Functional and Conceptual Design
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Lecture No. 16
FAST Method

We are discussing the functional decomposition and then trying to understand, what are the functions needed in a product to get its final outcome or the main function of the product.

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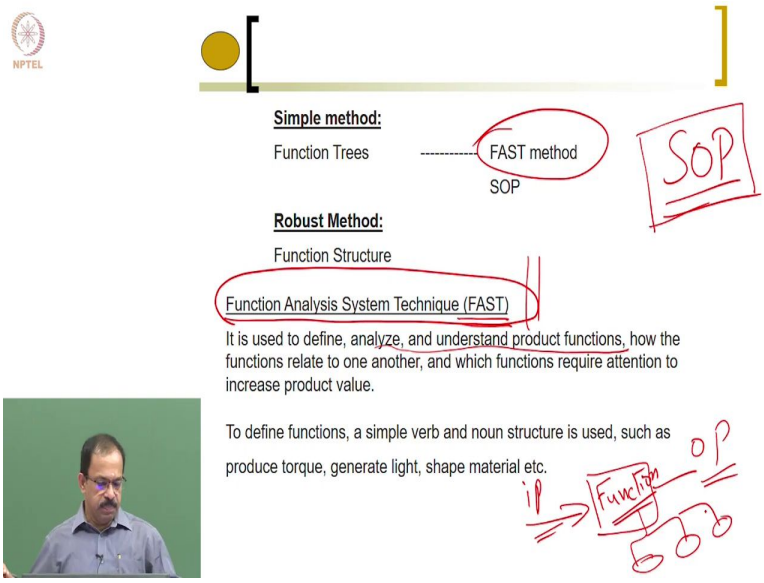

We discussed about 2 methods, just briefly mentioned about our first method which is known as the SOP, which is Subtract and Operate Procedure and this is used for products which are existing. By removing the components you will be able to get the functions identified, which is basically known as the Subtract and Operate Procedure (SOP).

Another important method is known as FAST which we call this the Function Analysis and System Technique, it is used to define, analyze and understand product functions and how the functions relate to one another. The whole purpose of doing this functional

decomposition is to find the main function of the product and how we can get the main function through many small sub functions.

So, that is the need to do a functional decomposition and we saw that any product you can consider, something is going as an input and then you can say something comes out as output. This is basically the function. So, whatever is inside is known as the function of the product and if you want to get this main function, you need to have many small functions, then only you will be able to get the main function. So, how to identify these small functions is basically the functional decomposition of a product.

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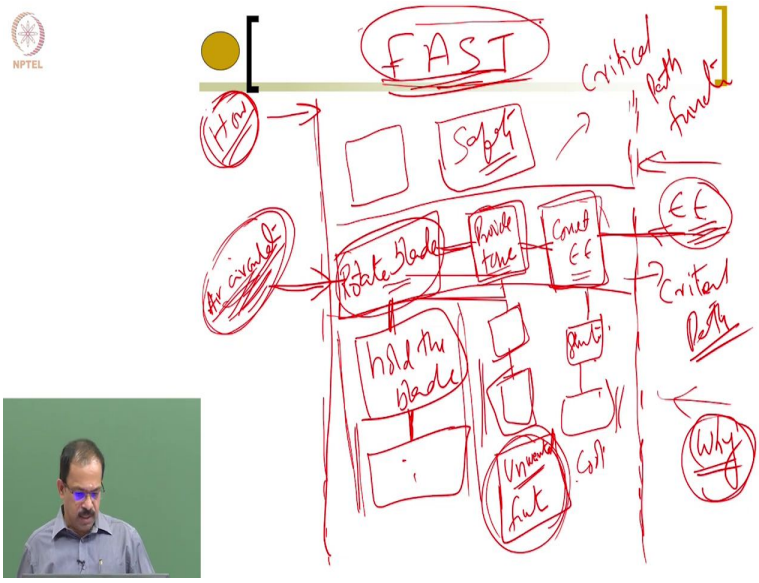

I briefly mentioned about what is the FAST method and how we do this? So, basically we look at the products, we will try to find out, we will try to draw two lines and identify, I will ask questions, How is it done or why is it done? So, that is what actually we do, how it is happening or why it is done, and we have a main function which is written here, and we have some assumptions that are written on the right side, on the right side we write the inputs. It is electrical energy. And on the left side we write what is the output of this, this air circulation for a fan.

