Rapid Manufacturing
Prof. J. Ramkumar
Dr. Amandeep Singh Oberoi
Department of Mechanical Engineering & Design Program
Indian Institute of Technology, Kanpur

Lecture – 40
Rapid Product Development (CAE and CIM)

Good morning. Welcome back to the course on Rapid Manufacturing. I am Dr. Amandeep Singh. We are in a module where we discussing Rapid Product Development. Dr. Ramkumar has discussed computer aided design and computer aided manufacturing. The brief introduction to these concepts have been given by him. I will take rapid product development forward to these concepts.

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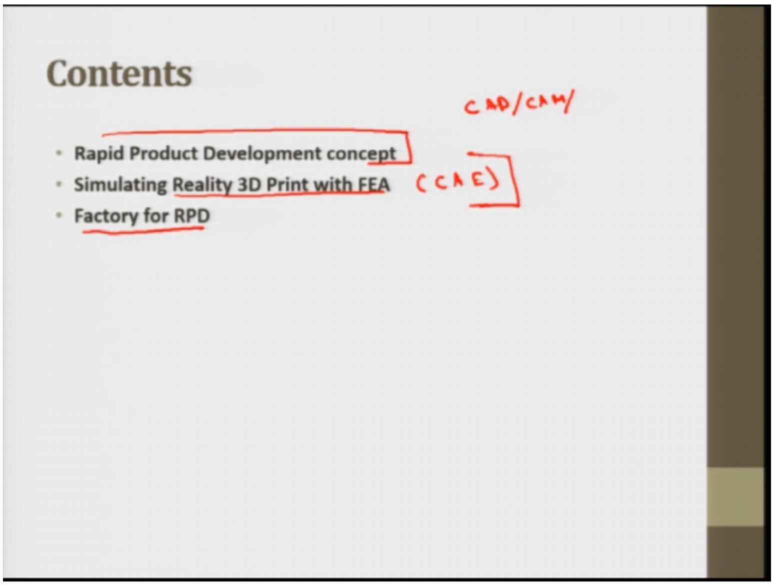

I will discussed the overall concepts of rapid product development first, then I will discussed simulating reality with of 3D print with FEA. FEA is finite element analysis. This is computer aided engineering. We have already discussed computer aided design and computer aided manufacturing a little. Now what is computer aided engineering the design that we make taking the dimensions or scanning the object we make a design then we need to analyse whether this design.

If we select a specific material, then and the dimensions that we give whether it would bear the realistic conditions or not then certain analysis have to be done, stress analysis, thermal analysis, fluid dynamics. All those things can help to conduct an analysis that would make the product viable in a virtual environment and what is virtual and real environment that we will discuss when we will see rapid product development scenario at first.

Then I will discuss factory for rapid product development. In this lecture, I will just introduce what is a reality manufacturing factory or a rapid manufacturing factory, but we will also see plant simulation like we can simulate for the product the various stresses, various parameters of the product are taken into account and are simulated before actually manufacturing the product. In a same way, we can design the factory in a simulation software and see whether our product flow is going properly or not.

So, as people say it is better to fail a simulation that to fail a real product or a real factory. So, those simulations are possible these days.

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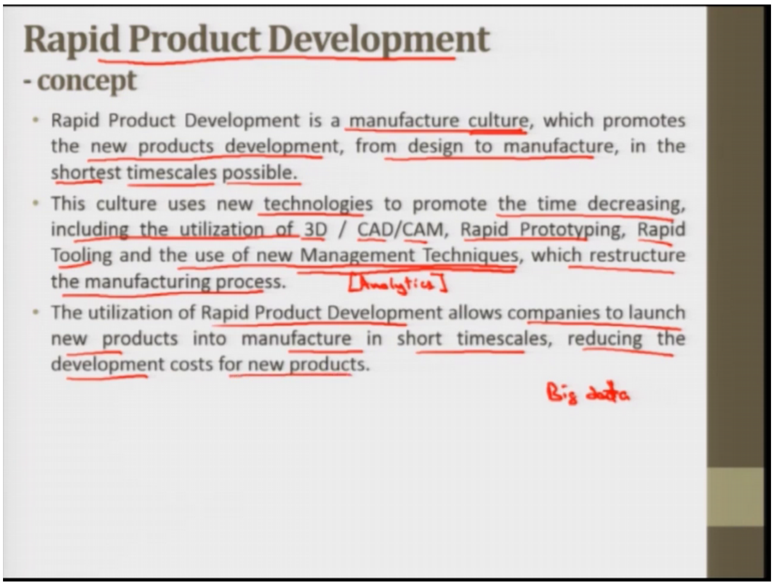

First I will discuss the concept of rapid product development. Rapid product development is a manufacturing culture which promotes the new products development from design to manufacture the shortest time scales possible. Now what is the aim of rapid product development? When I will do factory simulation, I will take time as the variable there time as the main culprit that we need to address.

We need to reduce the times because the short times to market. With the present scenario what is happening? This culture uses new technologies to promote the time decreasing including utilization of 3D, CAD, CAM, Rapid Prototyping, Rapid Tooling and the use of new management techniques which restructure the manufacturing process. So, what is there in the present or in the contemporary scenario worldwide competition has led manufacturers to a basic change into product development, one thing is additive manufacturing is coming into play, second thing is the product design is changing very drastically these days because new and new products are coming in the market and customers are demanding the change.

So, as in the first weeks we discussed that while production consumption cycle the production and consumption keeps happening and the customers keep giving feedback and a product design product, development processes are changing. So, management techniques are also there. There is a big analytics; analytics comes into play then, now this is the part of simulation. We have big data these days; big data is the large amount of data that we need to manage.

So, in order to continue to be competitive manufacture should be able to attain and sustain themselves as a worldwide or world class manufacturers. So, for that these manufacture should be capable of delivering the products in time, satisfying the customers and most specifically products of higher quality and fast to market and at the affordable or the rational costs because of the competitions.

So, utilization of rapid product development allows companies to launch new products into manufacture in short time scales, reducing the development cost for new products.

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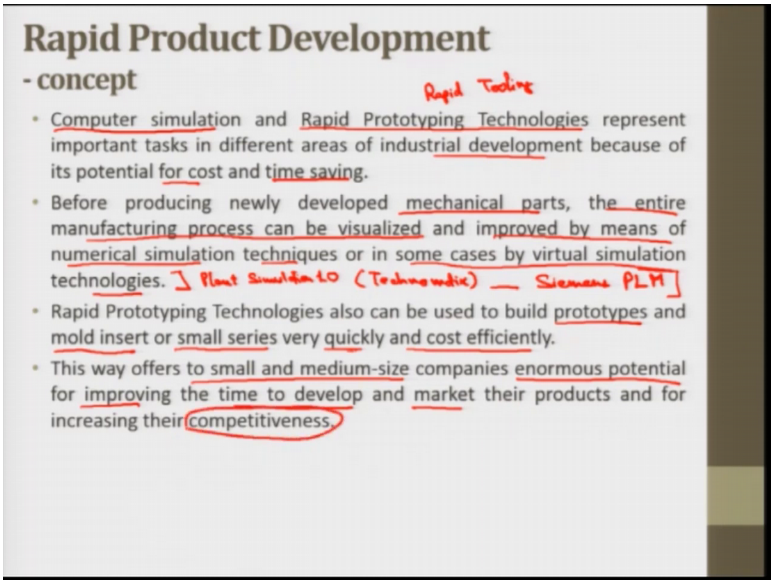

Computer simulation and rapid prototyping technologies represent important tasks in different areas of industrial development, because of its potential of cost and time saving.

Now, companies are finding these techniques to be extremely beneficial and they are being adopted at a rate much higher than ever. The use of a rapid prototyping, rapid tooling technologies, rapid prototyping I can also put rapid tooling here, use of these technologies in combination with existing in house facilities in designing then testing simulating then rapid prototyping then finally, mass production. So, these technologies are being used and these technologies represent important tasks in different areas of industrial development because of its potential of cost saving and time saving.

Before producing newly developed mechanical parts the entire manufacturing process can be visualized and improved by means of numerical simulation techniques or in some cases by virtual simulation technologies. This we will discuss when we will discuss plant simulation. Plant simulation 10 software that is also known as Techno matics we will discuss this and this is developed by Siemens. Siemens PLM software this is the name given to the broader group of modules that Siemens provide. Rapid prototyping technologies also can be used to build prototypes and mold insert a small series of very quickly and cost efficiently.

This way offers to small and medium sized companies enormous potential for improving the time to develop and market their products and for increasing their competitiveness.

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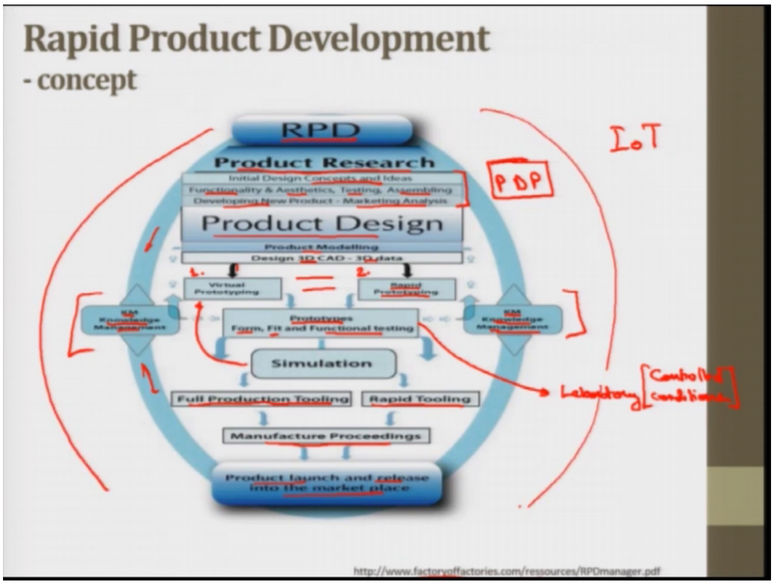

Now, this is the rapid products development architecture or scenario that is taken from this reference here. What this say? This is rapid product development, the external circle the outer circle is. What do we have in between? You can see in the bigger fonts we have product research and product design. Product design is nothing, but the CAD, 3D CAD and 3D data product modelling that we saw.

