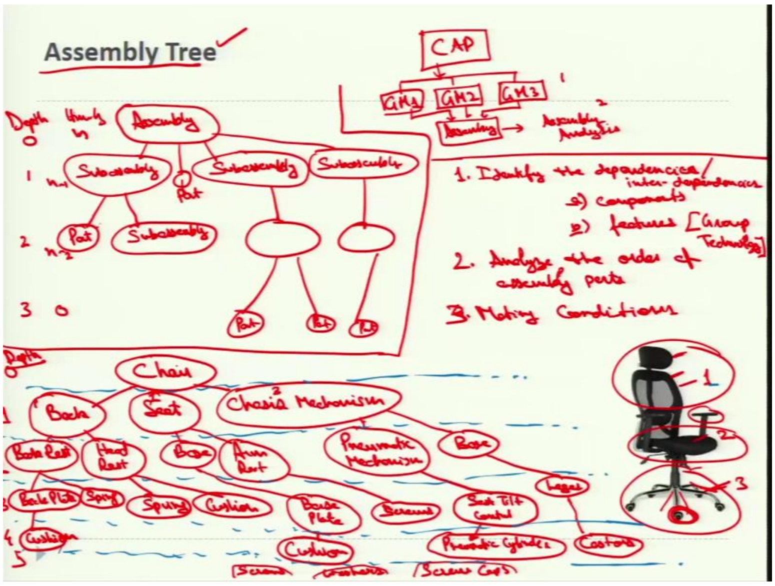
Computer Aided Decision Systems - Industrial practices using Big Analytics
Professor Deepu Philip
Department of Industrial & Management Engineering
Professor Amandeep Singh
Imagineering Laboratory
Indian Institute of Technology, Kanpur
Lecture 33
Assembly Tree

Welcome back to the next lecture on Computer Aided Design and Decision Support System for them in Computer Aided Manufacturing.

(Refer Slide Time: 00:24)



Let us talk about the Assembly Tree. Assembly planning is a very important aspect when we talk about Computer Aided Design and Computer Aided Manufacturing. When I say a CAD system (Computer Aided Design system) has a geometric model 1, geometric model 2, geometric model 3 and so on, these are all connected to have an assembly. This assembly model is now taken for the assembly analysis. Like the example of the pen that I took in the last lecture, the fit of the pen, the cap and the body of the pen, how does this assembly work? This is the assembly; geometric model 1, geometric model 2, is the body, one is cap, two is body, three is my back, 1, 2, 3, these three combined, refill is something replaced, this is also a fourth part. So, these geometric models, how do we combine them to get an assembly out of them. So, then we do the assembly analysis.

Now, this is taken through a phenomenon known as the Assembly Tree. In an Assembly Tree, we represent the hierarchical relationship between the various parts of an assembly in a very natural way. An assembly is divided into several sub-assemblies at different levels. For example, this is sub-assembly at level 1 or I would say depth of the levels and it goes in assembly at level 2 only. So, each sub-assembly is taken at a depth and is composed of various parts. So, leaves of the tree represent the individual parts or the sub-assemblies, sub-assemblies would be the upper levels and we keep on going down to the lower levels to have our assembly tree. Finally, concluding to the components of the body. For example, if I have a complete assembly here and I have a sub-assembly, another sub-assembly at one level, these are connected, then the sub-assemblies would have their parts, at some point it could have a sub part, or it could have finished here or it can have a further sub-assembly. Here, if it finishes here at first level only it is my pat. Similarly, things keep on going. Till the point we are only left with single components, these are all pat.

So, this is my depth and hierarchy, this is depth 0, hierarchy is n. If I keep on going down this is depth 1, depth 2 that is the detail of the assembly's, depth 3 level, hierarchy is n and here hierarchy is n-1, it is n-2 that is n minus is depth, or n-3 which is here n is 3 only, it becomes my hierarchy level 0 till the end point. So, assembly planning is a key to creating a successful assembly. It is specifically used when large assemblies are there.

For instance, we need to have a big assembly of the Rolls Royce engine itself, the assembly planning has to be there. So, there are models which are known as exploded views or we have the different components put in a single drawing. So, different views are there, where we try to see the assemblies in different parts, but assembly planning is always part of our Computer Aided Manufacturing System.

