Physical Modelling for Electronics Enclosures Using Rapid Prototyping

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Lecture – 04
Rapid Prototyping

Hello, we come to the what do you call important thing saying why not have something which is you know practically made by a machine and its first because all of the other many things what I have shown you invariably have tremendous involvement from the what you call a trained person as are self trained or his actually you know he has a diploma in that the people we work with all of them are you know have an engineering or you artist degree with them.

And hence now life is easy for us, but outside you know if you have a small timer they come to us to higher people.

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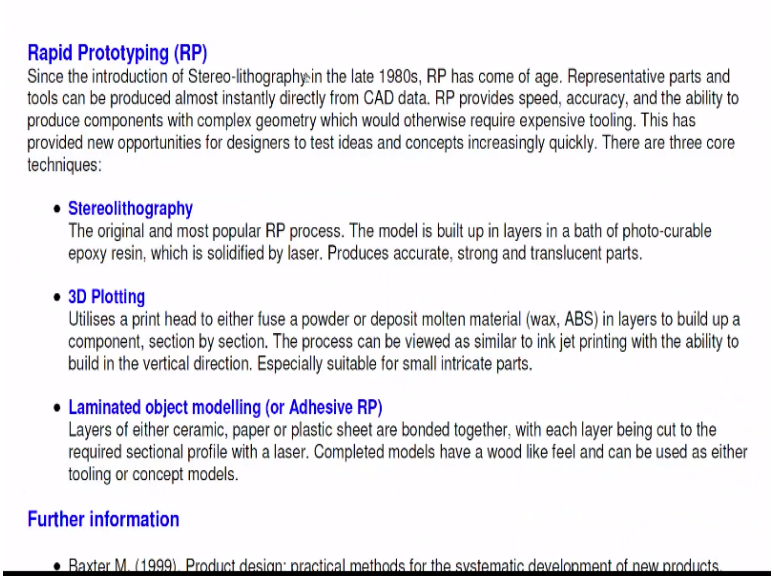

So we come to if you look at my display we come to the whole concept of a rapid prototyping. Since the introduction of Stereo-lithography in 80s RP has come of age. Representative parts and tools can be produced almost instantly directly from CAD data. Speed, accuracy, ability to produce components with complex geometry which would otherwise require expensive tooling. This has provided new opportunities for designers to test ideas and concepts increasingly quickly. So this is old.

Right now only this and what is now being covered everywhere else welcome. Stereolithography once upon a time was common. The original and most popular rapid prototyping, the model is built up in layers in a bath of photo-curable epoxy resin which is solidified by laser produces accurate, strong, and translucent parts. Why I continue to what you call stress on this is surprisingly the file formats which are made for this have become standard.

All 3D printed parts is STL file extension which is nothing but stereolithography one of the earlier thing. It is modified mildly now and you have a little more control on it so all 3D printing even today is done with STL files. We have so many. We have DFX. Then we have IGES, we have so many other things none of them can directly be used by printers, but if you give a STL file all printers accept it however if you have other files also there is no issue about it any of the 3D solid modeling files are even some of the surface modelers can easily be converted to STL.

Sometimes via basic DXF or DXS is the old thing started probably by autodesk previous to that we have IGES extensions. Momentous those things, you can print. So stereolithography was probably one of the earliest points. Next we came to 3D plotting you see. Utilizes a print head to either fuse a powder or deposit molten material in layers to build up a component section by section. A similar to ink jet printing with ability to build the vertical direction especially suitable for small intricate parts.

Long, long ago we had both the ABS molten plastic being deposited, or a powder right now almost all of them have been converted into using fused filament depositing modeling FFDM. So you have FDM is fused deposit and now filament depositing a thin wire like thing which is fed it is heated locally it is melted like let us say I mean just for this thing I am telling you the original wire may be as thick as this of course it is little thinner, but I am just it would not catch it.

And eventually it may made into 0.2 mm or 0.3 mm small thing coming out a nozzle using a heater and all methods are there one of them this is stationary. The table moves and now the table is stationery and this moves and all that. So fused filament deposit modeling has become

the depositing standard. The other thing including stereolithography including other methods are there little expensive, not easily amenable to table top and so on.

Finally, layers of ceramic, paper or plastic sheet are bonded together with each layer being cut to the required section profile with a laser. Completed models have a wood like feel and can be used either tooling or concept models. This is also is very, very interesting. Probably it started with architects you are only using variants of cardboard understand now simple cardboard and other materials have come about including foam board including foam core board that is both side you have paper and you have a foam inside.

When they wanted to do this undulation on the ground saying you have a vast acreage of place and then it has a gentle thing. First thing there to do was somehow recreate the effect so you must have seen maps and which have isolines. So what could they be? They are points of same height were all plotted together. That is the first surveying started about. You understand know? If you see a map we have this isolines all of them representing the same height being plotted on that.

So immediately you know it has a very easy way on somebody had to do take the map, trace it onto a piece of paper, cut it, place it on a cardboard and then we had this beautiful way of creating the built environment outside. There is a beautiful name for it suddenly my mind has gone this thing. One variant is called is landscaping. So how to make a land like a beautiful this thing interior designing similarly you have a garden designing everything all of them started with using flat cardboard in which land contours which are already available on via survey.

So that has been extended somewhere. If you take a contour take a thick cardboard and most contours are plotted with 10 feet height, then you also have 1-foot height and then you have other things. So if you have a 10-foot height contour and then if you are making it scale model usually 1 foot is made into 1 quarter inch. You make a cardboard of that and built it up you have all your landscape ready.

This was used extensively for laminated object modeling or adhesive rapid prototyping and the same cardboard are this thing thickness can be built and you can build beautiful architectural models. Next time, you watch any movie either the hero or heroine will probably working in an architectural firm and one of the most attractive visual cues that is given to you is the architect model then show the architect models and saying.

