescribed step exposing a fresh layer of the liquid monomer in the processes repeated like this and at the end of the job the whole part is cured once more after excess resin and support structures are removed from it.

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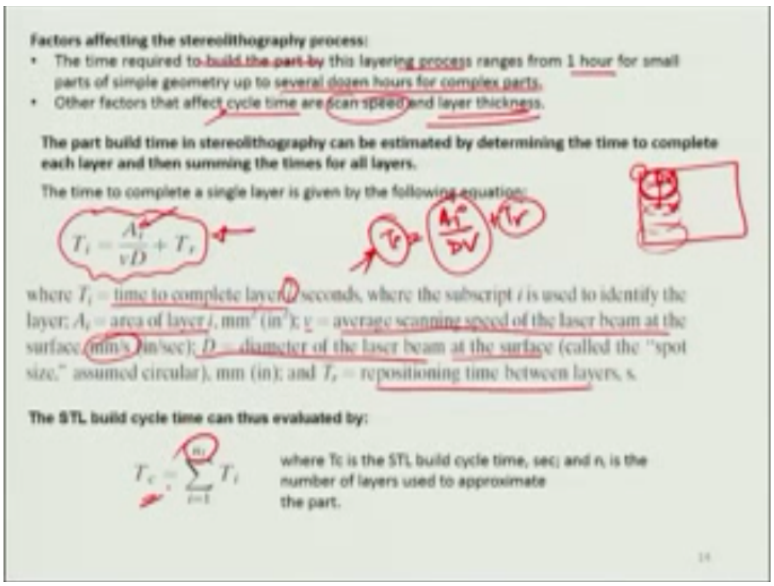

So that is how you do a layer by layer printing so the various factors affecting the stereo lithography process in fact we can estimate the time that is needed to complete you know one layer I basically there may be n such layers you can there in the system so we can actually estimate the time required to build part by this layering process from down one other for small parts.

And so other factors that would affect really as a cycle time the cycle time of a scan speed and also the layer thickness that is incorporated so in general there is a sort of a very simplistic way of estimation of the time so the total time that is needed to complete the layer I in seconds can be given by the area that you are trying to print off this layer I oaky in n2/the velocity diameter cadet of the scanning laser V.

So if V is the average scanning speed in the laser beam and at the limit is millimeter per second and D is the diameter to a laser at a surface spot so basically if you have a spot and let us say there is an area like this where this spot has centered this spot which is no more velocity V so the area that this spot would basically cover oaky is by its motion per unit time is going to be very Dv okay.

And so that is exactly what we are trying to say here that if Ai the total area is divided by the dv the diameter velocity product is going to get how much time this scanner is going to take scan out area Ai and added to this is the time for repositioning which are the between the layers between obviously between on layer on the other there is some kind of transmission time before the you know the scanner can be back to the position to the origin from here it is started this hole scanning activity.

And this origin could be this side wherever it has completed its last step or if you want to set it back it comes back to the 0 depending on what is going to be the strategy that you are using or variate the time in this manner and so that is going to be equal to the time required for the layer if you are exactly you know one layer I can say the total cycle time in this particular case basically represented as $\sum$of al such Ti is between I varying between 1 and n1 where n1 are the number of layers which are been used.

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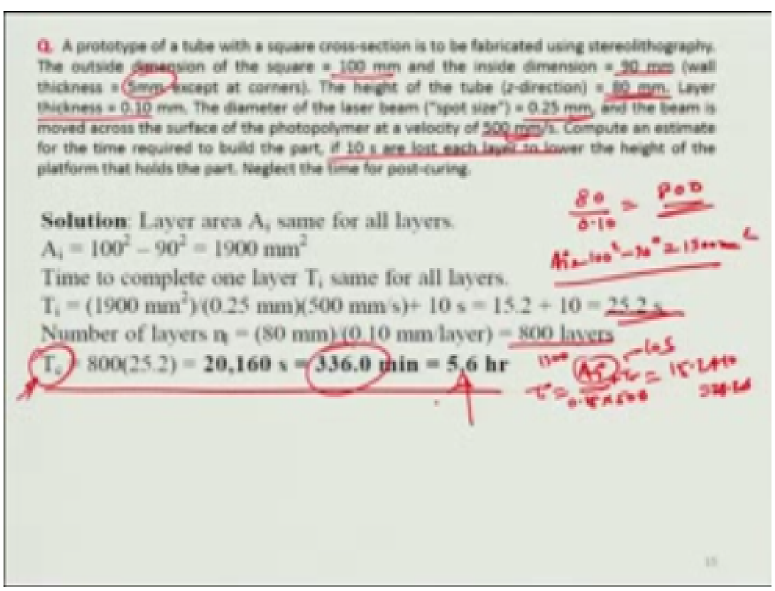

So this is the small example problem which looks at the prototype tube with this square cross-section is fabricated using SLA technique outside dimension to the square given to be 100mm and inside the dimensions are about 90mm and thickness is almost everywhere is about 5mm except at the corners where it is slightly higher and height of the tube in Z direction the height of the tube is about 80 mm and layer thickness that we are using here is .1mm.