So, in product research the initial design conception ideas this is the product development process that we discussed in the first week first or second week of this course functionality, the statics, testing, assembling, design for assembly all those things then developing new product, marketing analysis, the different analysis are conducted before actually designing the product what is the need of the consumer, what are the changes are consumer need in the present product, is it a new product, is it a change by evolution or it is a change by innovation those all things we need to identify then is comes the product design. In product design we make a CAD model.

And then we do virtual prototyping. Virtual prototyping and rapid prototyping are put parallel here, but this virtual prototyping would come first and rapid prototyping later. Virtual prototyping is the finite element analysis or computational fluid dynamics or certain other computer aided engineering that we do only on the computer without actually infecting the product that is virtual prototype. Now rapid proto typing is actually manufacturing the product, actually manufacturing the product and testing that product in the realistic or the control laboratory conditions.

So, these two things can happen. Now these virtual prototyping or rapid prototyping or both lead to the prototypes that is we get form fit and functional testing which I just said that we have this in laboratory conditions or control conditions. Sometimes in realistic conditions also this happens like Hero Cycles that is one of the biggest cycles manufacturing company in the world. When they come up with a very new product, the first product the prototype they develop they sell it to the internal customers, internal customers are people who are closely related to Hero Cycles maybe milk vendors or supplying milk within the factory or the people who are the employees of the factory or other people who are closely associated with them.

Then from the internal customers they get the feedback and try to see what is the change if the change is there is that change required then they inculcate that change and then produce the product to make it reach the final consumer end user to the masses. So, that is prototypes. So, we get the form fit functional testing of bikes in this case. So, that can happen also simulation happen here as well. So, here we have simulation and after simulation full production tooling and rapid tooling is done Full production tooling for mass production for big size production, then manufacturing proceedings that we get a final manufacturing then product launch and release in to the market place.

So, this is the final step. In between what is the circle doing. This is knowledge management, knowledge management is new field that is coming up as I said data analytics is one thing that manages tools are to be conducted internet thing is the IOT. Actually we have data, lot of data is already available in many forms documents, internet, catalogues, journals. From the data some information is extracted for the people and that is also recorded.

But to extract the knowledge from the information, knowledge is something that is that has some applicability. If we apply information that we call can call as a knowledge, knowledge is something in the mind of the experts. They have the knowledge, they do not have only information when we collect multiple pieces of information and something come out as an application that can be used it is known as knowledge. So, this knowledge management which is now formal subject in many universities; subject of study or course of study that is encapsulating all these things right. This is rapid product development concept.

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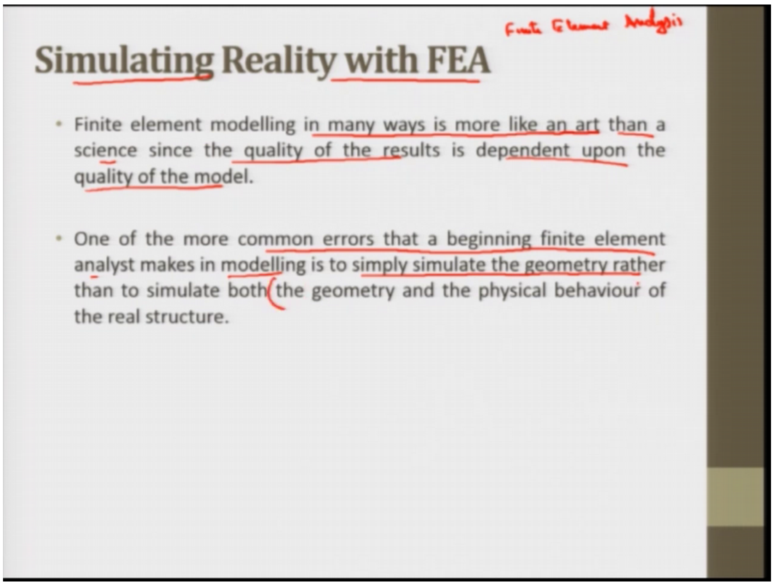

Next I like to discuss the computer aided engineering. In this I will just take an example of a 3D manufactured, 3D printed product that was that is a lever it is used to take the piston off from a machine that lever was made of a metal before. Now it is produced from a polymer which polymer we selected and how the finite element analysis happened there that we will discuss. So, simulating reality with finite element analysis, FEA is finite element analysis. FEA is again it complete course itself we cannot discuss the details or the a complete explanation of finite element analysis or computer aided engineering in this 1 hour lecture.

But yes I will try to introduce you to the overall idea what computer aided engineering does? Finite element modelling in many ways is more like an art than a science since the quality of the results is dependent upon the quality of the model. One of the more common errors that a beginning finite element analysts make in a modelling is to simply simulate the geometry rather than to simulate both geometry and physical behaviour of the real structure ok. If we only simulate the geometry, but not the physical behaviour geometry is just the size.

I need to manufacture this pen holder, it has this diameter in the this and this some diameter smaller diameter, bigger diameter this curvature all these things we can thread scan this that is geometry, but physical behaviour would it be able to hold this pen? What is the strength that is required? This is actually at style as well.

So, do we need to put battery in here? So, what are all those things required? Do we need to provide some rubber, some anti friction coating here. So, that it does not slip on the table. So, all this physical behaviour are to be simulated.

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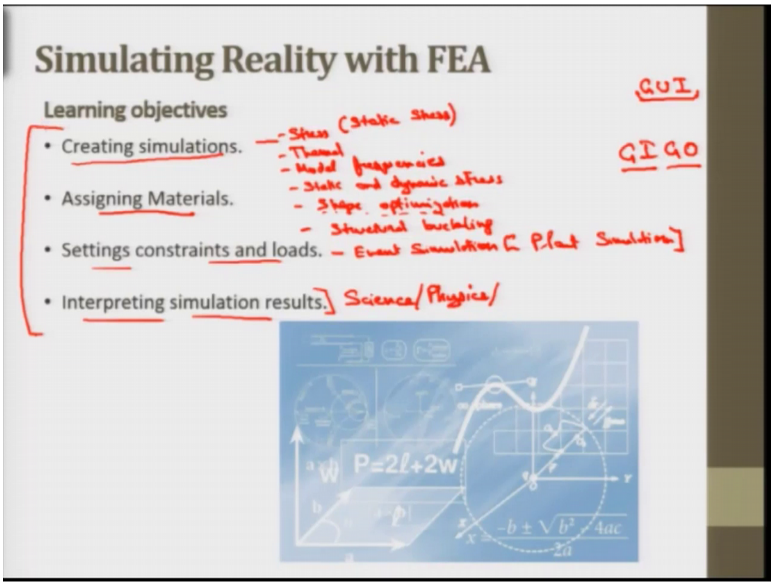

Now, simulating reality with FEA the learning objectives in simulating reality are number one is creating simulations, creating simulation is do we need to do stress analysis or thermal analysis or maybe model frequencies right then we can have static stress, static and dynamic stress, here dynamic means kinematic then we can have a thermal and thermal stresses that is discussed then maybe shape optimisation, shape optimization that what exactly should be the shape of the object that we are trying to produce then structural buckling if it is there, buckling is a phenomenon that is more associated with columns.

Buckling of columns in one subjects that is thought in man mechanical engineering specifically in civil engineering in construction it is actually the when column is subjected to the load from both the sides a compressive load it tends to buckle from the centre that is known as buckling. So, structural buckling this can also one of the simulation other than that we can have event simulation to this I will specifically discuss again in plant simulation.

These simulations can be created and in this presentation we will not discuss all these simulation, but specifically we will discuss stress analysis, stress or I would put static stress only, static stress and along with static stress we can also discuss some about the shape optimisation. Then second objective is assigning the materials. When we are conducting the simulation we can select different materials for instance what first thing is the process that we are choosing and the material that we are choosing that should vary we having compatibility. For instance if I am choosing laminated object manufacturing I should have a material in the form of sheets. If I have choose 3D printing I should have material in the form of wires filed stock or in the form of powders.

So, those things are to be taken into account assigning materials then setting constraints and loads constraints and loads are again the same example the loads that the buckle are subjected to these constraints that this the load will be from this side to this side equivalent, load would be there what will be the load on the in the engine in the centre for that one should know the physics or the science behind the research. This simulations are always GIGO garbage in garbage out. Whatever input you give the output will come accordingly.

So, a researcher or a simulator or an engineer has to know the basic sciences or the GUI as I say graphic user interface of the software. Sometimes though there are software's that have proven would to be very intelligent and one need not to understand the complete GUI of that they have proves proven the results to be very effectively realistic condition that can be trust worthy, but an engineer should better know the sciences behind the inputs that is he is or she is giving.

Next is interpreting the simulation result unless you know the science or I would pay say physics behind the outputs that are coming or the results that are coming we cannot interpret the results. So, that is important. So, these are the things which are generally covered in computer aided engineering.