This is the project and so on and the bad guys try to what you call smash it or finicky protagonist decides to start fresh by destroying the old model. You cannot do that easily in this old type of thing, but even all of those things you know have been made in sections such that the landscape portion of it has probably made separately and all the buildings and all are made separately you can place them as you like.

You can space them and in case there is a what you called a place for a children play area or in case you have a what you call a swimming pool or all of those things. All of those things are easily available wherever you want and that is where scale models like this have become popular. So depending on your scale usually at the bottom they write about what is the scale so 1:16 up to even 1:32 and some of you have played a little with trains and you have seen the train modeling people their nuts typically.

So if you take one of those 9 mm models they track you know spacing is 9 mm everything is available to scale. You can have the what you call all of Swiss alps, all of French alps, all of Italy everything all that tunnels everything you know they are available and you can build huge systems with it and you can probably buy it online. So I am sure when you see it you will be impressed.

So just out of curiosity you know go to YouTube look for the what you call all these modeling train modeling thing and check and look for all the accessories for sale. Now this laminated object modeling with paper, plastic sheet and all this has been extended very well. Let us say you want to show what I call a piece of a box like structure which has display. Display can be easily printed and stuck on to that so you have a project which is you know it works very, very well. I have a beautiful display.

You understood know. All these things including this I make a box I just stick it on top of it including this and including this. To make it look good I can even have a battery I mean a cell or a vertical battery inside, but having these LEDs and all and then including this buttons I have pressed something LED comes out. I can have a display which is stuck there and all that so making this laminated modeling also is very, very real.

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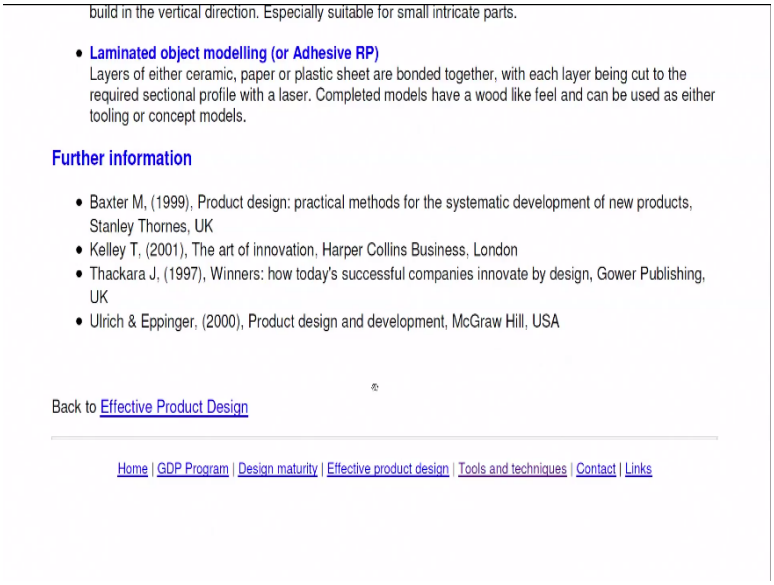

It is not so these all have been what you called taken from here. I would like to acknowledge and mind you even effective product design and good design program people have acknowledged Ulrich and Eppinger's book at that time.

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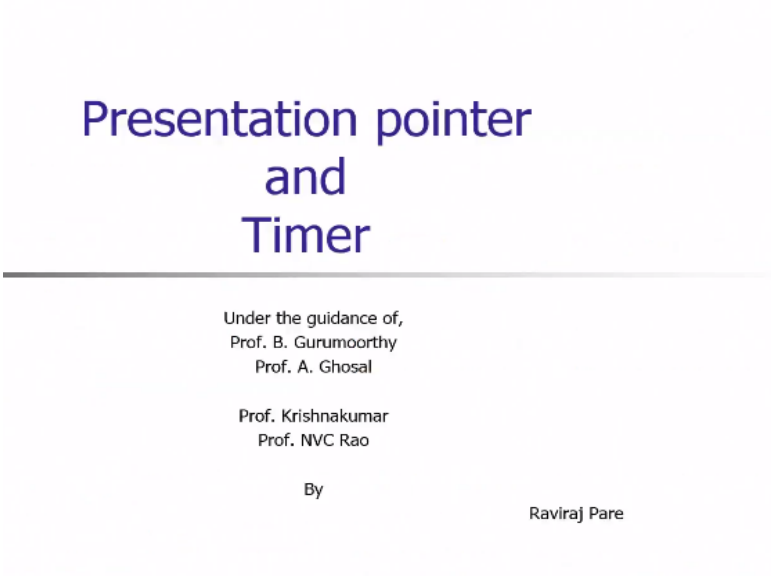

So now I will just quit this for a while and then say here one of my students along with 2 other professors I am sorry 3 of them he is a purely what you called you know functional. He decides all the. Professor Krishnakumar does all the electronics, then professor Gurumoorthy and Ghosal are the people who do all the CAD modeling and I am a person who is involved in the physical or other thing saying he has gone to a large extent of that point or what I was talking about saying what all can be done I will just sort of started and go back again.

