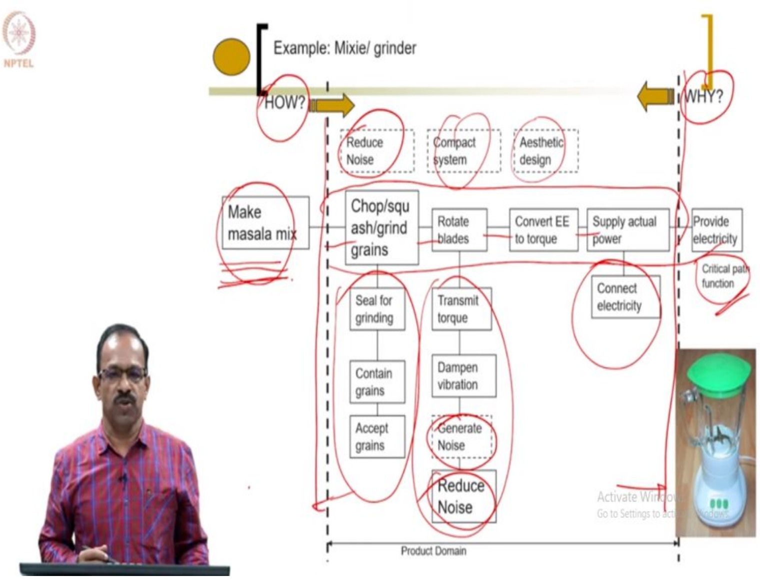
Functional and Conceptual Design

Professor Dr. T. Asokan
Department of Engineering Design
Indian Institute of Technology, Madras

Lecture No. 17

Function Structure (Flow Method)

(Refer Slide Time: 0:13)



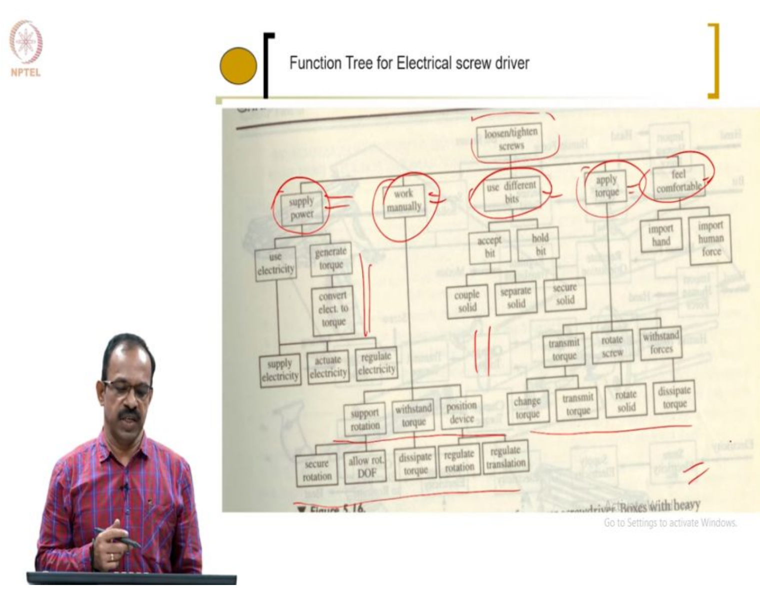
Good morning and welcome back. We discussed functional decomposition in the last class. We found that a functional decomposition is basically to identify the small sub-functions needed in a product in order to meet the requirements of the product function as well as to meet the customer satisfaction. And we found that there are different methods to do the functional decomposition and one of the methods we discussed was FAST or the Functional Analysis System Technique.

As you can see here in this screen, the FAST method basically tries to identify all the functions within the product, assuming that there is something provided as an input to the product and something is coming out as an output. So, what is coming out as an output is considered as the top level function of the product. And what is given as input is what you provide to the product so that the product will be able to provide the output. Now, whatever is happening in between these two lines is known as the product functions or the sub-functions needed in the product.

In FAST method, we try to identify this by asking the question, how or why. How something is happening in the product, by trying to answer that, you will be able to get the critical path function, which we mention as the critical path functions. And these critical path functions lead to the sub-functions associated with each critical path function. So by looking at each one of these, you will be able to get all the functions needed in a product. So, this was what we discussed in the last class.