So, the important issue is not only creating the assembly, but also updating it whenever required. So, whenever there are changes in the design, there are the changes in the analytics feedback that we have taken from the customer, so, then updates should be done automatically and correctly. So, that is why there are CAD models which are assembly-based systems and component-based systems are also there. For example, Preview and 360 is a software that is assembly-based software. SolidWorks is an example of a component-based software, where each component can be varied separately. In an assembly-based software, if you vary one component the whole assembly has to be altered individually sometimes. So, it depends which kind of software we are using, how independent is a software from the other components or the components are related to each other are not. Generally, changing the component dimension at the base level, that is at basic library level. Changes the dimension in the overall assembly itself, that happens in the assembly-based software.

So, that is why it is important to have proper assembly planning. If I talk about assembly planning or assembly tree, let me take an example of an executive chair, this is the chair there, you can see different components are there, we have the complete chair, chair has a back, it has a seat, it has the chair mechanism here. If I try to put a tree for this, let me say I have a chair and the sub-assemblies are back, seat and chassis mechanism. This is 1, 2 and the whole mechanism 3. 1, 2 is this, 1, 2, 3. I can put 1.1, 2.1, 1.11 or so, or I can put the depth level for the, so at the back you can see we have backrest, we have headrest, so, let me put those components here. These are connected. I have a backrest, then I have a headrest. In the seat, we have the base of the seat. Then you can see we have armrests here. In the chassis mechanism majorly, we have a pneumatic mechanism and we have the legs in which casters are there. In the chassis I would put a pneumatic base.

This is the next level: depth 0, depth 1, depth 2, let me come to now depth 3 levels, in which the backrest I have a back plate over which net is there. So, I will call it net or cushion whatever we can think over. So, we have an adjustable spring in the chair, adjustable spring at the headrest and adjustable spring at the back. So, we have a pneumatic mechanism that can uplift and down the chair whenever required. So, caster wheels are there which helps to rotate the chair in the base. So, all these go in the third and the fourth levels. In the third level with the backrest, we have backplate, then we have spring, it is at the back rest.

Now, spring becomes a single component, like, a part was left here up there and a part was left here, in the first level and the second level. Now, spring becomes a single component here. On the back plate, we can put another fourth level that is my cushion, cushion or net, it is for comfort. Then, in the headrest also, we have springs and cushions, these remain at third level. Let us talk about the base of the chair, which is the main seat. The base has the base plate that comes from here. On the base plate, we have a cushion. Here, it does not have any cushion but armrests do have, I would say, screws. Let me come to the chassis mechanism. In the third layer of chassis mechanism or in the third depth level of the chassis mechanisms I will put depth here, we have this seat tilt or tension control, that is 1. And we have the pneumatic cylinder at its lowest level or maybe the sleeve whatever you call it.

Then, in the base that is a complete base down where we have wheels, we have legs here on the chair and below the legs we have casters, casters or wheels, whatever you call them. So, these are different levels down there for everything to connect, we have maybe at the 5th level. At the 5th level we can say we have screws, washers, maybe screw caps, because this is an executive chair, the appearance also has to be great and so. So, these are different levels if I draw with a dotted line, where the levels, this is my 1st level, 2nd level, 3rd level, 4h level and down we have screws and everything. So, you can see just like the normal Decision Support System or the decision tree that we have to make the decisions, the Assembly Tree is also having a similar pattern or similar hierarchy.

So, the systems that we apply to the Decision Support System, how do we take the decisions while wearing the dimensions of the component or the geometric dimensions of any component of these. For example, the base plate sizes may be previously decided as 15 inches or so, 15 inches is changed to 14.5 inches accordingly the armrest, the back cushions where do we fit them the dimensions would change the decision will keep on changing.

So, this is how we go about in the assembly tree as well while changing a single dimension of a single component or maybe within a sub-assembly, the overall assembly is affected, affected or it has to be changed. So, these changes do make a matter when we talk about Computer Aided Manufacturing. So, this design is generally this kind of chair that I am showing this is manufactured using the plastic molding machines and the systems are cut only the metal part would be manufactured on a manufacturing machine such as a CNC or other cut and the screws and bolts are majorly made by the special purpose machines.