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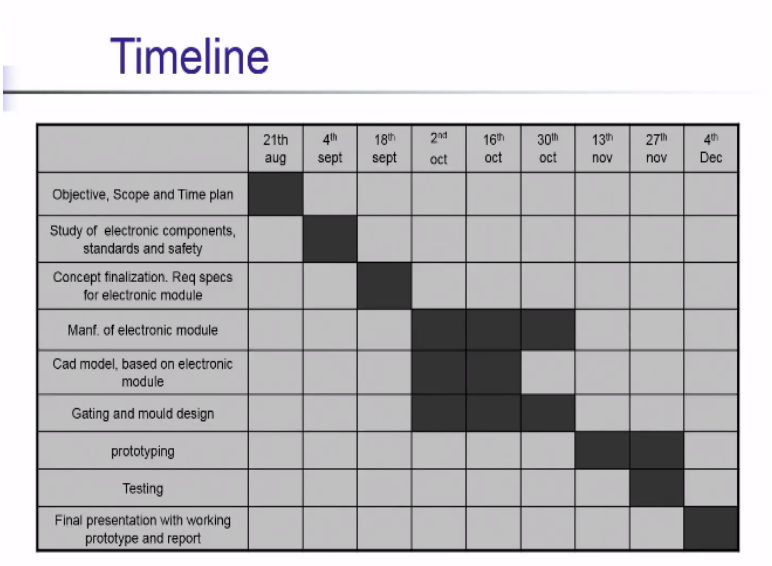

You need a Gantt chart where you start.

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Product Components

The components of the product,

- Laser pointer:

  Gives a straight beam, compact, has a range required in a big auditorium, easily recognized by the eye.

- Electronic timer:

  Accurate, maintenance free, option of electronic display (countdown timer), independent use as timer, etc.

- Rechargeable unit:

  runs on batteries which are rechargeable, and which can be perhaps be charged by 'cell phone chargers'.

- Time and data display:

  An add-on which allows user to see time, and interactive data settings, etc

And then components like you have so many of these components.

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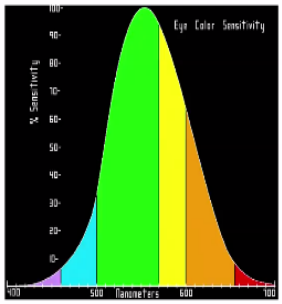
Laser selection

The colour selection of laser was anything but choice of colour!

The options were,

- Red laser: 632nm
- Green laser: 532nm
- Yellow laser: 594 nm
- Blue laser: 473nm



Factors used to decide,

- Safety
- Sensitivity of the eye
- Cost
- Availability
- Size

After gather everything a little bit of technical study saying which is useful for us.

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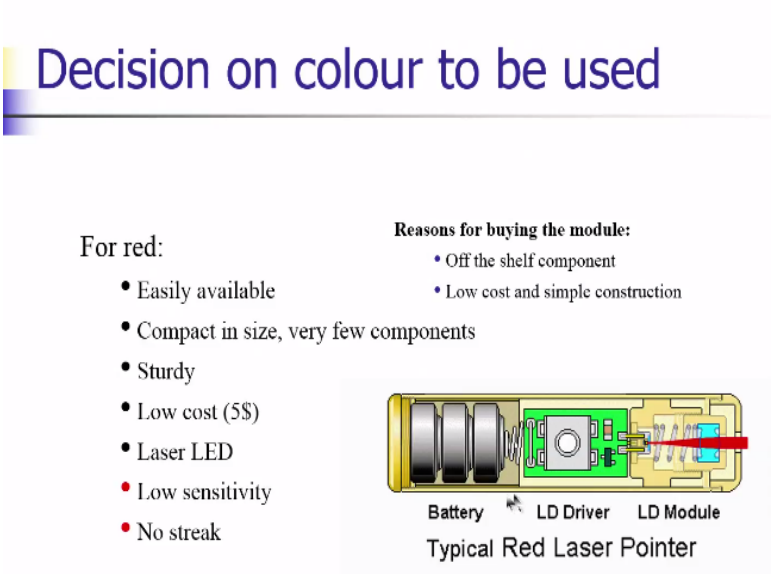

And this is where now slowly we are coming into how do you pack all these things. This is available off the shelf I mean nothing against our what you call hardworking neighbours but everything comes from PRC are now made in China nothing against it there were most of the people I know work there.

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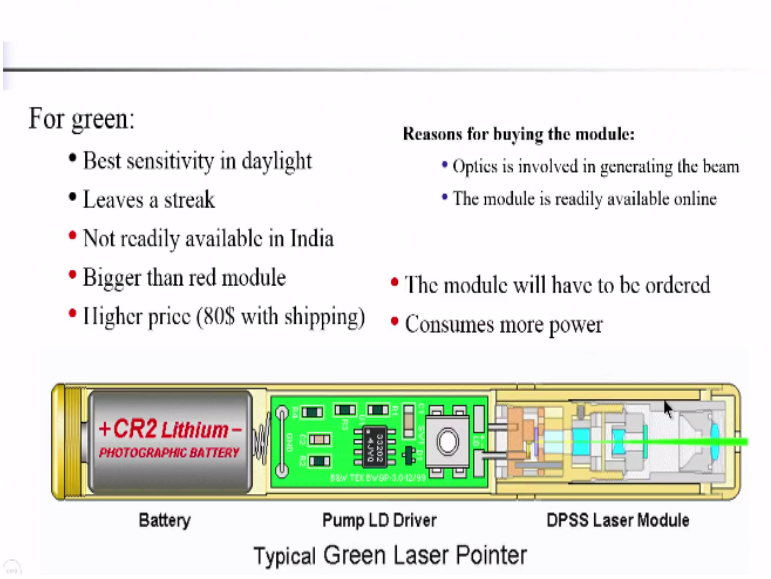

You see here if you observe something everything is here so he has used the built up all the what you call necessary optics here, board here and then something.