Now we will try to find out how this electricity is converted to air circulation and what are the functions needed in the product within these two lines in order to convert this electrical energy to air circulation. We will try to ask the questions, how air circulation is obtained, that is the first thing to ask how is air circulation obtained? So, we will get the answer that you have to rotate the blades in order to get the air circulation.

Then ask the question how rotation of blades is obtained and we will say we provide torque to the blades, and how do you provide torque, probably we convert electrical energy to rotational energy. So, you will get torque and how do we convert? You provide electricity then you can use something to convert that. That is basically the critical

functions of the product or we call this as the critical path functions. This is known as critical path function.

And then in order to get each one of these critical path functions, we will have many sub functions that somebody has to hold the blade, someone has to provide its degree of freedom, one directional degree of freedom. So, these become the sub functions coming here, then provide torque, when you provide torque you need to have a transmission of torque, you need to have, you will be having vibrations then, you need to reduce the vibration, so, that we call this unwanted functions and then provide some functions to reduce these vibrations.

Like this you will be able to get all the functions in a product using this method and that is known as the FAST or Functional Analysis System Technique. This is one of the very common methods used for functional decomposition. This is summarized here. So, we will be having the assumed function which is the input function, and here is the higher order function which is the output and all other functions which are actually coming out of this between these two is known as a critical path function and this is by asking the question, how, or you ask from the right side why, you will be able to get this function.

That is how we get the critical path function and all the functions that happen at the same time of these basic functions are known as the sub functions. This is caused by critical path function. These are the functions, which are caused by critical path functions. Unwanted functions are the one which actually result because of this for example, vibration, heating, these are all known as unwanted functions. You may get some vibrations or you may get some heating up of some of the elements. So, these are known as unwanted functions.

In order to reduce the unwanted function, we may add some other functions here, like reduce vibration, control temperature or provide cooling. So, these are known as the

functions which will come as an outcome of unwanted function and then all-time functions or something like safety, one time function is something like transportation requirement or any other user training all those things are known as one time functions, and project objectives are, every design, there will be some objective, like reduced cost or reduce cost, increase comfort, these are the project objectives which may lead to some other additional functions.

This is how you get the FAST or the function analysis system technique based functional decomposition. We call this the functional decomposition. Compared to SOP, the difference is that this can be used for any new products, so, not only for existing products, FAST can be used for any new product as long as you know what is the input you are giving and what is the output that you are getting. You will be able to find out that critical path function.

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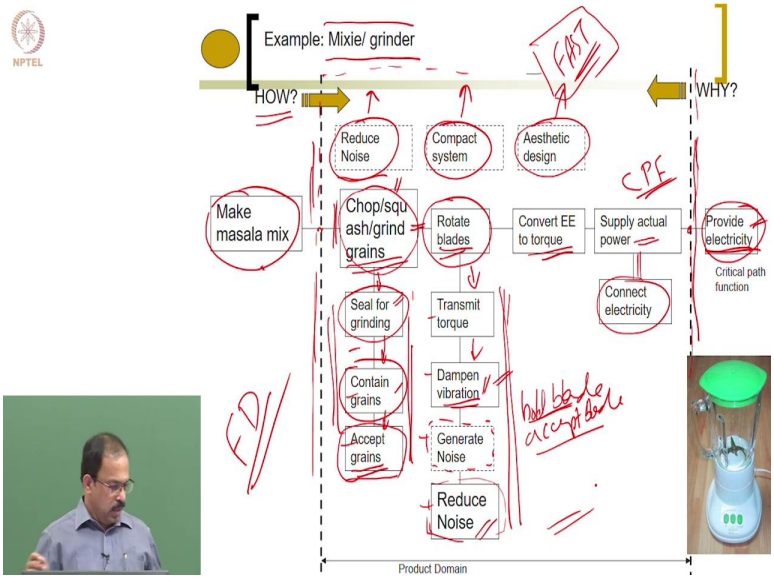

Let us take an example. We will see how it is being done, for example. You take the case of a mixie or a grinder, whichever it is, they are electrical mixers, it is a wet mixie or a dry grinder or a wet grinder, you can use it. What we do is we first draw two lines, two

dotted lines which says this is anything between these two lines, these two lines are basically the functions of the product or the decomposed functions of the products.