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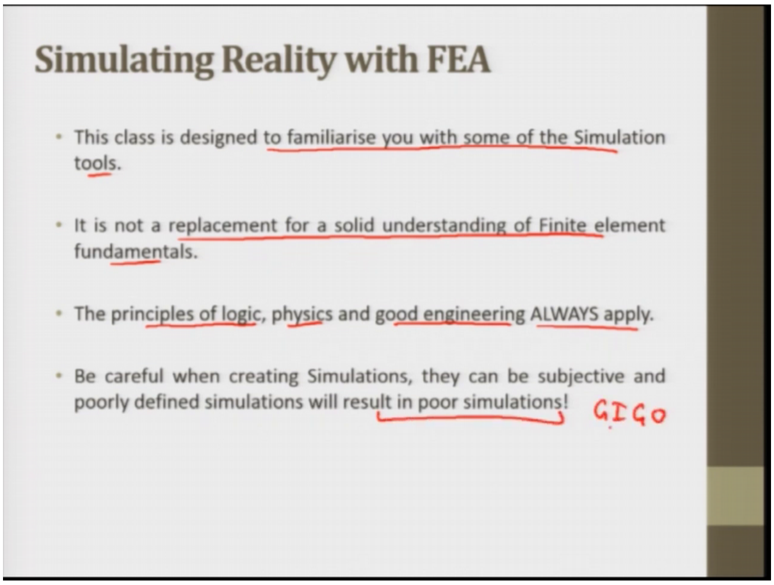

Now, this class is designed to familiarize you with some of the simulation tools. It is not a replacement for a solid understanding of finite element fundamentals.

The principles of logic physics a good engineering always applied as I said. Be careful when creating simulations they can be subjective and poorly defined simulations will result in poor simulations again GIGO garbage in garbage out.

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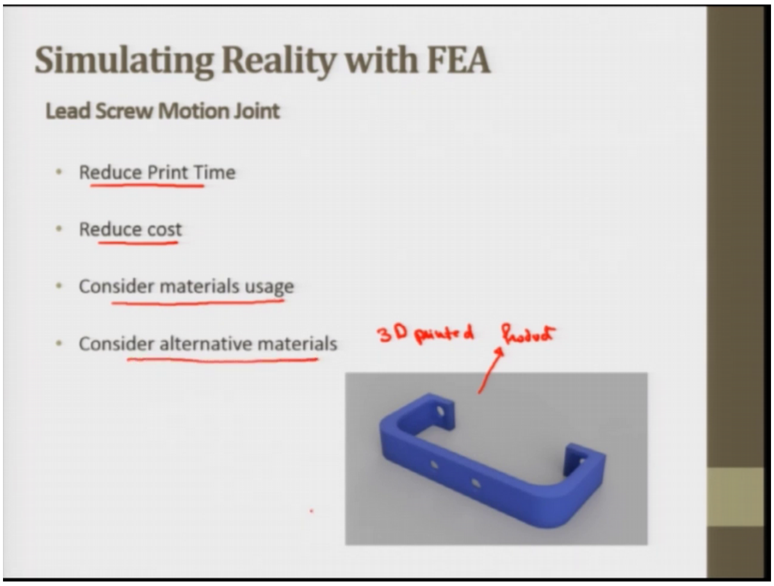

This is the product that we have taken, this is the liver that is need to be designed. This is the final product that we have obtained. Our purpose in this was to reduce the print time because this is a 3D printed, 3D printed 3D printed product. Also we needed to reduce the cost, we needed to consider the material usage and consider alternative materials as well.

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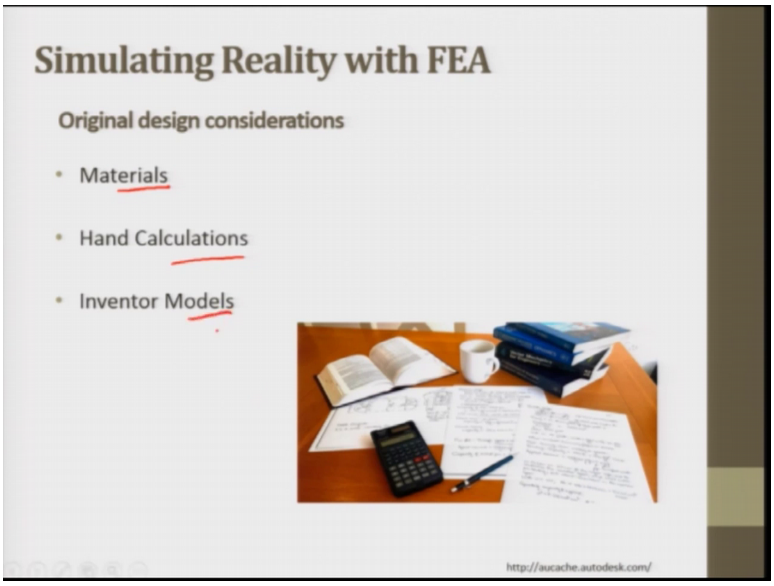

Original design considerations, what original design conditions are there? Originally what person do? He has to have the knowledge of materials then have to do hand calculations their inventor model has to be carried out.

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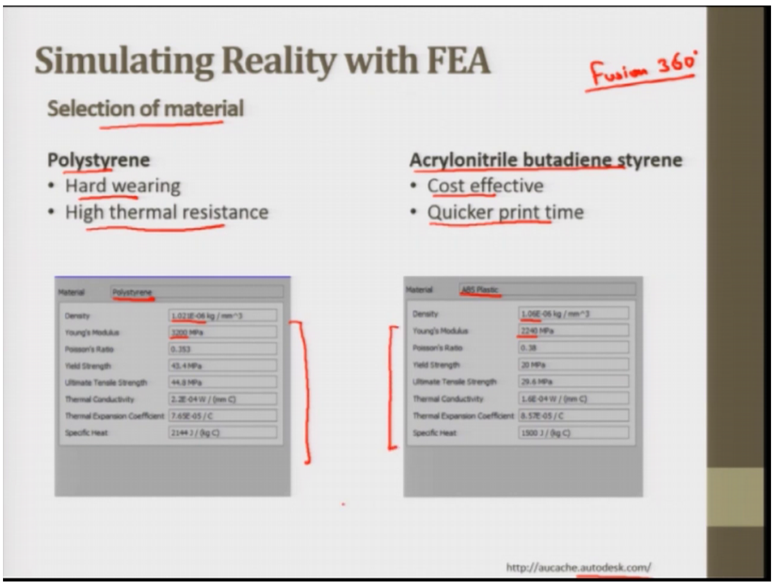

But in simulating reality with a computer software this is actually the auto desk softwares specifically we have used Fusion 360 software to develop this modelling.

And some of the slide content is taken from the auto desk website only. First thing is selection of material, one material for this product could be polystyrene or other could be ABS. Polystyrene the properties were hard wearing, high thermal resistance. ABS was cost effective because of its close availability and low cost as well and it has a quicker print time.

Now, these are the properties which are the files in built in the software. These are called the material libraries, material libraries or we can have certain libraries in the software that carries the information that can be used to put the input. Also we can generate our own material and our own simulations in certain software that provide the provision for this.

Now, this polystyrene has this density, this has density a little larger than polystyrene. The Youngs modulus for the strength is a little higher in polystyrene, in an ABS it is lesser. So, these are all material properties we have already discussed what are the kind of materials.

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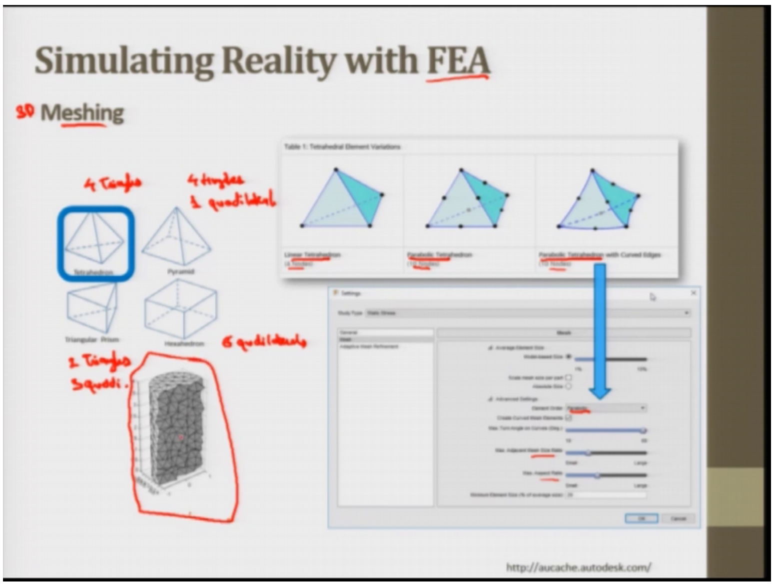

And specifically which material to be chosen that can be finally decided when we do finite element analysis.

Now, first thing is what is mashing? Meshing is as we have seen in the 3D scanning when we scan the model point cloud is obtained, from the point cloud different points are joined together by the software itself and they create a mesh. At least three points are there, three points would make a triangle. So, that is known as mesh. So, what are different kinds of meshing that we produce these are this is 3D meshing. Actually this is three dimensional meshing, one is tetrahedron, another is pyramid if we know the shapes, tetrahedron has 4 faces all the 4 triangular four triangles.

Pyramid has 4 triangles, in one quadrilateral, triangular prism has 2 triangles and 3 quadrilaterals, hexahedron has it is kind of a cuboid it has 6 quadrilaterals. So, these are the different options available different softwares when we select first is tetrahedral, tetrahedral meshing we will select, after tetrahedral selection we can have linear tetrahedral that is with four nodes, parabolic tetrahedron that has 10 nodes and parabolic tetrahedron with curved edges it again has 10 nodes. It all depends all the experience of the engineer who is conducting the simulation what kind of product do we have and how dens meshing do we need and what is the specific strength that we require.

For instance in this product we will see that there are holes this is actually liver that will be taken and we fixed to something. So, these two ends should have higher strength at these points. At the centre we will see where is the loading happening when one is pulling the liver, pulling the piston or put pushing the piston in. So, this is attached to that. So, here we need to have a little denser a machine and at the corners also we need to have literal denser meshing. Let us see how it is done?

So, in meshing this is selected tetrahedron then parabolic tetrahedron with curved edges is selected and this gives this kind of information we selected parabolic tetrahedron as an option and the maximum turn angle all these parameters are set maximum adjustment mesh size ratio maximum aspect ratio these are sometimes default and sometimes it is set. So, this is a mesh that how it looks like in a solid model.