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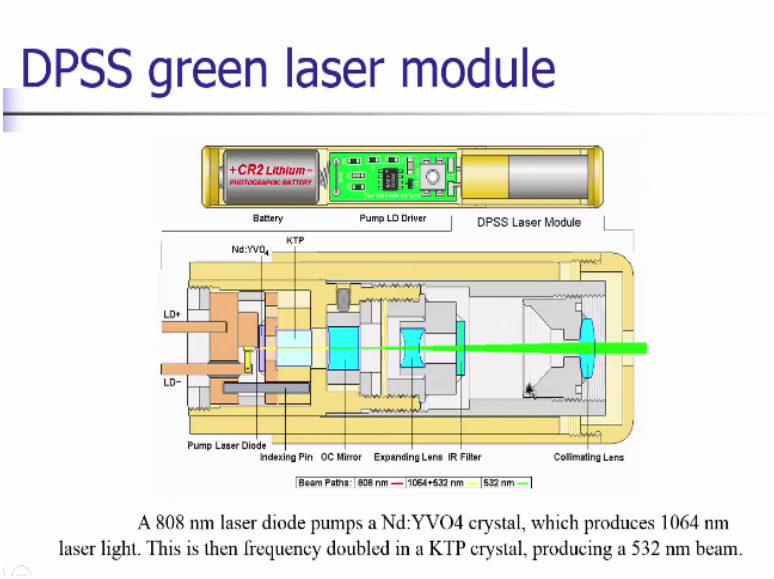

A 808 nm laser diode pumps a Nd:YVO4 crystal, which produces 1064 nm laser light. This is then frequency doubled in a KTP crystal, producing a 532 nm beam.

And then use here tremendous amount of work in making all the stuff and safety timer model concepts and one of this and finally electronics.

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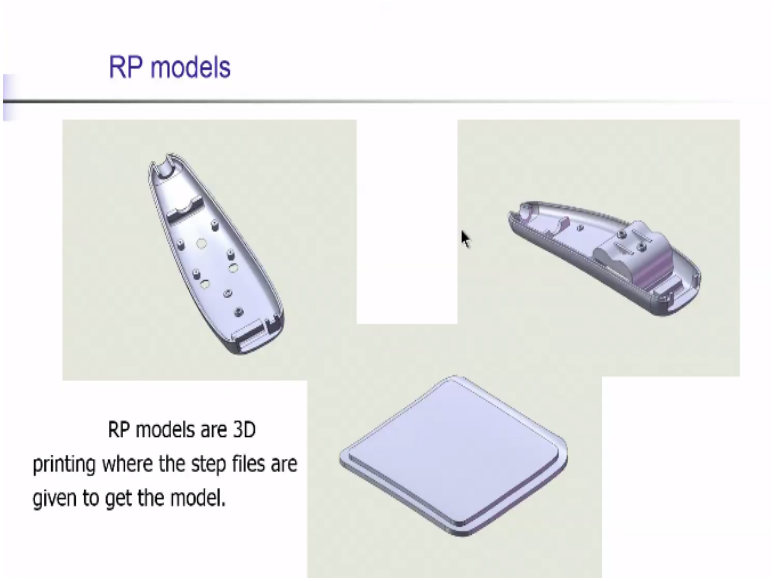

You see here this is ideally a 3D printed model. You see everything has been nicely you have a predict. I will continue with this now very fully you see here. I will stop here I will continue in the next session from where I have stopped. This whole thing I will start from the beginning gain and I will continue and show you the presentation saying this should be the starting point of any 3D printing. Hello I can continue from a little earlier where I had left off.

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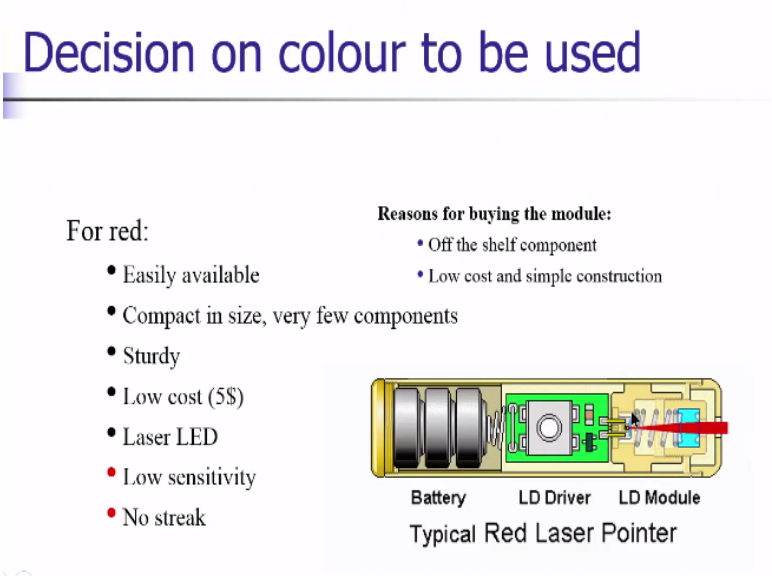

So if you look at my this presentation here it was made by one of our students and the topic is saying how do we make a pointer which has a laser inside which is little more powerful than the conventional tings. So please look at the almost toy thing which is when taken from I am not sure some toy thing is this also has all the necessary things what we think will make a laser. It has a laser diode and then at the back we have all these.

What you call batteries inside I mean a battery consisting of some 3 cells and then there is a button and this is if you press the button it will start working. It is about as simple as that. So this is in fact the starting point where the design student wanted to proceed within now you may want to know why is that we are taking about prototypes all the time when our own interest is to talking about 3D printing.