And then we say that we have a requirement that the product should have reduced noise so that is basically known as the project objective. They are existing mixies. So, you want to have a mixie which actually has got very less sound that is the project objective. And the one time objective is that it should be compact because of transportation requirements, it should be compact, and all time requirements are aesthetic design, it should be very appealing to the user. So, these are the objectives, one time function and all time function.

Now, we have this to provide electricity is the assumption, so that we know that we provide electricity to the product and then we get the Masala mix as the outcome of the products. So, we have a masala mix coming as an outcome and then we provide electricity as inputs. So, inputs and outputs now, what is happening in between these input and output, the other basic functions of the product, and so whatever happens inside is the function or the other functions of the products.

So we start asking questions, how do we make masala mix? How do we get masala mix, by chopping, grinding? So, you chop, squash or grind grains and you will get a masala mix. So how do we chop them? You need to rotate the blades, the blades of the grinder you need to rotate them inside. So, you will be able to chop, how do we rotate, you convert electricity to torque. You will be able to convert electricity to torque and rotate the blades and how do you convert, you supply the power to the system and how do you supply power, you provide electricity.

We have reached the other end of the boundary. We have 2 boundaries. So, I started from one boundary and then reached the other boundary. We stopped, that is the, this is known as the critical path function or the primary functions. Now, when we do this critical path

function or when you try to get these critical path functions, there will be many sub function which are needed In order to do this critical path function for example, chop, squash, grinding the grains, you need to first of all seal for grinding because you cannot keep it open, the items or the material need to be sealed.

That is one requirement and then you need to have something which can actually hold the grain that basically contains grains and then there should be something called accept grains because you need to have opening and closing of it so that you can add grains and then remove again that is basically accept grain. There should be functions which actually allow us to accept grain, contain grain and seal for grain. These three functions are needed in order to do this function.

Now you look at that from a point of view of suppose, you want to grind something you cannot do it in the air. So, you need something to contain the grain, you need something to close the container, and as well as you should be able to remove it, and close it and open it. That is the requirement of accepting grains. So, these 3 functions are needed in order to chop or squash or grind grains.

And now, rotate blades is a function which is needed in order to chop the grains, but then we need to do this, we need to transmit the torque. Similarly, when you transmit torque there will be vibration. So, generating noise and vibration will be the unwanted function, so dampen vibration because whenever you try to transmit torque there may be vibrations. You dampen vibration, generate noises and unwanted function. So, this is an unwanted function. So, we need to add a function to reduce the noise that becomes another function.

These are the sub functions that you can identify when you are rotating blades. Not necessary. This one not necessarily that you need to follow how and why, how and why

is mainly for the critical path function. While looking at the critical path function, that actually, you can actually add some or more also. For example, hold a blade.

Now, suppose you are thinking of something where actually you can replace the blades, then you need to have accept blades because you are able to change blades, so, accept blades or hold blades. So, these are actually additional functions you can think of here. I mean that is the way you try to get the sub functions from the main critical path function, supply actual power you connect electricity that is basically we are telling you to have something to take electricity from the main socket to the equipment.

That is basically connecting electricity. Now, this actually shows the decomposition of the function now, if you look at this each one, you will see that there will be a product, there will be a part, which actually do this job, in any product, every product when you design you need to look at which part of the product is going to do this task.

That is basically how you convert this into the physical structure. But by looking at this you will be able to identify all the functions and that actually is the functional decomposition of this project. This is the way we decompose using FAST methods. So, what does FAST stand for? Function Analysis System Techniques or function analysis system techniques allow you to identify all the sub functions in the product and then you can actually design products based on these functions.

You can design a better method to reduce noise, you can think of how to reduce noise, can be added as a new concept, can be added to reduce noise or you want to dampen vibration you can think of a new method to dampen vibration or ceiling of grinding can have a different method. By looking at these functions you can identify how the product can be improved or can be very, say innovative one, compared to the existing product. That is why we need to do the functional decomposition of the products.