And we saw that the relation, the main functions may lead to some unwanted functions in the product which something like generate noise or generate heat and that will lead to additional functions also, which may need to compensate for the additional, to compensate for the unwanted functions. And then we will be having something like an objective project, objective all time functions and one time function, like this we will be having additional functions also. By this way, we will be able to get all the functions needed in a product, in order to meet the main function or the top level function of the product.

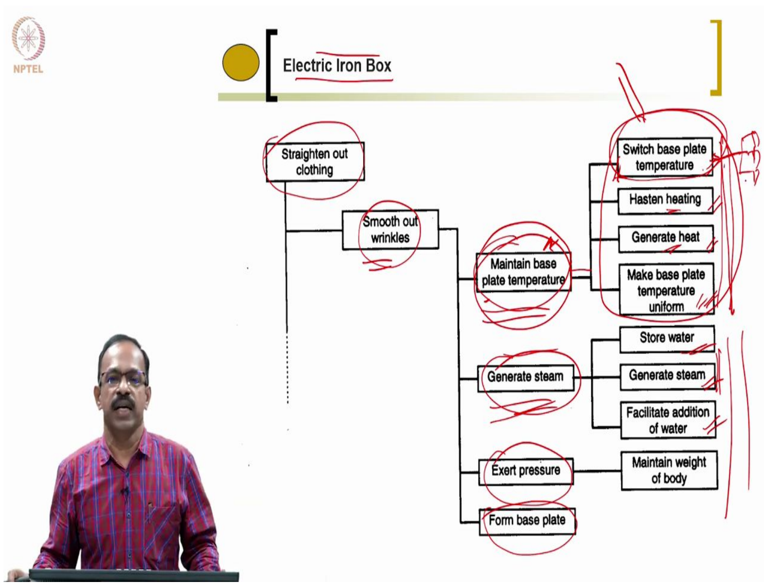
(Refer Slide Time: 2:34)



Once we identify this function, we will be able to create a function tree. A function tree is one, you will be having a top level function at the top and then we will try to identify the main functions needed in order to get the top level function. And then we go for the all sub-level functions at the bottom level and then create a tree structure with all the lower level functions coming at the lowest level of the tree. So any function decomposition will effectively lead to this kind of a function tree and that function tree is needed to design the product at a later stage.

Because we will be able to identify what are the sub-functions needed, or what are the modules needed in a product in order to meet this requirement. And then, under that what are the functions that can be identified. This is an example of the function tree for an electrical screwdriver which, when we do the functional decomposition, we will be able to identify all these functions and then create the function tree. So this was what we discussed in the last class.

(Refer Slide Time: 3:39)



Just to give you one more example about the functional decomposition or the function tree, so this is an iron box, electric iron box. So we can see that in an electric iron box, the top level function can be assumed to straighten out clothing. So that can be considered as the top level function and you can have additional things also. And then, smooth out wrinkles will be the way how you can straighten out the clothing.

To smooth out wrinkles, you can see that there are many things that we need. One is that you need to maintain the base plate temperature, you need to generate the steam and then you need to exert pressure and you need to have a base plate which can actually provide the necessary pressure, temperature and then remove the wrinkles. So these are the functions that are needed. And then you can actually divide this into smaller modules or the smaller functions.

And that will be getting as switch to base plate temperature, hasten heating, generate heat, and make base plate temperature uniform. Unless you satisfy these functions, this function will not be able to provide the necessary outputs. If you have to maintain the base plate temperature, you need to have some kind to switch the temperature, you need to have the heating control or the speed at which the heating takes place and how to generate the heat and how to make the temperature uniform at the base plate.