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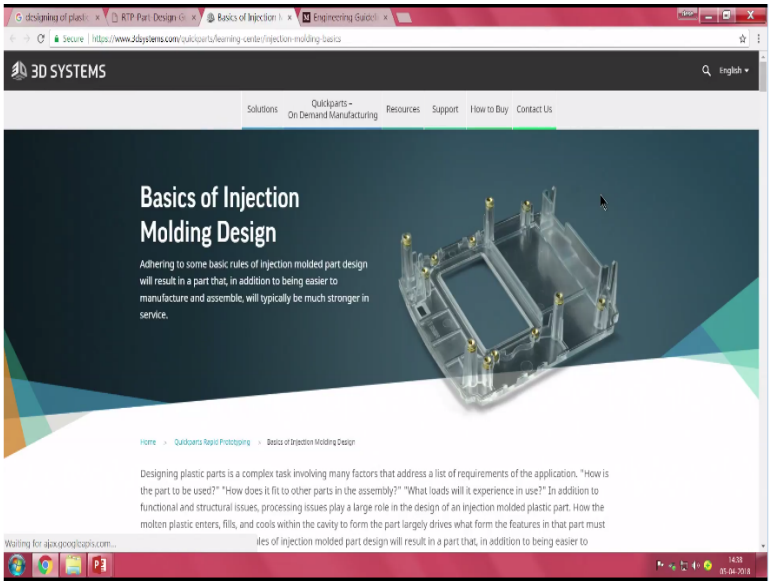

The issue being if I now have a look at my monitor invariably 3D printed parts like this are made for injection molding and then when you make it for injection molding certain what you call simple guidelines are passed. My suggestion is go to this 3D systems, their website and then you can see a lot of things suited.

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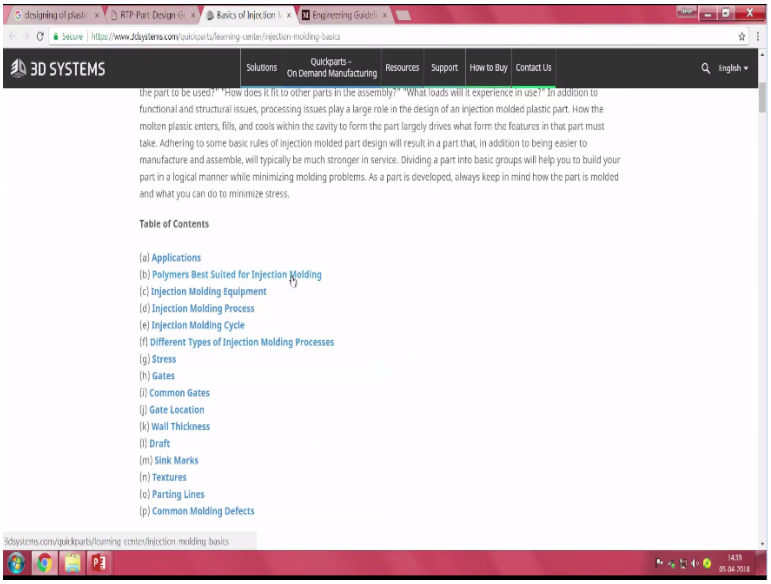

For injection molding and then what you call about wall thickness and draft. So enough amount of data is available. This one is a 3D printed part. Except difference being while just like we have the issue in using these plastic parts the detailing is very critical here. One of them is in case you want to have a metallic insert.

You see here lot of trouble has been taking Bosses have been made and the metallic insert has been inserted here. So same thing if you see my picture here so here this one looks a little like that. So we will notice that details regarding how you assemble things together that contain you to be very similar to the injection molding part design and then I will just try to close this window so that we can get back to it later.

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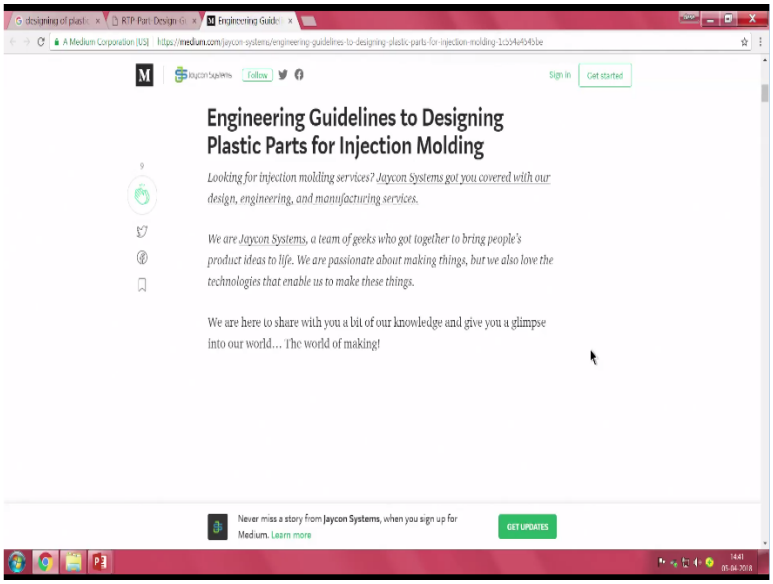

There are engineering guidelines designing plastic parts for injection molding.

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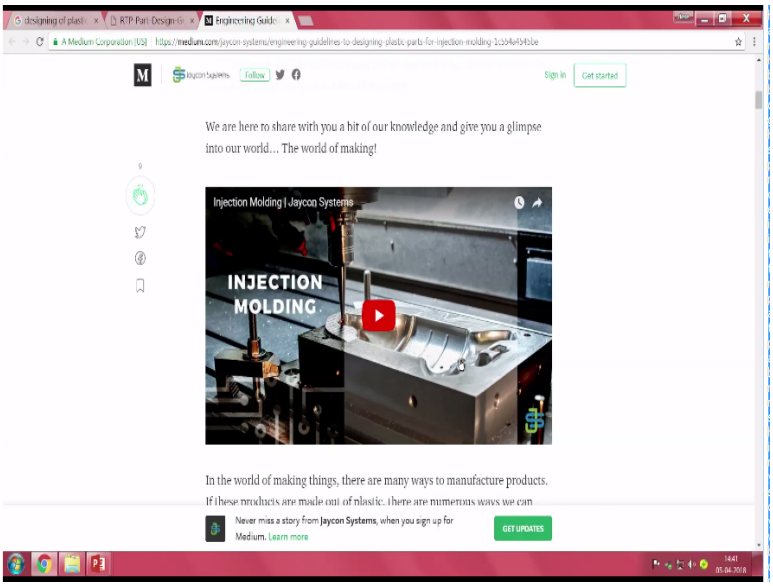

So you see here this one is a small cavity which is part of the injection molding thing or just let me see if it works.