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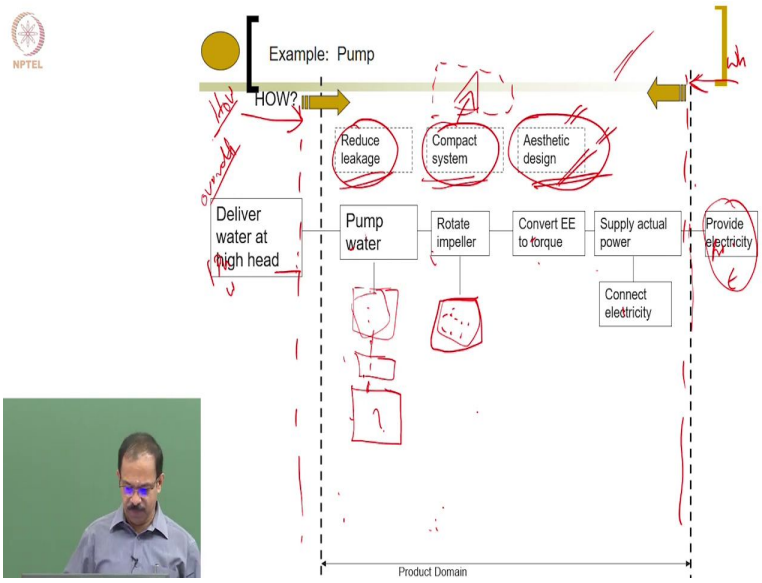

If we take an example of a pump, I think most of you have done pump as a lab experiment. If you take the pump as a product, you will see that so, we can actually have two lines. Let me identify these two lines. What will be the function here and here? What is an assumed function for the pump? Pumping water is the output. We can say pump water or you can just pump water assuming that, basically you want to increase the head of the water, right from a lower head to a higher head you want to try that is basically the function of the pump.

So, this is the overall function or output. So, that is the overall function and what is the input we assume here? Electricity, assume that it is an electrically powered pump, so to provide electricity is now, we need to ask the question how and why? In an electrical pump, we need to ask how to pump water. So, how do you answer this question? How do you pump water? Pardon, so, how will you do that? What will be the first primary function?

Basically we are trying to find out the critical path function, which actually provides or converts this electricity to pumping water. So, pumping water is basically you increase

the head of the water and you pump water from a lower head to a higher head. So, you can say rotating the impeller so, you rotate the impeller to increase its energy so that you can actually pump it.

So, probably you can say this, rotate the impeller, and how do you rotate the impeller, you provide torque, and how do you provide torque, you convert electrical energy to torque and how do you do this, you supply power. That is the way you can find out about this. Now, this is the, means, this thing will actually give you more important functions.

If you want to rotate the impeller, there are many things, one should be, you need to hold the impeller, you need to not only just by rotating impeller you do not get power so, you need water, you need to accept water, water should be accepted into the pump, then water should be taken out of the pump and then impeller need to be held in a particular orientation and then it has to be rotated. All those become the sub functions over here.

Similarly provide torque, as you saw that, there will be here, there will be something like transmit, transmit torque and you will be having functions here. So, these are the sub functions that you can identify what are needed in a product and what would be an unwanted function here, maybe noise or sometimes vibration. So, noise and vibration. Sometimes other functions may be leakage, leakage may be coming here as an unwanted function, because water may leak. You need to reduce the leakage, may become an additional function, so leakage becomes an unwanted function.

You need to add another function which will reduce leakage. So, vibration is an unwanted function, noise is an unwanted function, leakage is an unwanted function. So, now we need to find a function to reduce leakage, reduce noise, and reduce vibration that becomes additional functions. This way by looking at this you will be able to identify the, all those sub functions in a product and then as a designer you can see, find out which function you want to improve, in order to improve the product or in order to make the

product better than the existing product. So, that is the way we look at the design of this. I mean the functional decomposition of that.

And this is, this side also you can say why, why to provide electricity, because you want to provide supply power to the product. Why are we supplying power, because you want to convert that into torque, why are you converting torque, because you want to provide torque to the system? And why are you providing, because you want to rotate the impeller and why are you rotating the impeller because you want to pump the water. So, this way we will be able to answer why and how in both cases and you will be able to get the functions identified.

The critical path functions and then all the functions which are coming as a result of the critical path function will become the other secondary functions in the project. Ok. So, if you look at this, so pump water, rotate impeller, convert electricity to torque, supply actual power, magnetic electricity these are the critical path functions you can identify and by this function the pump water you can identify some sub functions and accept water, hold water, allow water to move. These are the sub functions that you can identify in this case.