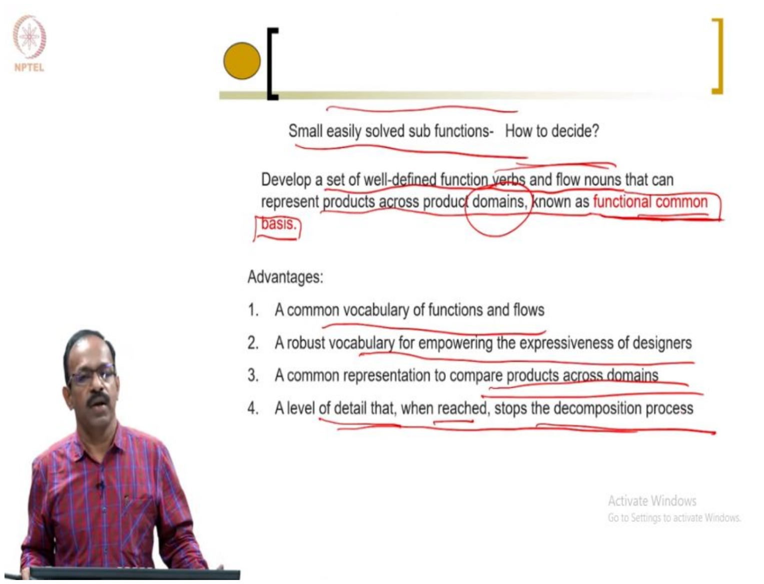
If you satisfy these functions, you will be able to satisfy this and if you satisfy this, you will be able to satisfy this. So this is the way you can actually identify the functions needed in a product. So, what is the importance of identifying this? Because if you are trying to design a new product, a new iron box, and you find that in the existing product, there is a problem with the heating, then you know out of this which function is the one that creates the problem.

And then you can take out that function and then try to identify a new method to satisfy that function. Because this is only a function, how you actually provide that in the product depends on what concept you are using. And therefore, you will be able to modify this function in order to improve the product. So you do not need to improve all the functions in order to change the product, you can see, identify which function is the one which actually creates the problem and then you can, you will be able to modify it and then get a new product.

So this, the way, how we use the functional decomposition at a later stage to improve the design of the product. Similarly to generate steam, what are the things you need? You need to store the water, you need to generate steam, and you need to facilitate addition of water. So you can add water, you have to store water and you need to convert that into steam. These are the requirements of generating steam.

So this is the way how you will look at the functional decomposition and create a function tree for a product. Okay, so that is about the first method of, I mean, we discussed about this FAST method. And one important question you will be having is, how do you actually know that these are the, where actually I need to stop, should I actually go further and then do the decomposition. So when will I know that I do not need to do further decomposition of the function?

(Refer Slide Time: 6:50)



And to do that, we will actually have something called a functional common basis. We will try to answer these questions - small easily solved sub-functions by having something called as a functional common basis. So this is a set of well-defined function verbs and flow nouns. So we have function verbs and flow nouns. And then, that can represent the products across product domains known as functional to common basis.

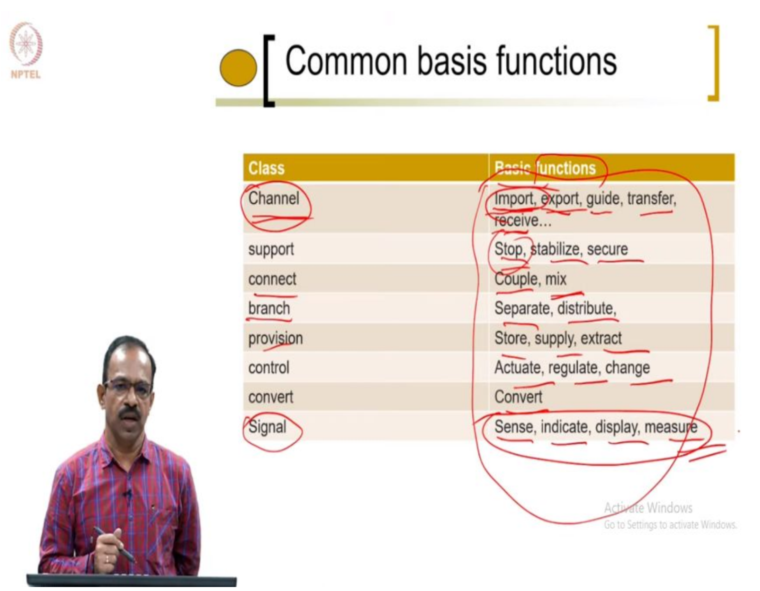
Across the domains, we will be able to use this functional common basis and then, we know at what level we will be able to stop. Because if you can actually represent it as a simple verb and a noun and that is a well understood function, then we do not really need to go further down for decomposition. So this is the purpose of having a functional common basis. And moreover, it is irrespective of the domain.

So it can be an electrical product, or a mechanical product, or a hydraulic product. We use this common basis to represent and therefore it does not really matter what is the domain, we can still use the same kind of a verb and a noun to represent the function. And we know that with some experience, we will be able to know that, okay, oh this is something which is commonly available and we do not need to go further decomposition.