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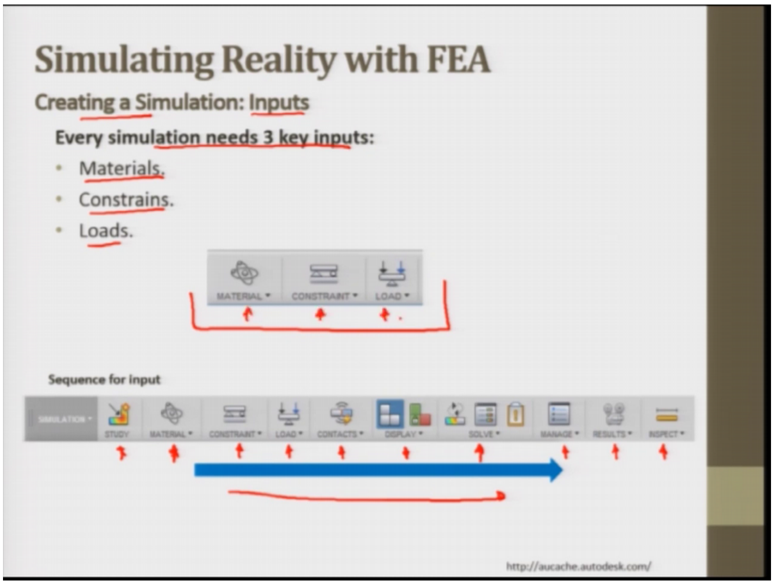

Again to be noted this is a 3D mesh. Next is creating a simulation what are the inputs will simulation? Every simulation needs three key inputs materials, constraints, and loads.

So, in this software these three inputs are just here of one after another it is actually giving everything in a sequential order in the specific fusion 360 software, first we need to put what is a setting we are going to do then what material is there, after selecting the material we can put the constraints that are we need to identify then what are the loading conditions then what are the contact points, what do we need to display, what do we need to solve thermal analysis, static stress, buckling etcetera, and what are we trying to print here, what do we need to manage, finally what do we need to obtain and finally, we can inspect or validate?

So, this is a sequence of input that is going on here. So, these are the major three countries that will work on material, constraint, and load.

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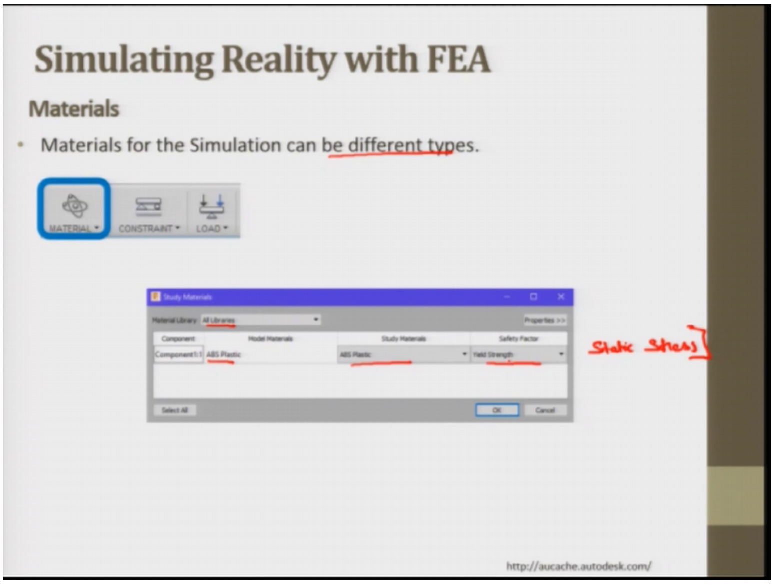

First thing is material, materials for the simulation can be of different types like first when we click material this window pops up for all libraries, we select the material libraries and for the component the components in named component one ABS plastic is selected and this ABS plastic selected. We can also select the safety factor what do we need to safe here yield strength because we are doing static stress, static stress analysis has to be done.

So, we need to add fix the yield strength here. So, we need to put yield strength as a factor here safety factor.

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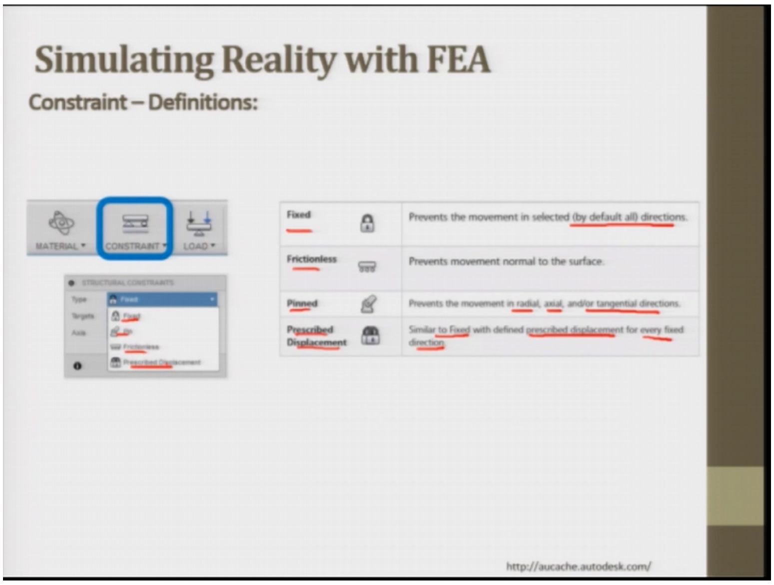

Next is constraint after material we have constraint here. So, what are the constraints to do those need to be fixed is it fixed constraint, friction less constraint, paint or describe displacement. Fixed is that prevents the movement in the selected by default all directions, friction less is prevents movements normal to the surface. fixed for instance there is some screen that is happening, it is fixed at this point some screw is there.

It is fixed at we fix it here it cannot move at all. So, the point where holes were there in the end of the livers it is fixed. Friction less is when we need to slide something and it prevents movement normal to the surface. Then pin is kind of a hinge when it is moving something like this, pin is something for this is pinned here and it can move like this. This is it is pinned here at this point it is pinned and it can move like this. So, this is pinned it prevents the movement in radial axial or tangential directions then prescribe displacement this is similar to fixed we define prescribed displacement for every fixed direction. So, in fixed kind of a choice in all directions the movement is fixed.

But in prescribed we can change some of the movements to friction less or pinned or non constraint. So, these four options can be selected. So, we selected fixed at the ends.

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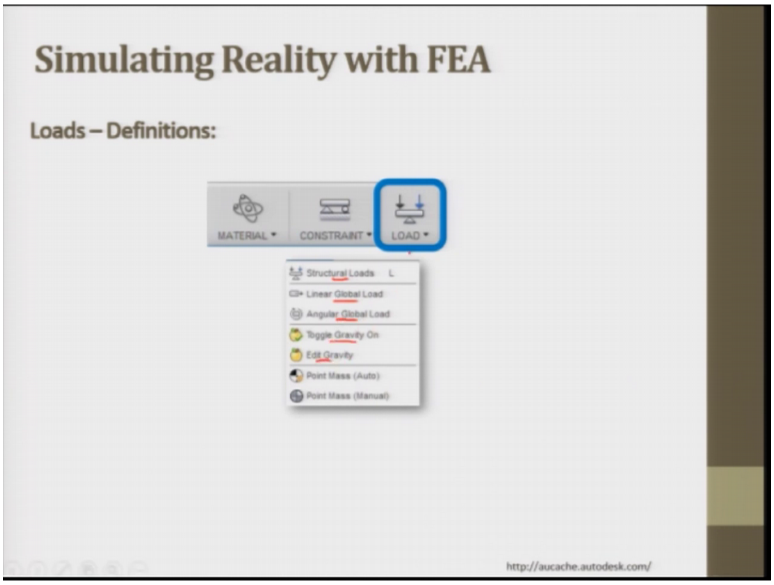

Then is load, load what kind of loads are to be put structure loads, linear loads, angular loads, toggle gravity, added gravity all these options are available.

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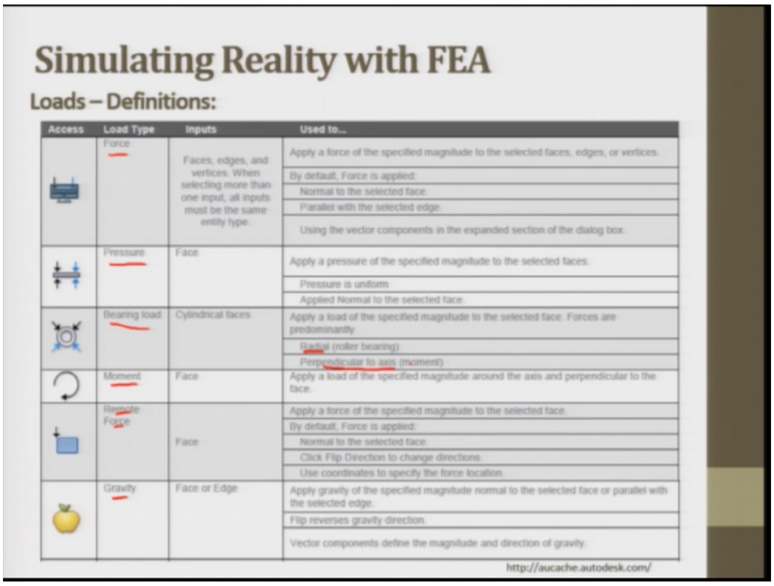

Then we put the load specific loads those are there. So, these are the load definitions we can put force, pressure, bearing load, movement, remote force, gravity etcetera. What specific magnitude of force apply on faces or edges? So, what is the normal force or pedal force and pressure? What is the pressure that is applying on the face? What is the magnitude of pressure the bearing loads.

All these load types of specific magnitudes and their specific conditions are putting here. For instance in bearing load radial or perpendicular to axis that we need to tell. Now these load definitions are given. Now these three things are fixed.