Aesthetic design is an all-time function. You will not be able to identify your function corresponding to this in the decomposition. That basically this is an all-time function that you the product whenever you design the product, no one, yes it is more of a creative thing. In the functional decomposition, you will not be able to get that aesthetic design as a function.

What actually says that whenever you design any of these elements that should have this component of aesthetics built into each? That is what actually says that okay, aesthetics is an important requirement in this product and whenever you design the any, because these are the functions suppose there is a transmit torque you are designing a transmission

elements and it should not like projecting out of the product it should actually feel that it is meant to look like a very nice design.

The aesthetics should be brought into the design of when you develop a new concept for this particular function, make sure that it is aesthetically appealing. That is what actually it says, this place, it is an all-time function. The electricity is considered as input. Yes, it is not a function of the product per say. So, providing electricity is not a function of the product. A product assumes that electricity is there. That is why it is not given outside this the scope of the product.

This is, these two lines are within the scope of the project. So providing electricity is outside the scope of the product. So we assume that electricity is there, if electricity is there, what is the product should do? So that is basically known as the functions of the product and aesthetic design is considered an all-time function because think that, whatever maybe the situation the aesthetics of the product should be maintained, that is what actually it says.

Bigger size of compact system says that it is a one time function, see, why it is compact because this has to be transported from a manufacturer to supplier and the supplier then the salesperson to the home. So, only during that stage only just to be compact otherwise, once you have installed it, people do not really worry about slightly bigger or smaller, it is not a big issue. You make the compact system compact so that this is a one time function.

Once you made that one then no need to change anything with that. So, it is only not a continuous requirement of the products. If you are looking for that design which is bigger or you want to make it then this may not be a function provided in the products. In this particular case, we are assuming that it has to be compact, but when you are looking for a bigger one that will come under that capacity and that specifications itself when you

design, when you develop the product specification there itself. We will say, what is the maximum size, maximum weight that will be there in the specification itself.

That comes from there itself in the specifications. So, here as a function, what is to be needed is given in the compact or as a one time function for the product. Reduce leakage is an objective of the design process. So, we need to identify the function which actually leads to the leakages and then how to do so, and have some function which reduces leakage. So, we need to develop new concepts for this reduce leakage function and then make it as satisfying these conditions that is how it is done.

See, that if it is like compactness is a requirement throughout its lifetime. I mean use a continuously transport or somebody like for example, for like a mobile phone we carry it all the time so, combine this becomes an all-time function requirements, but in this case pump is not going to be carried by somebody once you install it then there is no need that is when the first only one time you need to main make sure that it is compact for the purpose of transport and other things. Otherwise it is not a requirement.

One time and one time does not have, one time does not mean that only once in a lifetime saying that it is not a continuous requirement only some particular incidents only that may be needed. So, you do not need to make it as an all-time function you just make this a one-time function and then solve it. But then it can be more than one time function also so that actually we can add here if you have more than one time function, you can add it here.

This is not again as a totally not a unique one. When I develop something I have my own way of designing bodies of one time artists of all time, but someone else designs they may think we'll probably need to add another one time function. So, he may enter one time function also. This way you will be having different will not be a unique way of identifying, but the most important part is that you can you should be able to identify all

the functions needed within the product, so that, you will be able to develop concepts for these functions to make it a new products that is the idea here.

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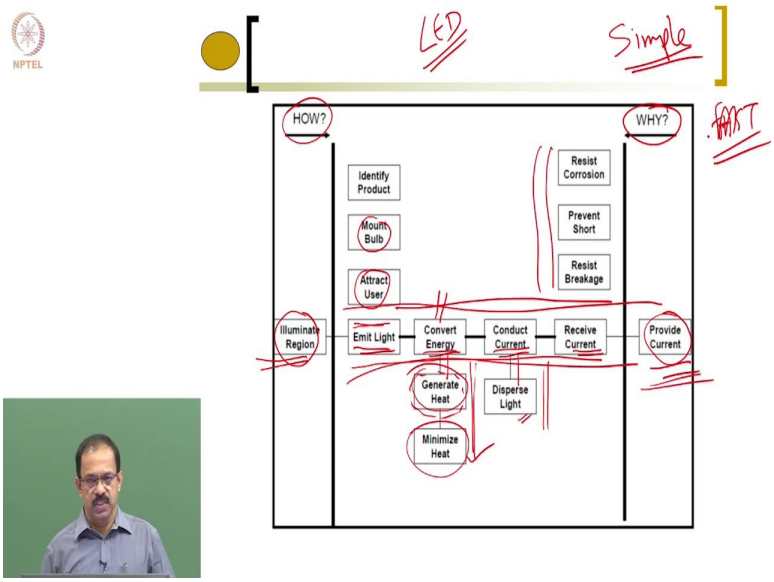