And the advantages are basically a common vocabulary. So as I told you, independent of the domain, you can have a common vocabulary of functions. And then, you can have a robust vocabulary for expressiveness of designers. It is very robust, so that any designer will be able to understand and represent the function using this vocabulary. And across domains, you can compare the products and functions and level of detail that when reached, stops the decomposition process.

When we can actually reach that level, then this says that you do not need to further decompose. You can actually, if you can actually represent it in that, in a common functional basis, that shows that you do not need to further decompose it because it has already reached a stage where we have the required functions or required decompositional stage achieved. This is the purpose of having a functional common basis.

(Refer Slide Time: 9:05)



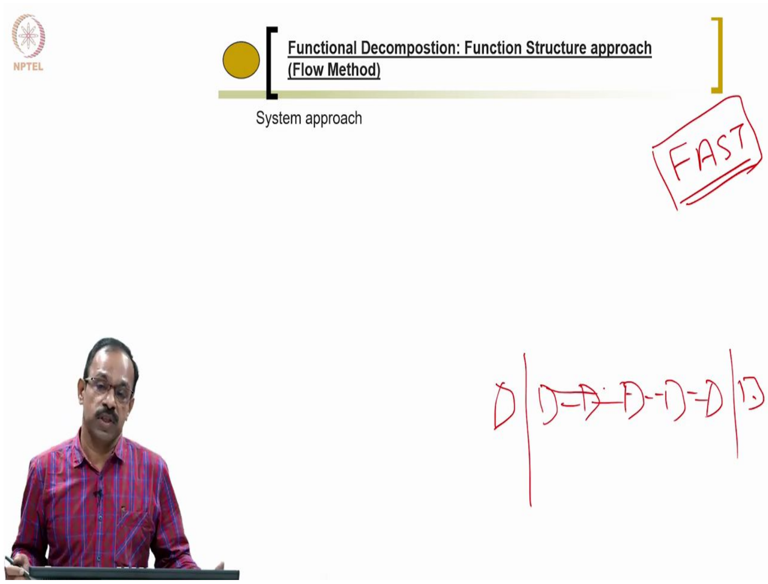
Let us see some examples of this common basis. For channeling of something whether it is channeling of a material, energy or whatever it is, we use the terms called imports, exports, guide, transfer, receive, etcetera. So transfer power, or get material, export material or import material, receive material. These are the ways in which we can represent the channeling of material, energy or whatever it is.

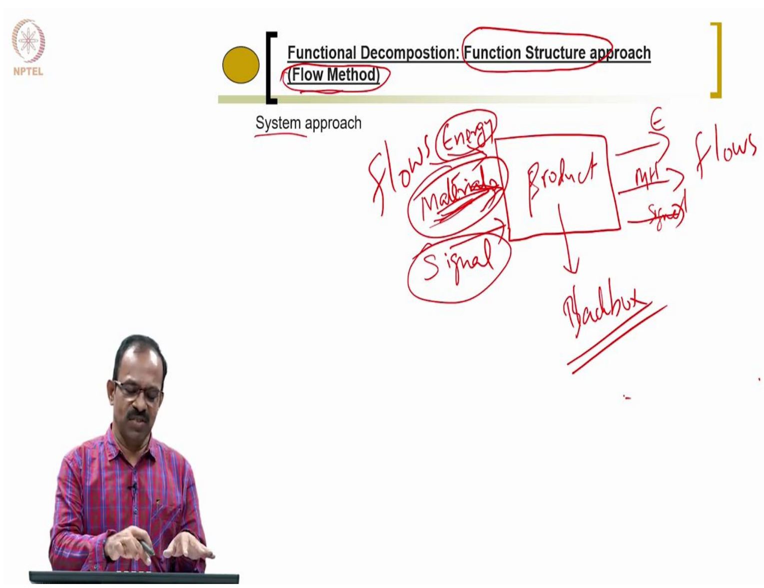
Similarly, to support we will say the stop, stabilize, secure, couple, mix - for connection, for connecting of two objects or two substances, you can have a couple solid or couple liquid or whatever it is. So you can actually mix liquid, couple solid etcetera. Then you can have branching of energy or materials, we can say separate or distributed. So separate solid and liquid, or separate larger size and small size grains etcetera. And then provision is, store, supply, extract.