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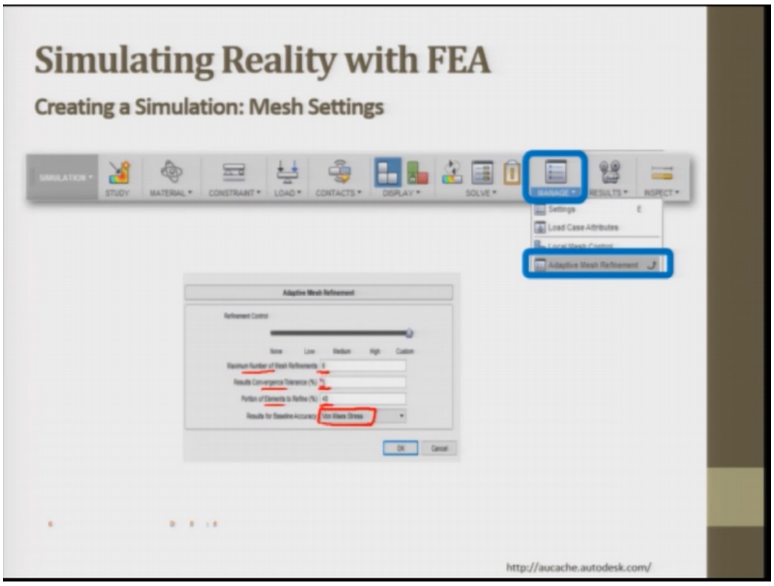

Now, we come to manage. In manage we say, we need to have adaptive mesh refinement. In adaptive mesh refinement we get this customized, maximum number of mesh refinement is 6. So, result conversion tolerance is 5 percent and portion of elements to refine is 40 percent and the specific mesh and why magistracy specific model is chosen here.

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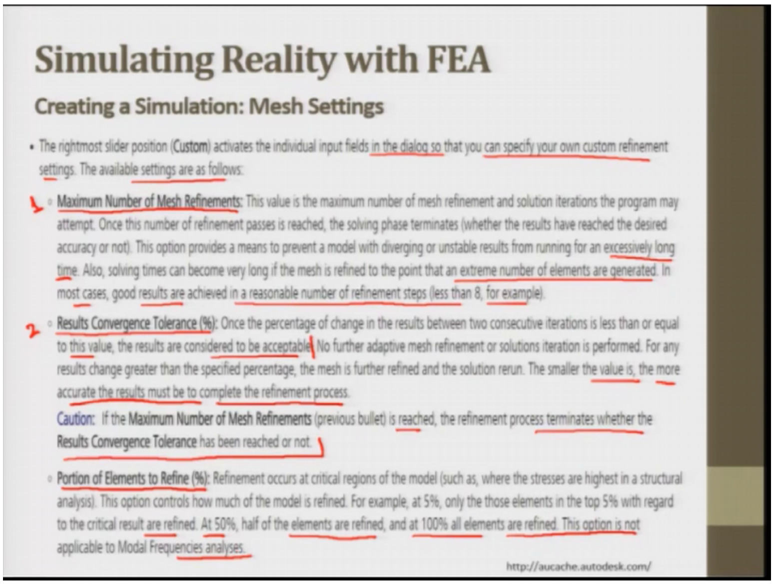

So, this is creating mesh settings how mesh settings happen. So, this is the right most slider portion or the custom activates the individual input fields in the dialogue so, that you can specify your own customer refinement settings. The available settings are as follows maximum number of mesh refinements, results convergence tolerance percentage portion of elements to refine. So, this is the details of these three options those are there. Maximum number of mesh is convergence tolerance and portion of elements.

So, what is the maximum number of mesh refinement? This value is the maximum number of mesh refinement and solution is the program may attempt. Once this number refinement passes is reached the solving phase terminates whether results have reached the desired equation of this option provides a means to prevent a model with diverging on stable results from running of a oven and excessively long time

So, when mesh refinement is maximum it stops the program there, it will not rather simulation it would not waste that time there. So, this is maximum number of mesh refinement that we allow and that is put as a value 6 here. So, also solving times can become very long if mesh is refined to the point that and extreme number of elements generated. In most cases good results are achieved it in a reasonable number of refinement stuff less than 8 for example. So, mesh refinement number is generally put lesser than 8 to optimise the time of the simulation. Now results convergence tolerance once the percentage of change in the results between the two consecutive integers are less than or equal to its value to the specific value that we have put in we have put this value as 5 percent

The results are con to considered to be acceptable, the 5 percent tolerance is acceptable. So, that is we have put. No further adaptive mesh refinement or solution iteration is performed. For any results strange greater than this specific percentage the mesh is further refined and the solution rerun the smaller the value is the more accurate the results must be to complete the refinement process question if maximum number of mesh refinements is reached the refinement process terminates whether the results converges tolerance has been reached or not. So, this is the priority that is taken by these software. This is taken later. Mesh refinement is the first priority and second is results convergence tolerance.

Third portion of elements to refine, refinement occurs at critical range of the model such as where the stress is the highest in a structure analysis, this option controls how much of the model is refined. So, for example, if 5 percent only those elements in the top 5 percent with regards to critical results are defined, at 50 percent half of the elements are refined and at ha 100 percent all elements are refined. This option is not applicable to modal frequencies analysis. So, this is the portion of elements to define. 50 percent of elements are refined while conducting analysis. We have put this value as 40 percent and convergence tolerance is as 5 percent number of mesh refinements as 6 so, interpreting the results.

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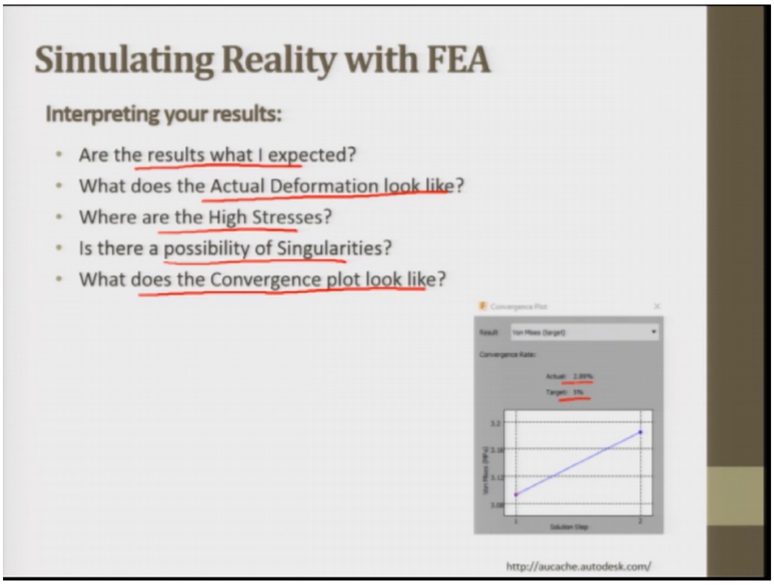

So, what are the results that we expected from here? So, what does the actual deformation look like? Where are the high stresses? Is there a possibility of singularity? What is singularity? We will just tell what does the convergence plot look like? These things we need to see. So, base line target here put was wire meshes. So, this is a wire meshing mega Pascal and solution step is something like this actual and target, actual is 2.89 percent convergence rate.

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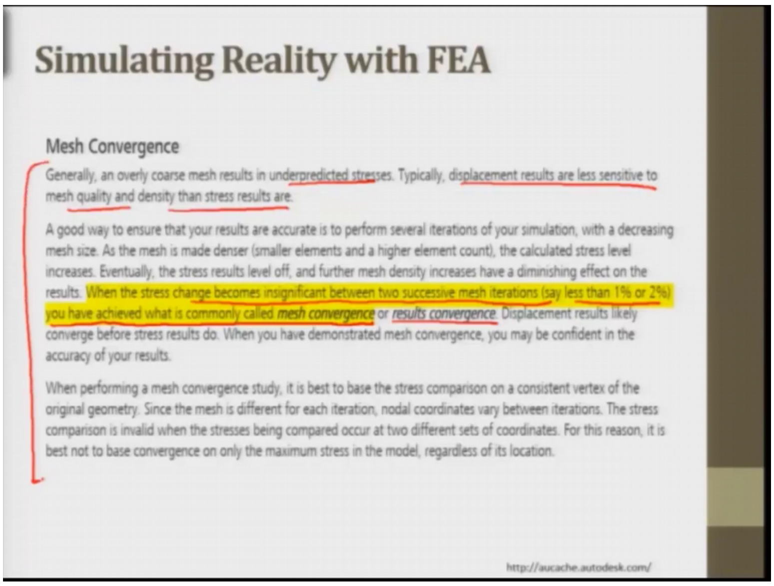

So, mesh convergence generally and overly course mesh results in unpredicted stress is typically displacement results are less sensitive to mesh quality intensity then stresses are.

When the stress changed becomes insignificant between two successive mesh iterations say less than 1 or 2 percent you can have or you have achieved what is commonly called mesh convergence or result convergence that is the finally, mesh convergence has happened and final results can be seen or obtained. So, this is what is it is telling to say you can read this all.

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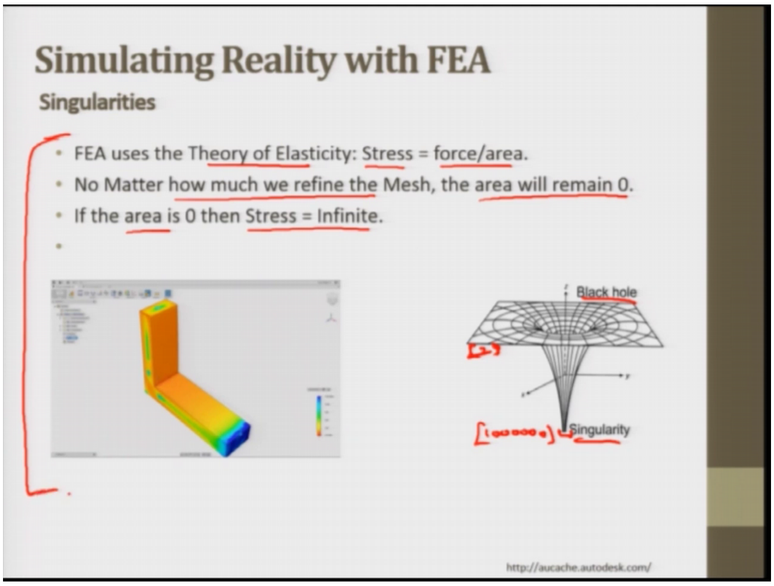

Now, singularities, what is a singularity? Finite element analysis uses a theory of elasticity that is stress is equal to force per unit area. No matter how much we refine the mesh the area will remain 0. So, if the area is 0 then stress is infinite.