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See here this is a mold if you see here these are those parts which in the morning I tried to show you also detailing is about the same for both of them. This is how actually what you call a small casketing system is working and then this is the usual you know the use think about how to load the machine, how the parts come out you see here the once including all these process and all the gates what is falling down at high volume manufacturing.

The issue being that this is one is the simple small scale press and then some few items like this can easily be manufactured here. So you can my suggestion you can over the internet that one is what you call handle for a screw driver so you can go around and check all these things I am sure there is enough information or enough material is there saying how to make all those parts, how to make things please check it up. I will exit this.

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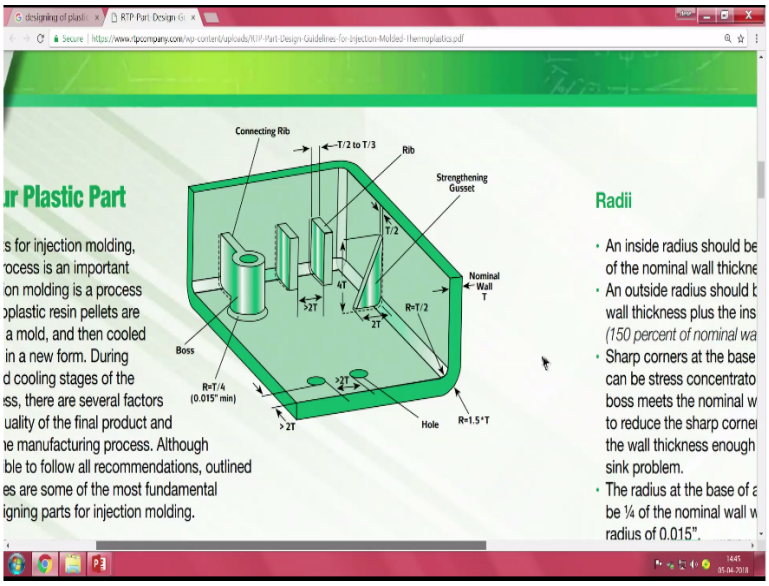

And we come to actually issues and detailing most important is, this is where the difference between an injection molded part and 3D printed parts comes in the case of this injection molded parts you would have noticed that there is a rule applied everywhere saying the corners have to be made with a radius why is it because there is a nominal wall thickness somewhere the material is injected and slowly it is supposed to flow along these lines.

And when it flows along the lines several things happen one of them is the tendency for it to be you know turned a little cold, but then those items are kept you know very much under control and when you want to release it out of the mold you end up with a hand tappered draft, Draft means a small taper such that it falls out easily.

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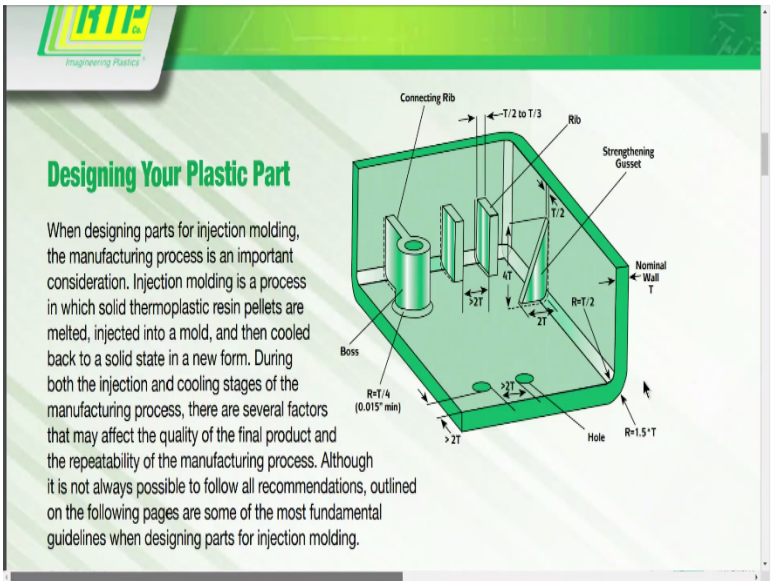

And then a lot of you see all this you know nominal I mean sorry the names that are written here saying this is a rib so that something can be held strong then you have a Boss. A Boss is what holds circular piece insert so that screw or something can be kept there and then you see this is a triangular Gusset which make sure that the these things are you know maintained stiff it is maintained. This is strengthening Gusset.

This is for you know some other rids similar applications slightly better and this picture has lot of detailing and data built into it. So one of them you see here is everywhere they have given small thing saying how far should a hole be away from the edge and then what should be the spacing between the 2 holes because material has to flow around the hole and go to the other one.

Similarly, what should be wall thickness and see here if you see here now what should be the radius that has to be given while it is convenient here 2 sharper radius leads to problems 2 smoother radius leads to another type of problem because in principle the wall thickness has to be maintained constant all over the place. So the wall thickness varies something called shrinkage will occur and the other side and the opposite side you will see the shrink marks on the opposite side.