So obviously if you are having 80 mm and 0.10 mm as 1 layer thickness so it is about 800 layers that you are trying to obtain okay and each layer should have a time which is based on obviously the size or the diameter and of course the total area and this case the area is cross-section because it is hollow tube of square cross-section that we are creating we have the area 100^2-90^2 which is about 1900 mm^2 so that is Ai okay.

And with this Ai if I wanted to find out what is going to be the total time for 1 layer it is going to divide those width with the laser beam diameter times the mm per second of the time speed of the laser beam so this comes out to be equal to so the Ti basically comes out to be equal to this plus the repositioning time Tr which is about 10 second in this case.

You know it is change that principles are lost to reach layer low by platform and whole the power may be just take in to the origin so here therefore the Ti comes out to be 15.2+10 that is 25.2 seconds okay. Ai been equal to 1900mm^2 and therefore the total number of layers that you manufacturing is 800 the cycle time is required about 336 minutes which is 5.6 hours so that is how you estimate you know in the preliminary manner what is going to be the time for the total cycle okay to happen you can see this part has been manufactured relatively higher time of 5.6 hours that is because of the extremely slow nature of the SLS.

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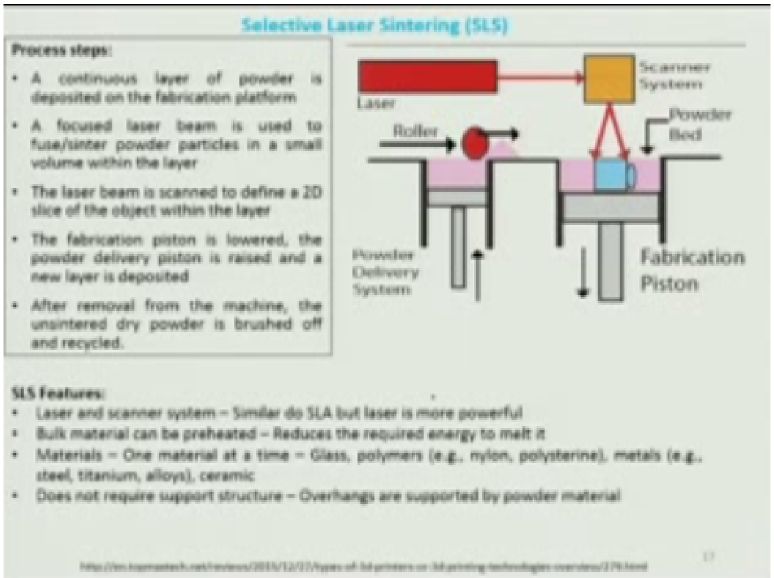

So you have again the selective lesser sintering which is normally used by having this powder delivery come fabrication post there is one piston here which shows the you know the feeding of the powder which is actually a sort of you know, you can say a part of fuse together to create the whole part okay and then also the feeding of this powder using the roller to this other piston which moves in steps downwards and each time it moves, it moves after the scanner system using a laser as scanned and symptom proportion.

So this is a actually fabricated part by part sintering, as a result downward motion of the question BM. So that I show the SLS work, the advantage in this system as polymers but also it is able to do on metals and after removal of machine from the machine unstinted dry powder is brushed off and recycled, so that you can have the part without the powder. So materials that you can use typically vary between glass polymers, nylon, polystering, metals particularly steel, titanium so on so forth, it does not require any supports structure or over hangs, they are typically supported by powder material.

The thing you need to do is sort of retain the powder without putting the laser into the region and then this powder can be again reused that into the system. So that is how SLS is done.

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There are some part here manufactured by simple SLS process, obviously it is expensive related to the few position modeling or even the 3d printing done earlier by the other step but also there is other limitation the quality of the material bars that could produce nearly as not as high as a machine would produce and in this case you may not serve the distance requirement that is need by some of the dynamics machining to produce such parts.

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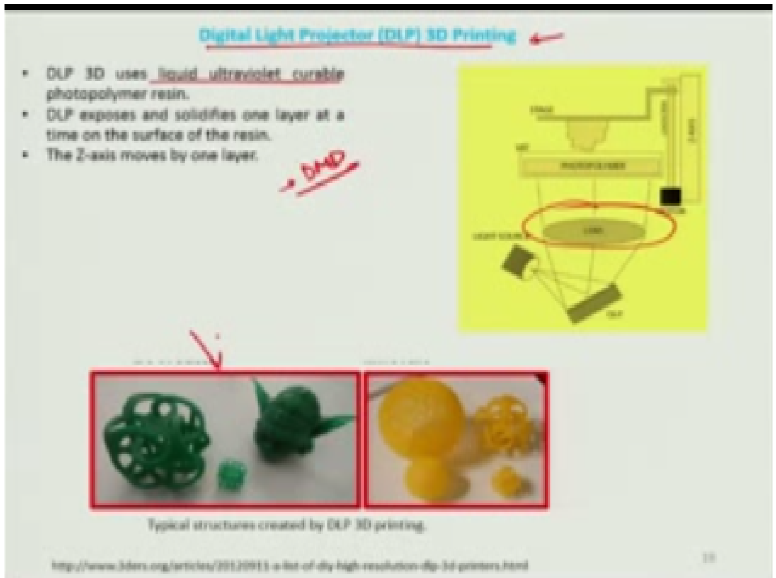