So, this is known as singularity. At some specific point it is like a black hole. At some specific point it shows that it is a very high stress. So, infinite stress this is known as singularity. So, these are the certain issues that finite element analysis person faces. There are certain errors that could happen while we are conducting this FEA analysis, finite element analysis. The modelling errors due to simplifications we try to model for the real world yet not able to do 100 percent more simplifications is sometimes lead to error, sometime discretization errors that reside from the creation of mesh that discretization or the division of mash is not proper then numerical errors for the solutions of the equation those we are putting here.

So, these errors can be many. This singularity is also one of the issue I would say. So, a finite element model will sometimes contain this kind of singularity when the stress is very high or infinite at specific point. So, this is singularity. Singularity can be confusing because it may cause an accuracy problem inside the model, which implies the problem with visualisation because singularity extend the range of stresses. So, it has extended the range of stress here this means that smaller stresses can appear to be negligible. Let me put a number this is a million units of stress.

Is only two units? So, this looks to be negligible. So, this is why singularity is a problem here. What causes singularity? The certain causes of singularity the basic cause is the boundary condition sometimes are not put very fine. So, we are not having any singularity in our product, but just to give you an introduction what is singularity I have put this slide.

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Now, creating simulation, in this specific product we will create a simulation and this is the first step we just take the product and test joint V 1 is the name given to the product and we have selected this specific document settings and this is a body that is generated.

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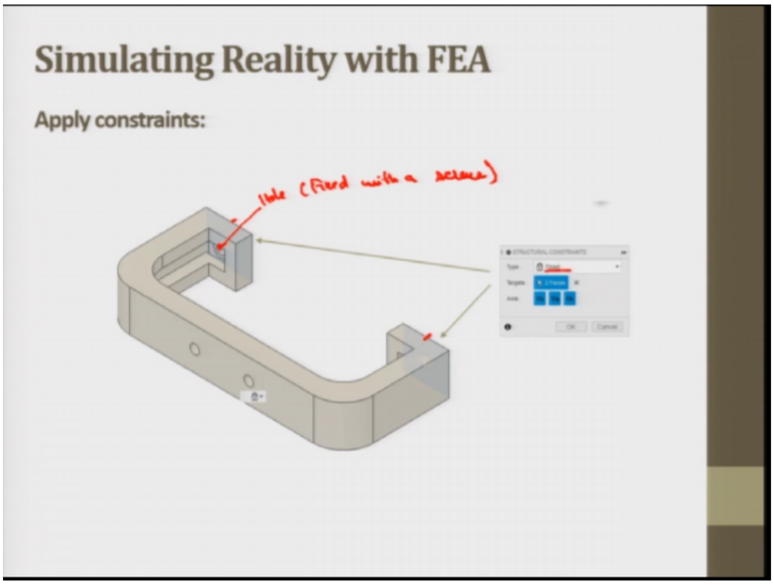

Then we apply the constraints this structural constraints as I said these are fixed. This cannot move because it has to be fixed there is a hole here, hole that has to be fixed with a screw that is why these are fixed structural constraints are there fixed one.

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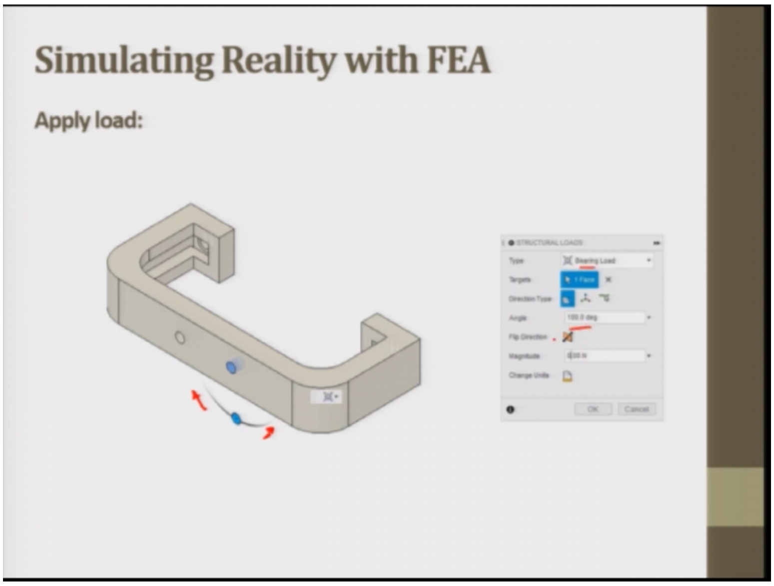

Then we apply load, a bearing load is applied here bearing load is this can be move in this direction and this direction then it is applied on one phase angle can be one 80 degree this bearing load is applied.

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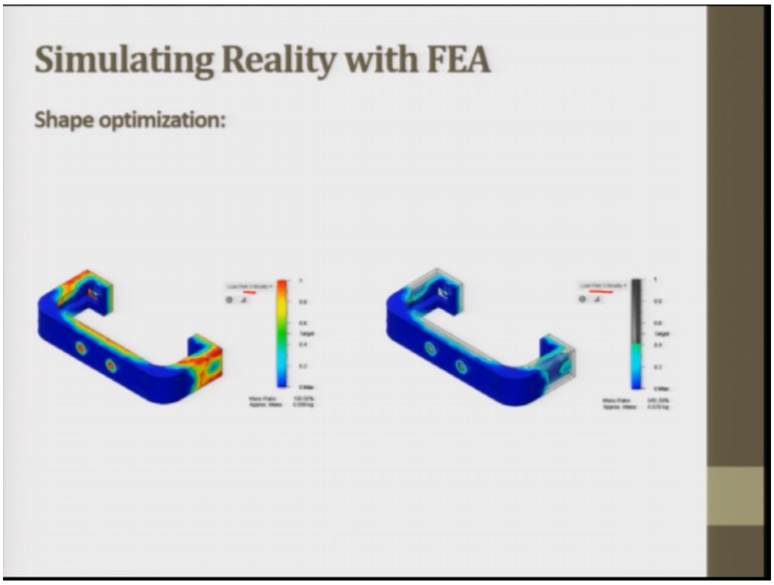

Then is shape optimisation, in shape optimization you can see that this is the load path criticality, but specific shape.

So, we can see the maximum load it is it is showing mass ratio from 0 to 1 here. So, the maximum load is at these points.

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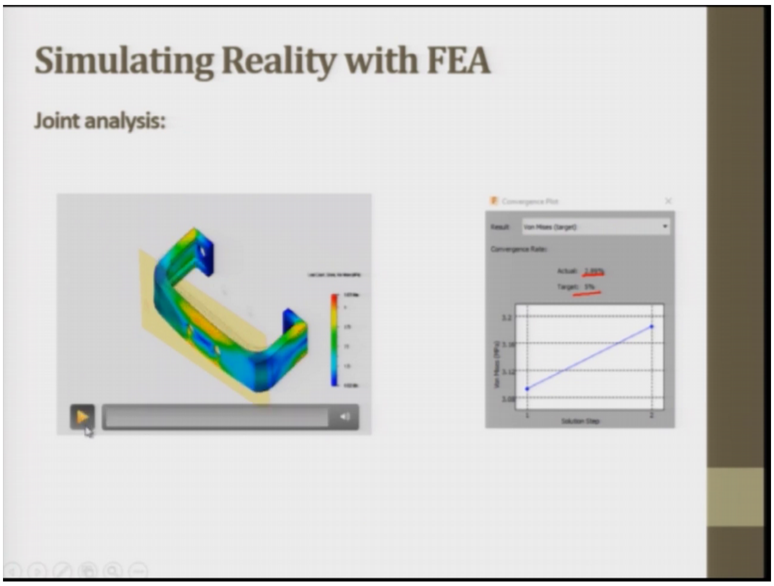

Next is joint analysis, in joint analysis we added this one vertices as a target. So, actual was 2.89 percent target was 5 percent. So, I have a video for you here, a short video. You can see the joint analysis. How the joint moved? When we this is how it moves. So, this is a animation that is there in the software.

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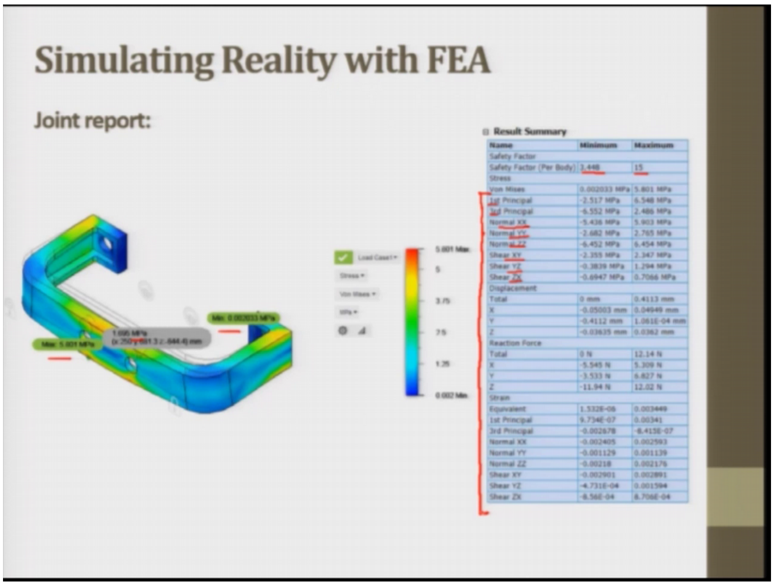

So, next is joint report that is generated. In joint report we finally, get this specific material and these summaries there.