Control is, actuate, regulate, change, and convert. Then sense, indicate, display, measure etcetera. For signals, we use sense signals or display signals or measure signals. These are the common terminology you will be using. If you use this kind of terminology, then actually it is a common basis or functional common basis. The basic functions are actually expressed using these functions. So basic functions are expressed using these terminologies.

These are the verbs which can be used to represent the basic function. So once we reach the level of this detail, then you know that okay, there is no need to further decompose it. That is the purpose of using a functional common basis. Whenever you do a functional decomposition, you need to ensure that you are using this terminology and then you know where actually you have to stop once you reach the required level of detail.

(Refer Slide Time: 11:13)





Okay, so that is about the functional common basis, and now we know that one of the functional decomposition methods is known as the FAST. And there, in the first we take a few examples, we did not use the functional common basis but here after, in all the methods we will be using the functional common basis to identify the functions. Now in the FAST methods, the function analysis system technique, we try to find out a critical path function.

Between these two lines, we identified that the outside is input and this is the output, and whatever is there in the critical path is known as a critical path function. So this FAST method is useful when you have one critical path function or one critical path. So some of the products or most of the products will be having more than one critical path. It may be doing two or three things simultaneously, and all the three may be critical in that particular product.

So for such products, this FAST method may not be a suitable one. We need to have a better method or more robust methods which can actually take care of all the products or products with, across the, products having multiple critical path, or there are multiple critical path and then there are multiple kinds of materials going inside and it is not a very simple product, it is a much more complex product.

For such products, we cannot use the FAST method and therefore, we need to go for a robust method which we call it as the functions structure approach or function structure method. Or sometimes it is known as a flow method also. So the functional decomposition using flow methods. So this is the most commonly used method. Whenever the product is slightly complex, and there are more than one critical path, then you can always go for a flow method.

The flow method is applicable to all the domains, so it uses independent of the domains, you will be able to use the same kind of functional common basis to represent the functions. So that is the advantage of having flow methods. We call this a system approach also because in this approach, we consider the product as a system, so we consider this as a system or we call, okay this is the product.

We assume that something is going inside to the product and something is coming out to the, from the product, something is going into the product and something is coming out of the product. And this is the black box where things happen inside. And as a user, we will not be knowing what is happening inside the black box. We are not worried about what is happening inside, right? So when I have this product, I do not really worry about what is happening inside.

I know that if I give an input, I will get an output. So for me, it is a black box. If I do not know the technology inside, it is a black box. So the same way, we can assume that initially, okay, a product is a black box, you give something as an input, and you get something as an output. So for example, in the case of a washing machine, you put soap powder, water and then dirty clothes, and then you switch on. So that is all. And you do not know what is going to happen, how it is cleaning and all.

And finally at the end, you will get clean clothes and then dirty water and other things like that. So we can say that okay, for any product, you give something as an input and then something comes as an output. Now, if we can actually find out what is happening to the input and how this input is getting converted to an output, then we will be able to tell what is the function inside or what are the functions happening inside.

So, that is the approach taken in the flow method where we assume that there are many flows taking place into the body, into the product and there are many flows coming out of the product also. And then, these flows we assume that the one of the flows is basically energy. So, any product or most of the products will be having some kind of energy as an input, say electric energy or mechanical energy or human energy, some energy will be going inside the product.

And in addition to energy, there will be something called, some other input will be the material. So we say that okay, there will be some materials going inside. Depending on the product this material may change. In the case of a washing machine, you know the materials are soap powder, water and then dirty clothes. So these are the materials which are going inside. Or in the case of a toaster, it will be the bread for toasting that is going as an input to the toaster.

Same way, you will be able to identify the material, what are the materials going inside. For example, you take the printer. If you take the printer as a product, what you are giving is an input. That is all that is going on in the material. You get paper as an output also, right? So we can get the materials, what are the materials going inside. Then, we assume that there is one more input which we call it as the signal. Some signals will be going.

This signal is more like a control signal okay, you want it to be a switch on or off, the toaster, I mean the toaster is on or off, printer is connected to the computer or not. So these are the signals that will be going inside to the product in order to make the product do its function. Without this signal, the product will not be able to do its function. That is known as the signal. It is information given to the product in order to make it do its function. So that is the signal.