So I thought of doing a class exercise. Let us keep this for some other class. I will give you one more example, to see how to do the, I mean, how to get down faster decomposition. For example, this is for a LED light development. Assume that you are trying to develop a led or some other light not be led. So, any electrical lighting system. So, we assume that providing current or providing electricity is the assumed function and then illuminating a region is the overall function of the product or output of the products.

So, the question is how do we illuminate then you say that you emit light and how do you emit light, you convert energy electrical energy. So, how do you convert? You can take the currents and receive currents and provide currents and generate heat is an unwanted function. So, minimize heat becomes a required function and dispersed light becomes another requirement here when you conduct current, you will be having light generation so that it needs to be dispersed and then emit light. So, you can see that it emits energy.

So, how do you convert energy is a question and what happens when you convert energy you get the heat so, that heat has to be dissipated or minimize the heat generation this becomes the, and other functions like do you need to mount the bulb and attract the user these are the functions additional function you can think then resists corrosion prevent short circuits and this is the breakage this becomes the all-time functions needed in the product, any question?

These are the ways how you can actually convert this by asking the questions, how and why. Any product you take you should be able to identify this critical path function and then corresponding to the critical path you will be able to get the functions so, this is a simple form of functional decomposition, it can be used for simple products. So that is one important thing. Because a product which has got only a single critical function or a single critical path, then we can use this FAST method.

Suppose some products are having multiple functions, then you will not be able to do this in a FAST method, because it is not only one critical path, there may be multiple critical paths coming, then it becomes very complex. So the user will not be able to develop functional decomposition using fast methods.

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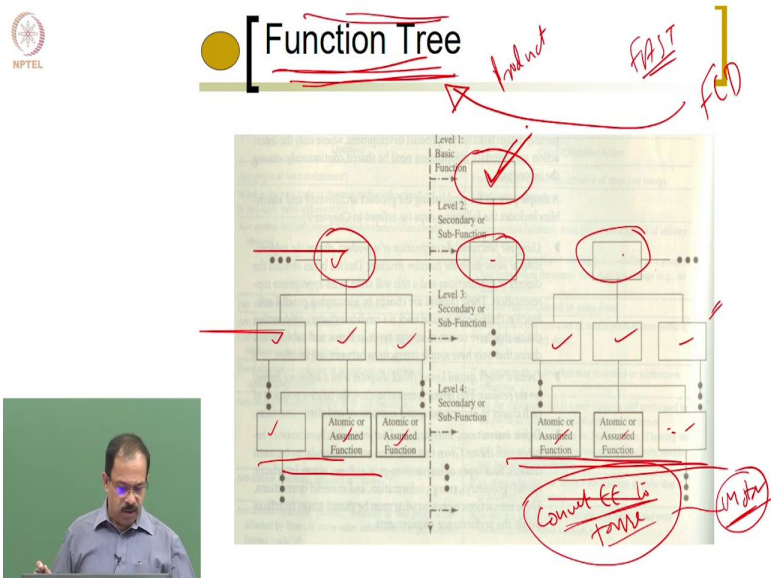

Finally with these functions we create a function tree. We will have that top level function, the basic function at the top level, and then we identify the sub functions at the secondary level or this becomes the critical path function. Then for each critical path function, you will be able to identify sub functions and then even for that you may be able to get additional assumed functions or functions.

From the first method or any other function decomposition method, you will be able to identify all these functions. And then based on this we will create something called a function tree. And in one of our lab exercises we used to create the product structure, your assembly structure you write that used to have, this will be the top level product, then you will identify all the sub-assemblies here and then the components here.

It is the same way the products will be writing it as the function and then the sub functions and then the sub functions and you will be getting it as a function tree for the product. The function tree is basically a hierarchical assembly of the functions in a product at the lowest level, you will see other small sub functions which may not be

decomposed further, or you will be able to identify a product or a part which actually provides these sub functions.