So, safety factor body is 3.44 has minimum and maximum is 15. So, the different principle stresses first principal stress, third principal stress then stress is normal to xx and yy and zz planes then shear in xy and yz and zx plains. So, all these parameters are printed here.

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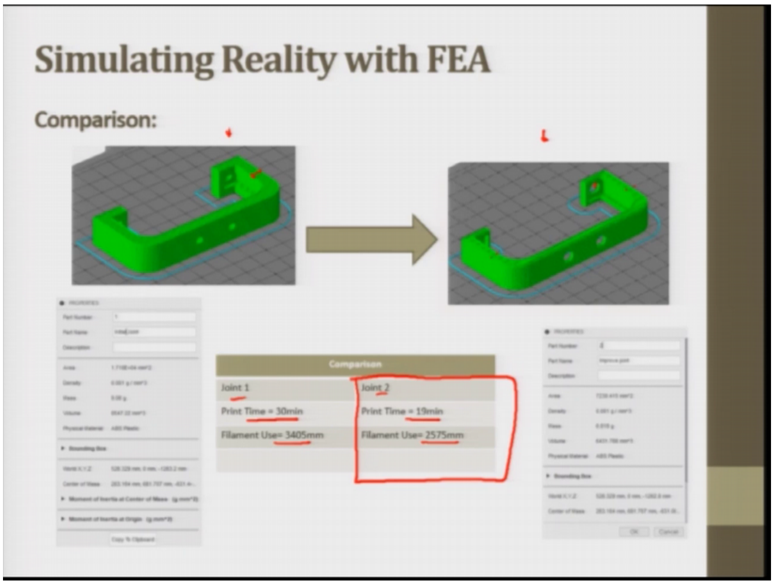

Finally we make a comparison between the properties of the initial and the final joint that we are doing joint one and joint two, the two shapes of joints this is shape one shape two in this you can see this hole is larger, this hole is smaller this width is higher, this width is lower. These two are compared and print time for joint one is 30 minutes, print time for point two is 19 minutes.

So, this filament uses 3 for 0 5 of millimetres and this case the filament uses lesser this job both joints are acceptable, but we are having lesser time in this and also the strength is acceptable. So, this is finally, selected. So, this is a broad example of finite element analysis. We can conduct a detailed analysis on thermal or on many other different parameters. So, I have taken all the parameters just introduction part was this.

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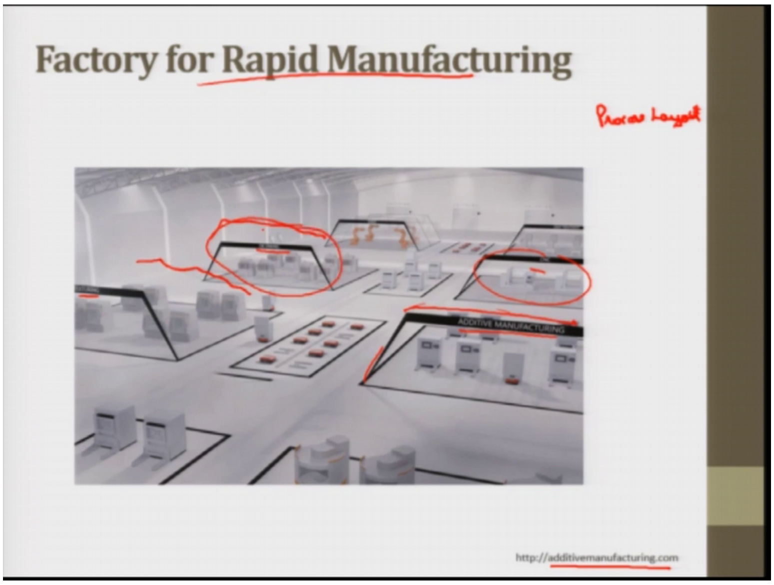

Next is factory for rapid factory manufacturing. Now, this is a figure it is taken from additive manufacturing dot com. It is showing different sections, this is additive manufacturing section, this is CNC sections. This is centring section, this is texturing section. It is showing the kind of a layer that is known as a process layout. I will just leave the layouts when I will discuss these simulation plant simulation.

So, this is a process layout it is showing that additive manufacturing this one part of the factory in the present scenario where we already have different machines here different set up, additive manufacturing can be put as one of the sections where only additive manufacturing happens. So, this is only one process additive manufacturing. This is only CNC machining, this is only sintering process it is happening. So, this is a kind of a process layout.

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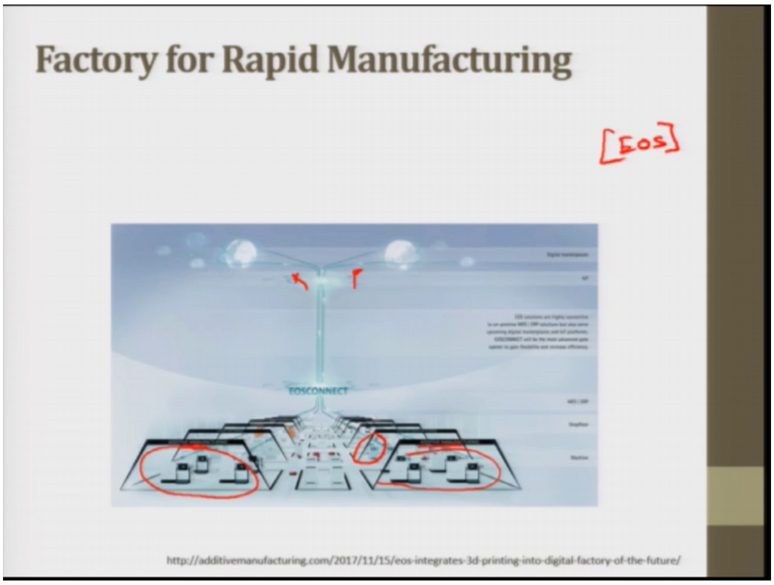

However the complete additive manufacturing process can have different additive manufacturing machines in one section, for instance this is all 3D printing, the second one is all selective laser sintering, this third one is all laminated or sheet manufacturing. So, these all can be there. What it is showing? This is an a again I have taken from the EOS systems which is a big company that manufacture or provide the software suites and the hardware for additive manufacturing they have given this connection with the cloud.

So, this is the factory for future or digital manufacturing we get data from the cloud and the data is being provided to all the units separately and the manufacturing is happening. There are a very less human intervention and on the shop floor in work your interacting with the computers and designing there and the data is just transferred from the cloud here.

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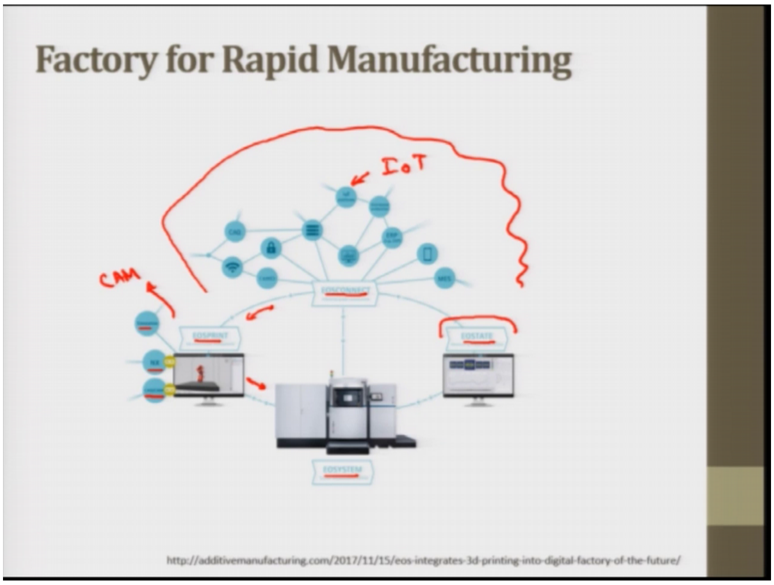

So, this is a clear presentation of that EOS connect, EOS print, EO state, EO system. So, these are different suits those are provided by EOS, for instance EO state this one is an automated and intelligent multi monitoring suit that enables customer to conduct a real time quality insurance of all the production and quality relevant data. It is composed of 4 different monitoring tools. For instance system for bad melt pool exposure etcetera then EOS print is an open a productive CAM tool, this is a CAM tool. It is showing it here it is a it is not simulation CAD CAM and NX design is there.

CAD and CAM tool it allows the business to optimise the CAD data using EO system. So, it supplies the data and does all the analysis that we just discussed finite element analysis other analysis and put the data here for where this data being received you can see the directions this is in either directions. So, data is being received from different modules it is web based design you can say web way or tell communicated design in which internet of things IOT internet of thing is playing a part. So, when with a bundle of new features that enhance productivity such as Z segmentation a specific unique exposure patterns all those things are coming these days.

So, these are different features those are coming in the current systems. This EOS connect as a study is very important, they are not only a solutions that connect with enterprise resource planning, but also serve upcoming digital market places or internet of things platforms. So, this is the next step towards a comprehensive or user friendly machine park surveillance.