We assume that these are the three flows going into any product. Any product you take, you can say that there can be 3 inputs, one is the energy, other one is the material, and other one is the signal. And we assume that, because nothing stays inside the product, everything comes out. So whatever energy you give, energy comes out, it is not staying inside. So there will be an energy coming out, there will be material coming out and there will be signals coming out.

And this will be in a different form. The same, this is not the same material which is coming out. The material may change its shape or size or its quality or whatever it is. So some material goes inside and it comes out as something else. But it is material. So material is going inside and material is coming out. Energy is going inside, energy is coming out. And signal is going inside, signal is coming out. Now, once we assume that, this is a black box and these things are the, these are the flows going inside and the flows are coming out.

The question is, what is happening to this material, energy and flow, is the function of, functions inside the product. So whatever happens to this material, energy and flow inside, these are, those are the functions of the product. For example, okay, so material is, energy is normally represented using a single arrow and material is represented using a double arrow in order to make it distinguished from the other one - material and energy and signal is represented using a dotted arrow.

This is the energy, this is the material and this is the signal. So here, you get the energy outputs, you get the material outputs and you get the signal outputs. Now, as a designer what we need to look at is, okay, I am providing electrical energy here and then this is coming out as a sound or heat, that is energy. So I am trying to give electrical energy as an input and it is coming out as a sound energy and heat energy.

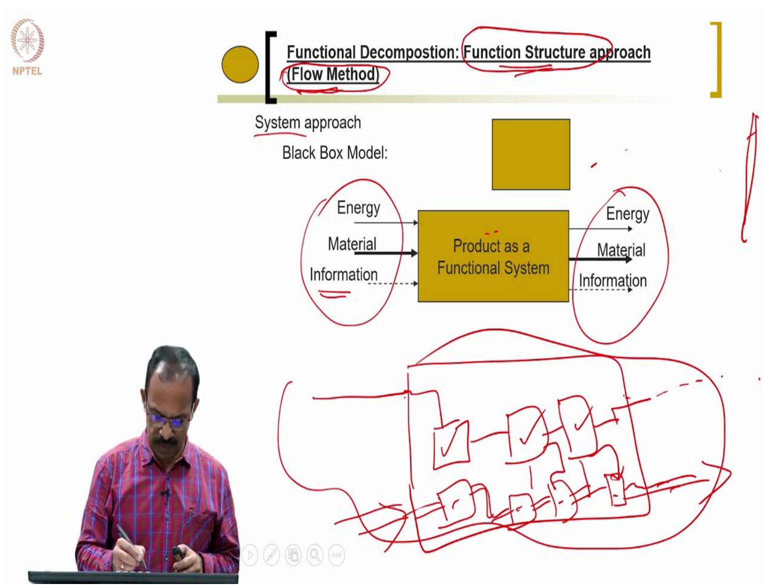
What is happening to this energy, and how is it coming out as a sound or heat? So all those things, what happens to this electrical energy inside this, are the sub-functions of the product. Or we can decompose those functions which actually convert the electrical energy to sound or heat using this. Similarly, what is happening to the mechanical energy, sorry the material? So I am giving water and clothes.

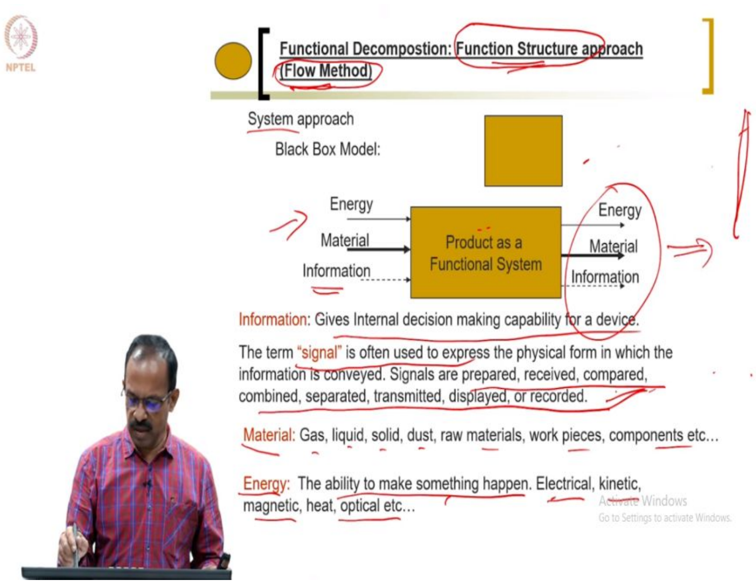
And then, how is it coming as dirty water? I am giving good water and soap powder, how is it coming as dirty soap water? So, what is happening inside in order to convert this water into dirty water? Similarly, I am giving dirty cloth, I am getting a clean cloth. So, what is happening to the cloth inside in order to make it clean? All those things that are happening inside this box are the functions of the product. So, this is the way we decompose the product functions using the FLOW method or the function structure methods.