When I say special purpose machines, those are machines which are used for mass production. For example, bolt maker, this is a machine in which you put the billet as the input, billet means a round piece as input. It first transforms that round piece into a hexagonal shape, it is metal forming, then cut it, then try to do machining operations over it and try to make the both of the sides that will require, this is a special purpose machine.

General purpose machines could be any general lathe turning machine or milling machine. Those are general purpose machines. So, those machines are used and when those machines are used, what kinds of inputs do you require generally, in business analytics when we talk about the decisions of make in or buyout are also important. The general small components like a chairman fraction company does not make all the components of it, it buys generally the screws, bolts, nuts, washers are brought out, then cushions or the net muscle might also be brought out, only the design the plastic that is the molding machine, injection molding machines might be their major forte that they are working in. So, it depends upon what kind of the system that you are working in.

So, this was an assembly tree where the questions in the decisions that arise would be,

1) Identify the dependencies. So, identifying dependencies means whether the assembly components are individual parts or entire sub-assemblies, does it consist of other sub-assemblies or parts are not. So, identifying these dependencies or inter-dependencies helps us to determine the best approach to create the assembly. The bottom up or top down or any approach could be followed depending upon the systems that you have to develop. So, the bottom-up approach would be starting from the very component level going to the assembly level. Top down would be considering the overall assembly to be manufactured, then we come down to have the components of it. Sometimes we value engineering where we work on the function. For example, if it is a chair, the purpose of the chair is to give comfort to the body, the purpose of the chair is to support the body weight, maybe it is designed for 100 kg of the person's weight. So, a 100 kg person should be able to sit it. When the tier tells it should not break the factor of safeties kept like that. In value engineering, it works on the function, whether this chair cushion is required, net is required, the size everything is decided by the function that the chair is supporting.

So, it depends upon what you are trying to do. So, to identify the dependencies, I would better say inter-dependencies as well. So, the best approach to create this assembly is to create the two blocks as separate parts and merge them into a blank assembly model. So, this is known as the bottom-up approach, making the small components, making sub-assemblies out of it, then trying to make a full model out of it. Then, the more important part as I talked about value engineering is, we identified the dependencies between the features as well.

a) Dependencies between components A. B
b) Dependency between the features. Switches means when we include the symmetry, or geometric arrays or patterns, understanding these dependencies helps us to optimize the creation of the full assembly.

Now, considering the creation of the military, we say the base of the chair, that has five legs and each of the legs have an assembly system or a small component. And, at the edge of each leg, we have a screwed hole here, where we try to add the castor or the wheel there. We can create holes as separate features and then we create a pattern of them and we can only create one rim and create an array of the pattern of them. So, these are the features. Generally, identifying the similar features this is known as, if you try to manufacture them to gather is known as group technology. Is when we go to computer integrated manufacturing in the flexible manufacturing system. The group technology plays a very important role with similar components which are of the similar shapes, components which require drilling, components which require milling operation, components which require turning operation are taken as separate groups. So, group technology that is identifying the dependencies between the features is also important when we talk about. So, that is how it works.

2) And also, we analyze the order of the assembly parts. That is, we determine the ease of assembly process on the shop floor. It also helps us to identify the cost of creating the assembly. The order also affects the manufacturing process of the part. For example, if an assembly requires a part with a flat blind hole the hole must be milled first. If the base of the plate is chrome plated, you can say the base or the wheels where at those are attached, it is chrome plated chrome plating has to be taken at the last after the heat treatment has happened. So, the process flow has to be designed accordingly. So, analyze the order of the assemblies. So, when do we cut the holes, when do we try to cut the screws into the holes, so these are very important. Also, meeting conditions are very important here. Meeting conditions means the individual parts of an assembly are generally created using CAD, CAM and those are merged together merge or insert command when it is used different points, lines, circles, arcs, the volumes when those are assembled together, what are the basic conditions, where do we make them, is it

through the center, is it through the surface. All those conditions are important when we try to talk about the assembly planning.

So, I will take a little break here and we will meet in the next part where I will discuss the modern techniques in Computer Aided Design. The general techniques that you will see is geometric modeling, various started through. Nowadays, because we have more sophisticated heuristics that are variable with us, we can select the models from the existing data, the secondary data could also be used. So, that we will take in the next lecture. Thank you.