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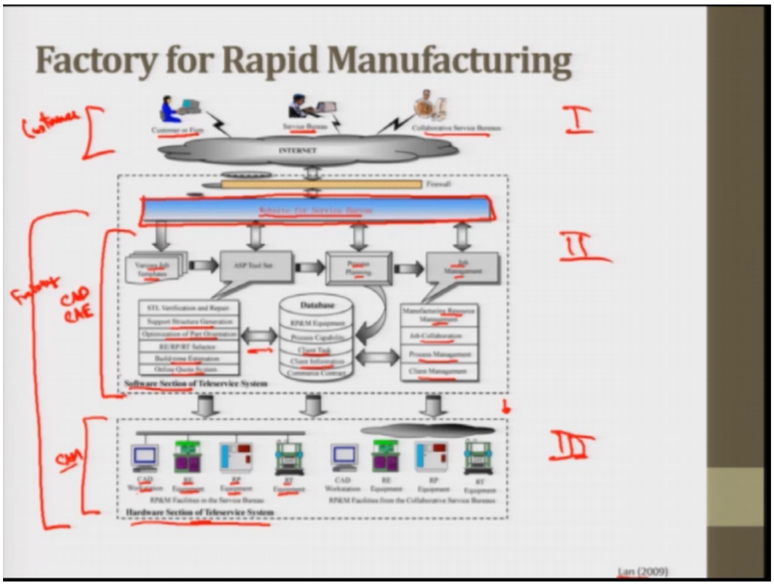

So, this is happening also an extensive research is done by LAN in 2009 and he developed an web based raid manufacturing architecture. What he said an internet customer or form or service burro a collaborative service system can provide the information and this information is what it is using some website of the manufacturer and they to use various tools, various job templates are already available which interact with this is the main thing web based website that is interactive with them.

So, they have the ASP tools that process planning a job management this is all the factory part. So, this is customer this is our again the part of factory only and manufacturing this is actually completely this is factory. So, here we have CAD CAE all those things and here we have manufacturing. So, what it is telling that the data base that already there that rapid prototyping and equipment are there all those data base client task, client information they interact with the different machines those are available and different parameters are taken into account that is built time estimation online course system of mission optimization or part orientation suppose structure these are different parameters.

Then what they need to do they need to manage the job as well that is manufacturing resource management, job collaboration then process management, client management and they finally, give the input to the manufacturing that is computer aided manufacturing in which the CAD work station is there, CAD work station can be here as well in the second part I will put this part one, part two, part three. CAD can be in part two and part three both this is reverse engineer equipment. The cad work station can be in part two and part three board and after we have reverse engineering equipment in rapid prototyping equipment and repeat rapid tooling equipment the finally, rapid tooling happens and after rapid tooling the final product is taken to the mass production.

So, this is hardware section it is mentioned very clearly, this is a software section. They are putting it software section, the second part this is a hardware section, the third part this is the web based manufacturing that is new concept that is being applied by many of industries.

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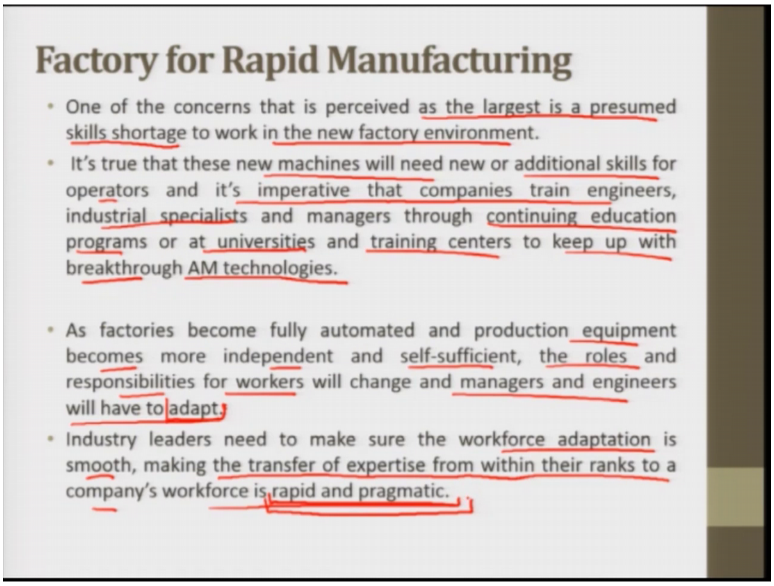

Now, for this kind of this setup the present skills of the manufacturer the production people would not work, we also need to have this specific level. One of the concerns that is perceived as the largest is a presumed skill shortest to work in the new factory environment.

It is true that these new machines will now need an additional skills for operators and its imperative that companies train engineers in the specialist and managers to continuing education programs or at universities and training centres to keep up with breakthrough additive manufacturing technology. So, this is a good news for the students or the people who are taking this courses that these skills are required for the present scenario that is coming up

The future manufacturing is digital manufacturing in that needs the skills from all the different streams not only in engineering, but also in data management in designing through website and different modules the customers changing demands what are the marketing strategies all those things needs to be done. So, as factories become fully automated and production equipment becomes more independent and self sufficient the roles and responsibilities for the workers will change and managers and engineers will have to adapt the present scenario present situations.

So, industry leaders need to make sure that the workforce adaptation is smooth making a transfer of expertise from within their ranks to a company's work force is a rapid and pragmatic because we are talking about rapid product development we cannot have any leverage in the skills as well we cannot allow any weak points here. So, this is all supply chain management that we are talking about where human resource is also one of the link of the chains.

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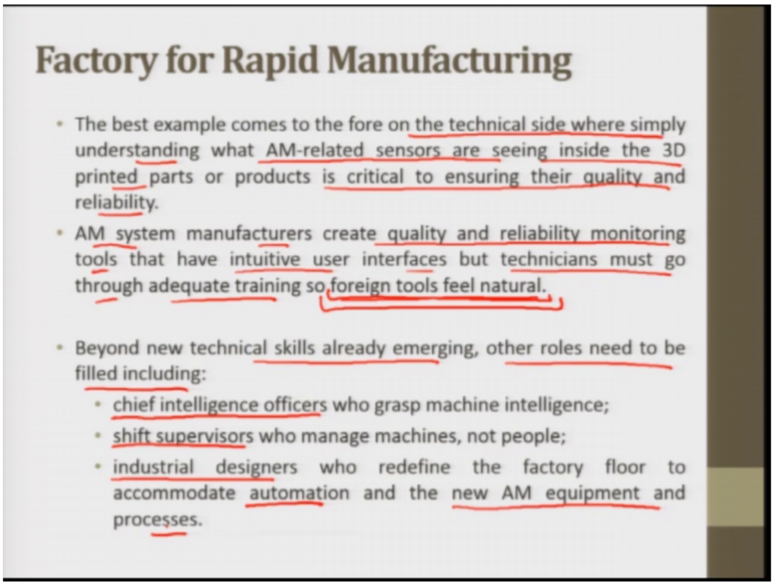

The best example comes to the fore on that technical side where simply understanding what additive manufacturing sensors are seeing inside the 3D printed parts or product is critical to ensuring their quality and reliability. Additive manufacturing system manufacturers create quality and reliability and monitoring tools that have intuitive user interfaces.

But technicians must go through adequate training. So, foreign tools field natural to them. So, this training continuous training has to be conducted. So, beyond the new technical skills already emerging other roles need to be filled including chief intelligence officers who are grabs the machine intelligence, shift supervisors who manage machines not only people who manage machines as well and the people with them, industrial designers who redefine the factory floor to accommodate automation and new additive manufacturing equipment and processes.

So, this is the factory for rapid manufacturing and also have touched a little about digital manufacturing.

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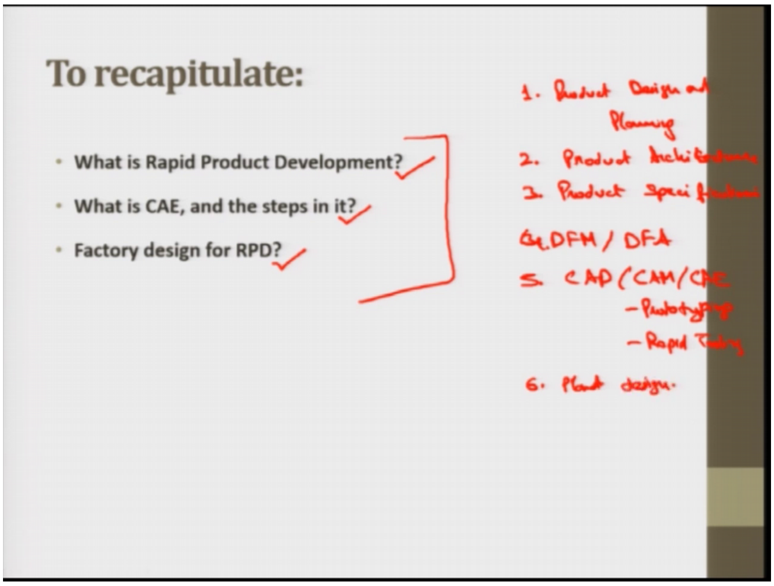

So, to re recapitulate we discussed what is rapid product development, we discussed what is computer aided engineering and certain steps in it, we discussed what is rapid design for rapid product development. So, this is rapid product development process and we have discussed these issues here rapid product development, computer aided engineering and factory rapid product development factory for the additive manufacturing. We will discuss the factory simulations in the next lecture and also we will see what is the factory what is the kind of that we can choose specifically for additive manufacturing and how event simulation can help to simulate the realistic conditions

in the computer only when we use specific software we will use Siemens Techno Matics software. So, this is rapid product development we have and we have covered these topics as I said also in rapid product development that will just like to list them again one should be sure about the product design and planning, number two the product architecture, number three product specifications. The difference between architecture and specifications is in architecture we define the product requirements scope gather the data manage requirements in product architecture we translate and realise the functional requirements determine the types of product architecture that can be used actually.

And in product specifications we establishes target specifications. If refine the specifications and function analysis has conducted after this the DFM or design for manufacturing, design for assembly all these things we have already discussed in the previous lectures then we come to the computer aided design and computer aided manufacturing and computer aided engineering.

So, this includes prototyping rapid tooling and all these things and also we need to have factory or plant design. So, this is what we have discussed in raid product development. Next we will take the product lifecycle management. First I will like introduce to products product lifecycle management in the next lecture, then we will go to the plant simulation. So, let us meet in the next lecture.

Thank you.