Similarly the signal, we will be giving an on-off signal, and then finally you will be getting a signal saying that, okay cloth is complete, and the washing machine, washing is complete. That is a signal coming out. When you are giving a… on signal, you are getting output as either it is an off, or it is some noise or whatever it is, you are getting a signal saying that it is complete.

So you will be getting, you will be giving an input and you will be getting an output. And this, the relation between this input and the output and what is happening to this input as it passes through the product are the functions in the product, and this is basically known as the black box approach for functional decomposition or the flow method of functional decomposition. We will take a few examples to make it clearer.

(Refer Slide Time: 21:21)





As I mentioned we consider the product as a black box, and then consider the input as a flow, there is a flow going into the input and, going to the product and there is a flow coming out of the product. And this flows, we assume that these are the energy material and information or the signal. Okay, and then the energy material and information, so information and signal I mentioned it as signal, it is information, so that information in the form of a signal, you will be getting the energy material and information going and then energy material and information coming out.

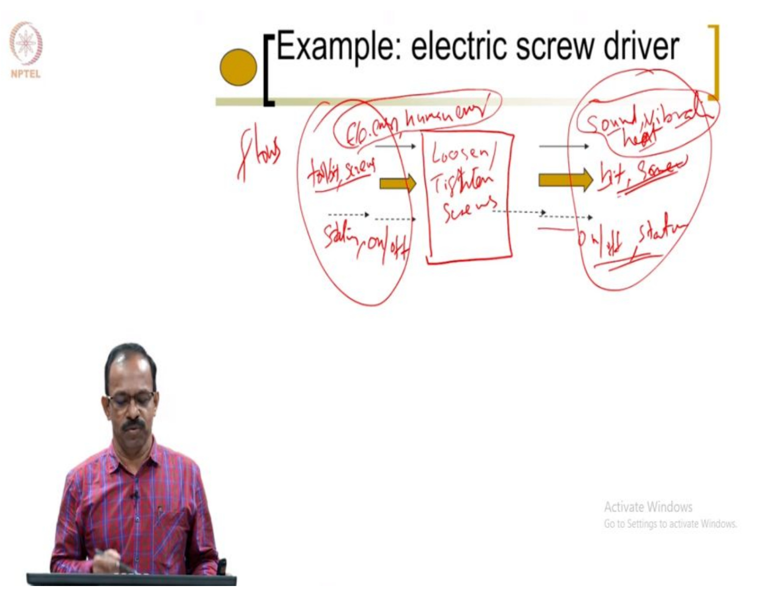
And what is happening to this energy? As the energy is going and then in this box, it actually passes through many functions. Okay, transmit energy, convert energy and then generate heat, so many things will be happening there. And finally coming out will generate noise or heat or whatever it is, this will be coming. What are these functions, we need to identify. Similarly, the material will be coming inside so we see, material is accepted, then transmitted or coupled or mixed and then doing something, something and coming out.

So there might be interaction, this may be coming here and this may be going here. So we need to look at all this and then see what these functions are and how the material is coming out in a different form. So this is what the flow method of functional decomposition is. Okay, now what are these material energies, and I already explained it. So, information gives the internal decision making capability. So, the information or the signal gives the internal decision making capability.

And the term signal is often used to express the physical form in which the information is conveyed. So signal is the common form in which the information will be normally conveyed. And signals are prepared, received, compared, combined, separated and transmitted or displayed or recorded inside the product. The signal can actually be transmitted or recorded or displayed, it can actually happen many things inside. We need to find out what is happening.

And the materials are the gas, liquid, solid, dust, raw material, work pieces, components or anything can be a raw material going into the product. We have the energy, the energy is the ability to make something happen. So electrical, kinetic, magnetic, heat etcetera, etcetera. So, this is the way in which we try to identify the flow, flow into the product and then find out what is the flow coming out of the product.