So details which are very much part of this you have seen that all these details which are shown here as part of these things seen that all of these things are there everything everywhere what should be the nominal wall thickness if nominal wall thickness is so much what should be the radius something regarding the radius is given here similarly what should be the location of the hole size.

And if you go to the top on the other end what should be thickness of the Gusset again same thing happens you see this Gusset is joining this what you call flat pieces so on the opposite side it may lead to a small shrinkage while it is being made.

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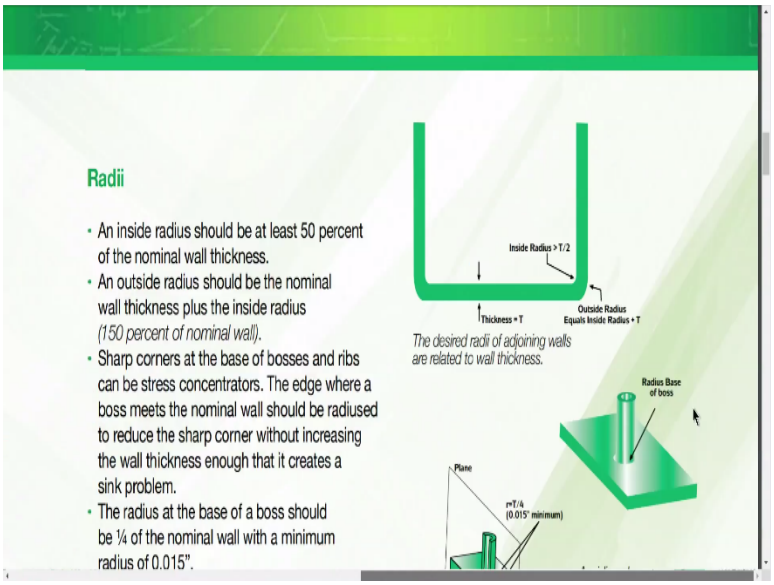

Lot of this detailing actually part of the detailing that is required for manufacturing, but it is in the designer's interest to follow these things. I want to show to this to you at a very early stage because while in this case the radius inside radius is always half of T, outside radius is a little equal to inside radius + T and then base of a bus, these are slightly different in the case of 3D printed part. So to start with it is almost impossible to give this internal radius.

Because in this case it is smooth, you inject the material it goes passes their but in the case of our printed parts it just prints vertically there is something which is stacked up and something which is there, there is no way of see this is printed and top of it now layers of this is printed. There is

no way of building a radius here. If you build a radius it will still come depending on the resolution of the machine.

So like all what you call catalogue claims under favorable conditions whatever they claim saying you can get a resolution of so much 0.1 or 0.05 limiters is for test samples. In your actual sample things will vary. So you will get a small staggered thing with a set of steps here which by itself is not bad but generally it is not worth building up those things. So what generally the people do is they build straight, straight here and if required I attach a rib here from outside.

Or build a rib directly inside or leave it like that and in general the material is not as strong as the injection molded material because in the case of injection molded material lot of advantage you have on formulating of the basic plastic so all of us know that Lego bricks the basic what you call brick with 8 dots 2 x 4 things. The material has been developed specially I do not know who is the supplier whether it is BSF or Roman or whoever this supply very, very carefully for there it is much stronger than anything we know.

Now the original patent is over so we have so many look alike or clone set that are available. Next time you take a clone and then you see you will suddenly notice that the original is always better because somebody has worked on it and made a very important thing. Same thing happens in the case of our plastic lunch boxes. All of you much have heard of Tupperware. So Tupperware usually has a base and then there is a lid on top of it.

The base is somewhat on that lid that particular way it bends and how the lip is created to make it water and air tight has been worked out in detail. Unfortunately, that same rule cannot be applied in case we want to make a rapid prototyping part. So you just need to be familiar with all these data that is they are saying how do you make a rib?

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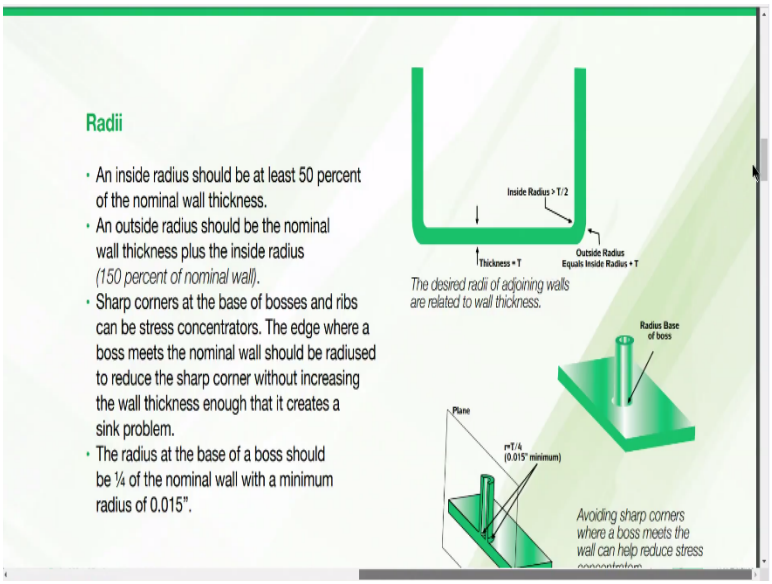

So here they have given a rib has to be you have seen this half degree draft is given here, but in our case you will not have half degree draft. So in case you are planning something should come inside and all that obviously the fit will not be the same. If it is a tapered part fits very easily, but it was a non-tapered part it does not fit. So you have here lot of these data rib should have a draft angle of half a degree easier ejection from the mold.