For example, convert electricity to torque or mechanical energy. That is a function right. And we know that there is a product or there is a motor which actually does this. So you do not need to really decompose it further saying that, you provide current to create magnetic flux. You do not need to write that one, you can just stop at converting electric energy to torque.

So this is the way we write down the function whenever we reach that level, then we do not decompose it further. You will be getting the same product. So, the purpose of doing a functional decomposition is to create a function tree for the product. So you should be able to generate a function tree which identifies all the sub functions needed within the products in order to get the top level function of the products.

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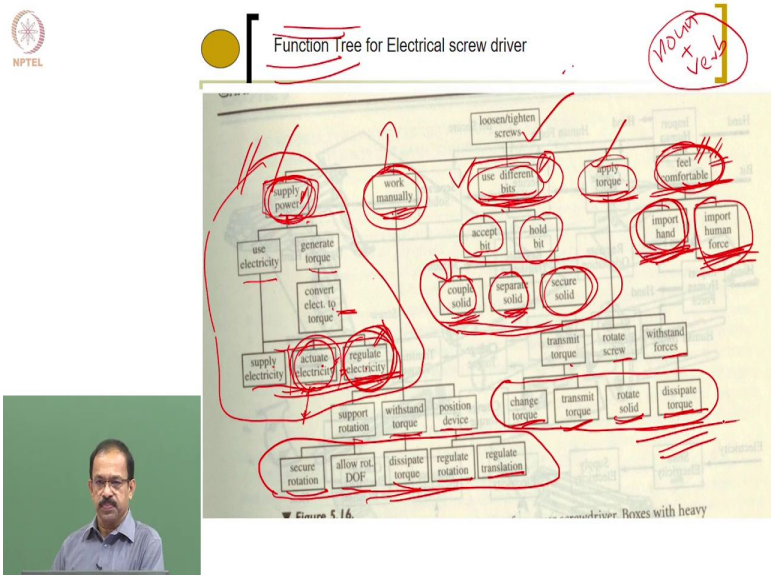

Here are some examples for the function tree. This is basically for an electrical screwdriver. So if I use the electric screwdriver and try to develop the function tree for this, then you would be able to write down the sub functions. So loosening or tightening

screws is the top level function of a screwdriver right. Now, what are the sub functions needed? We need to supply power that is one function, it should be able to work manually also.

And then use different bits needed, apply torque and feel comfortable. So these are the functions that you can identify from a, for a screwdriver. So these feel comfortable is more from the user friendliness or requirement of the customer. Now, for each one of these, you will be able to identify the sub functions where actually you can say use electricity, generate torque, and convert electricity to torque. So we stop here, we do not need to do further.

And supply electricity, actuate electricity and regulate electricity so what does this mean? Why do we have these functions coming here? Actuate electricity, regulate electricity. So it is an electrical screwdriver. So we assumed to say here take a screwdriver. So from where these functions are coming? Any idea? Yeah. So, one is that. See actually electricity means you need to switch on or off. We are to turn on or off the system that can be done only through actuated electricity.

That is you are actuating or not actuating that is basically actual electricity, basically you are telling that should be a function to stop or start the drilling process. The regulated electricity basically tells that you should be able to control the speed or the torque right because there should be some facility in the system in order to increase the speed or increase the torque or decrease the speed or decrease the torque, it is known as regulated electricity.

Every electrical product normally will have issues like taking the fan. Fan also has a switch and regulator. The switches basically to on or off, that is a function which is to actuate electricity and regulate electricity is basically you want to control the speed of the fan. That is the regulation here. So these two functions are important for most of the

electrical products. So if you take any electrical product, you will be able to find that this becomes a very common functional module in the products.

Most of the electrical products will be having this because it has to convert electricity to torque. And not only that, it has to actuate electricity and it has to regulate electricity also. Without this, most of the electrical products will not work. If you assume that there is no need to control the speed, then you do not need to have regulated electricity. But whenever there is a need to control the speed or torque or the outputs, then there will be something called regulated electricity.

Again, as I told you, we always use a noun and a verb to represent the function. So you can see we are using supply electricity, actuate utilities, and deregulate electricity as a noun and verb. That is the first part of the electrical module. So this becomes the electrical sub function of the product. You can see from the main function, we identify the sub function of the power module and here you will see all the functions in units.