So then there is digital light projector based 3D printing, which I had already illustrated earlier that instead of a you know of single laser points standing the whole structure in this particular case it is basically a digital light projector which is also keno as DMD digital micro device, which is actually used by scanning and rotating a ray of very small mirror, so that the limits can be formulated and the idea there package which can section, a particular geometry.

The section by section manufacturing can be done opening and closing you know the different layers on using that DMD technology or digital, the only thing it is very expensive because you should have optics precise to avoid or basically to beat the deflection terms. And basically it is again used to sort of cure the liquid curable for the polymer resumes like photo resist and the same manner is done by this earlier.

Instead of one short go this posses much faster actually then the SLS process you can actually have a structure cable. These structure created by DDLP 3D printing.

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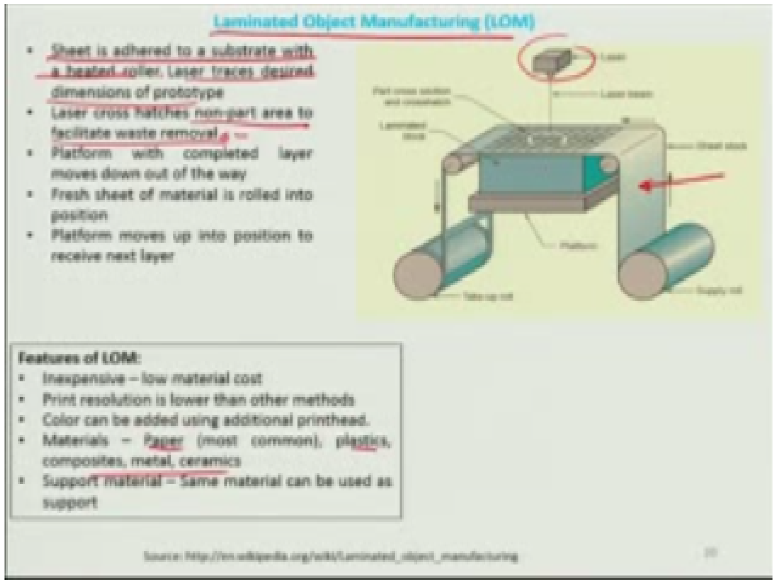

The other technology which is widely used is again is the animated objective method manufacturing, where there is laminar sheet which is made up of some kind of paper and plastic or composite or metal ceramics and what basically this technology does is that. In this case you know the sheet is near to the substrate with the heated roller and there is the laser which traces the desired dimension prototype and cut it off.

The laser cross hatches non part areas to facilitate the waste removal and basically bonds the part areas to the lower already deposited part which is there from the previous role. So role by role you can create such layer by not changing the position aligning different layers, so that you can have the cut parts welded together by laser and so there is laser by laser build sup structures this way. But this is you know complex process relatively the FDM happens to be much wider you know to applied, to parts manufacturing through 3D printing.

And therefore we have decided that we will, probably try to show the real applications of this title and feel free to watch the video for this, which is available in the next lecture. So with this I would like to close here for the whole manufacturing technology process to domain we have been able to cover, so far advanced to manufacturing process particularly, process related to small system like and we have seen how we can manufacturing on silicon, manufacturing on alternative materials like, polymers.

You can also manufacturing over glasses of ceramics or composites using non convention techniques and then you have done, some mechanistic modeling, some details regarding how metal forming can be carried out and you know you have classified different metal forming process and finally ended with small nice introduction on editing manufacturing. So this is going to be end of this particular course. I wish you all the best for your quiz and assignments and examination.

So if you have any question feel free to drop an email to us through the portal and we will be happy to answer some of the questions. The other issues the last assignment to be due as per the announcement that has been made on the portal and we are going to evaluating you on the basis of assignments and the final examination. Thank you for being patient to all the deliberation regarding all these course and I wish you all the best for your exam thank you, thanks.

Acknowledgement

Ministry of Human Resources & Development

Prof. Satyaki Roy
Co – ordinator, NPTEL IIT Kanpur

NPTEL Team
Sanjay Pal
Ashish Singh
Badal Pradhan
Tapobrata Das
Ram Chandra
Dilip Tripathi
Manoj Shrivastava
Padam Shukla
Sanjay Mishra
Shubham Rawat
Shikha Gupta
K.K Mishra
Aradhana Singh
Sweta
Ashutosh Gairola
Dilip Katiyar
Sharwan
Hari Ram
Bhadra Rao
Puneet Kumar Bajpai
Lalty Dutta
Ajay Kanaujia
Shivendra Kumar Tiwari