So these have been we have this unfilled polycarbonate and what you call polymethacrylate then we have ABS and how these materials behave determines a little bit of the design. Do you see here also they have given what is the shrinkage? So depending on the materials you know up to 0.01 mm or that much of percentage shrinkage is there and if you go to semicrystaline materials like polypropylene, polyethylene, and this acetal copolymer the things are little higher this is almost up to the order of 2.5%.

So before we actually commit ourselves to any of these materials and all it makes sense for us to rid is available open source literature and try to make our own first prototype. Now once the prototype is there it is very easy for us to pass it on to a manufacturer who will now take it from there and make your parts. You have seen this during the injection and cooling stages several factors may affect the quality of the final product, repeatability of the manufacturing process is always not possible to follow all recommendations outlined and so on and so on.

So one of the typical thing is imagine if some material is being injected here it will flow from both directions or I will take this corner I am just randomly I am taking this corner imagine material has been injected in this corner and material has a tendency to flow here. Material has a tendency to flow here and it will come and join in this place and we end up with what is called a cold shut.

So by the time they come here if you make it too warm or too hot there are some problems. If you make it cold, you may end up with 2 surfaces joining together with a joining line which is visible. It is a little possibility of a problem. So if you go to the internet tremendous amount of yes in this data is available here.

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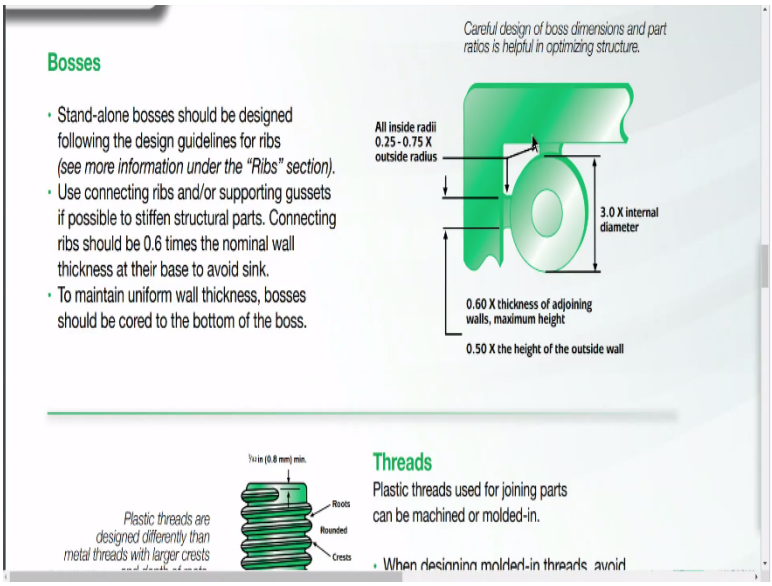

Boss dimensions and pot ratios are helpful in optimizing structures. So in the case of a injection molding we need to make sure that is space is left here which is an advantage, but the same thing in the case of our building up using a rapid prototyping are 3D printing thing we generally for various other reasons there is no risk in our filling this whole area all you need today; make this, make this, make a circle and then fill it carefully because layup will easier and part will become a little more stronger.

They do not do it here because as I told you there is a problem of increasing nominal wall thickness. If you make this problem of increasing nominal wall thickness the whole thing will

become a messy thing especially first of all it does not inject well and during cooling it gets badly affected. These are the small difference which you need to work out when you want to work with 3D printing machine.

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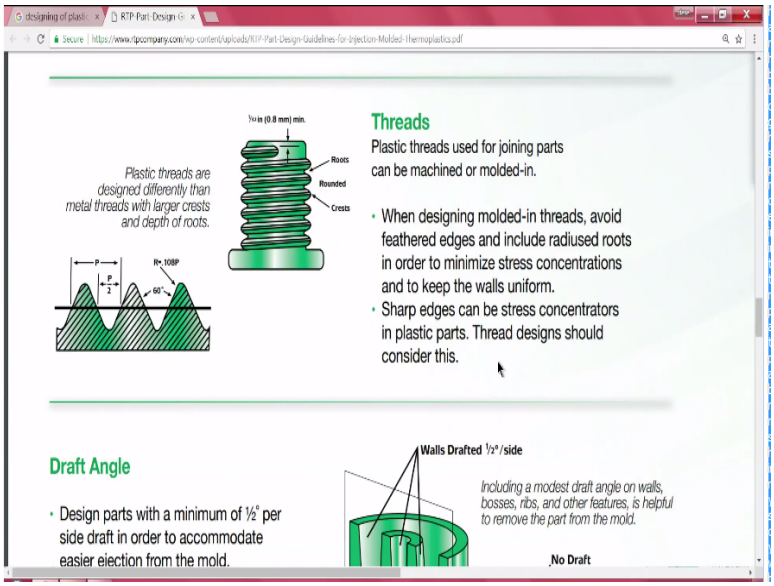

Now you see here threads you have seen that so I am not very sure feathered edge probably means something which is cut into very, very fine things by which in manufacturing usually by turning or by another what you call machine chop making this rounded things is very, very tough either internally or externally. It closely follows whatever dye or what you call tap which is used for making the operation and here since we have a choice.

If you have to leave it straight without this rounded things and what you call this crest and all that sharp edges can be stress concentrators and plastic parts. Thread design should consider this and one more important thing is whatever is said plastic in any form is weaker then the corresponding metal in small sections. There are special plastics with all the exemption they are little weaker in that and especially the common Lucas plastics which we were talking about are best.

So now if I come back to this you see here initial stages we did not know what to do so we over did it. We have put huge hexagonal pieces here and we tried to build a step and then after that we tried to put the, what you call insert here and it is really too much. It has occupied too much

space and wasted so much material and finally after the printing is over when to you try to release the part we end up with an absolute nuisance of a part.