We do not do it beyond this decomposition, because we assume that once you say actual electricity you can use a switch, regulate electricity you can use a regulator or a speed control that is not actual we assume. Now, there is a requirement for this to work manually. Without electricity you should be able to work, then you need to hold this support rotation, withstand torque or position device that is for work manually okay not without electricity.

This is somebody has to hold the equipment in use, that is, what, manually with the tool. So we need to support the rotation because rotation torque will be there just to withstand the torque and you should be able to position the device in required direction or in the required orientation. So that is the sub function secure rotation, allow rotation degree of freedom, dissipate torque, regulate rotation, and regulate transmission. So, you should be able to regulate the in out movement as well as the orientation of the tool manually.

That is why you should have this kind of function needed in the or provided in the product. That is the requirement to make it manually operational. And the next one is to use different bits, tool bits. You should be able to use different tool bits depending on the type of screws or the type of the nuts and bolts you want to use. Then you should be able to change the bit and hold the bit. That is, accepting bits is basically telling them to be able to take new bits or remove the old bits and hold the bit here. So two functions accept bit and hold bit.

And an accept bit we say just couple solid, separate solids. Couple solid means you should be able to couple one solid to another solid that is their new tool to be added. Separate solid you should be able to remove solid bars, remove the tool bit. And secure solid is basically should be secure so that you do not come out of it.

These are the functions needed in order to use different tools. So, if you are planning to use different tools, there should be a function to couple the tool, a function to remove the tool and a function to secure the tools. These 3 functions needed in order to get this one, that is what actually says.

If you want to get this done, then we have 1, 2, 3, 4 functions and we want to do this you need to have these 3 sub functions. Similarly apply torque, transmit torque, rotate screw, and withstand forces. And each one you can see change torque is direction of change, direction of torque can be changed, transmit torque, transmitted, the torque will be transmitted and you should be able to rotate the solid for the screw to be unscrewed or screwed and dissipate torque that is vibration should be controlled. That is the, these are the lower level functions you can identify for this particular function.

So feeling comfortable is again a more aesthetics and ergonomics part. So feel comfortable is that we are actually holding the tool so we are using our hand to hold the

tool. We are importing the hand to the product and we are importing the human force to the product. These are the 2 things you will be doing when we are using the product. So, how do we make this one more and more comfortable? That makes this feel comfortable.

So feel comfortable, these 2 functions need to be understood, how do we put our hand on the product to hold it and similarly how do we apply human force into the products in order to loosen or tighten the screws. These are the 2 functions that will affect a comfortable holding of the product by the user. So, that is these are 2 functions.

Now, we can see that we decompose this main function into four critical path functions and then each one of these. They are actually decomposed into small functions and finally we could actually bring out a functional function tree for the electrical screwdriver. So this is what we do when we are developing a function tree for any product.

Assume what we need to do is. We have an electric screwdriver. You want to loosen or tighten the screw using the electrical screwdriver right. So, one thing what we need is that, you need to have electrical torque generated or you should have some electrical module which provides you torque for the operation. The second one is you want to use it as a manual tool, it is not a machine tool where man will actually not be touching it. Actually, a man is holding it and using it. That is what actually you should be able to work manually with the products. That is one requires another function needed.

Another function is that you should be able to use different bits for different applications. And then you need to apply a torque for moving it in or out okay. And of course it should feel comfortable also. So when you provide these 5 functions, then only it can actually do the required job of loosening or tightening of screws. Got it. So, that is why we need to have these 5 functions in order to get this top level function.

Now we look into each one of these and then see what are the things needed in this one in order to get this particular work done. So that we see that, actuate electricity, regulate electricity and convert electricity to torque are the 3 functions needed in this module to provide the necessary power. Same way we look into each one of these and then try to decompose it then find out the lowest level function. That is what we do in the function tree generation.

We will stop here and discuss these in the next class and then we will go to another method which is, which can be used for any complex products. For example, if you take a refrigerator or any other or an automobile car or something like that. There can be many critical path functions so we will not be able to do it as a fast method or a simple method.

We go for something complex where we look at the material, energy and the force interactions and then try to find out how to do the decomposition of the products. So, we will stop here and then continue in the next class.