(Refer Slide Time: 24:06)



Let us take a simple example of an electrical screwdriver and see how we can actually identify the functions inside the product using the flow methods. So we will take this as the product, electrical screwdriver. So the purpose of an electrical screwdriver is basically to loosen or tighten the screws. So, we will write the main function, loosen or, so that is what we know, to fix screws or remove a screw, that is basically the purpose of an electrical screwdriver.

An electrical screwdriver is normally used by a human, so it is actually a hand operated electric screwdriver. Okay, so that is the screwdriver we are talking about. So loosening or tightening screws is the function. Now we need to see what the flows are going into the product. Okay? So what are the flows that we can think of? So, it is an electric screwdriver. So the energy, first we look at the energy. So of course, electrical energy is the one going inside, electric energy is there.

And then as I mentioned it is a human operated one, so human energy is also used in the process. So it is not only electrical energy, we have human energy also. We call it the human energy, what actually we apply as a user, what we apply is the human energy. So we can say that these are the energy going inside. Now, what are the materials going inside? So we can actually see what kind of materials are normally gone inside.

So one maybe a tool bit, so we may have to have a tool bit in order to screw the bit. So a tool bit will be used. And then maybe screws, we will be using screws too, to fix something. So the tool bit and the screws may be the materials going inside. And then, what is the signal or the information? So one information is that you want to tighten or release the screw, okay? You want to loosen or tighten the screw, so that is the information. So maybe the status of the, the screw, whether you want to tighten or loosen.

Then whether it is on or off, whether the screwdriver is on or off, power supply is there or not. So these are the information that will be going inside. And then, what are the things coming out? Okay when we use this screwdriver, you will see that something, some energy will be coming out. So what is this energy coming out? So one maybe, when you use this screwdriver, a lot of noise will be produced. Sound energy is something which you can expect.

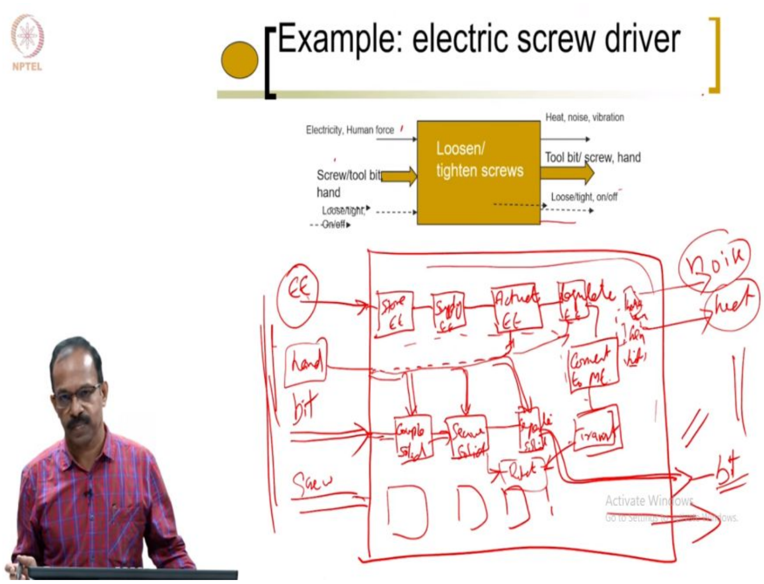
There will be a sound energy and there will be vibration, vibration energy or mechanical energy. And then there may be heat produced. So these are the energy that you can see. So the electrical energy is converted to sound energy, vibration energy, mechanical… heat energy. So that is the energy that you can think of. And then here, what is the material? So the tool bit may come out, after you use, you can actually take out the tool bit from the screwdriver.

Similarly, if it is unscrewing, then you will be getting the screw also as an output. So these are the material that you can get out, or at the say output from the product. And then, the signal again, whether it is on or off you can get, and whether the status also determines whether the screw is tight or loose, that information also can be obtained. You can see that in order to loosen or tighten the screws, so we will be giving this as an input and then we will be getting this as the output.

Now, as a designer, we need to know how this electrical energy is, and human energy is used to loosen or tighten the screws and then finally the bit and the screw comes out and this is converted to sound and vibration, and then you get the signal also here. So what is happening inside, as the flow goes to the product, into the product and it comes out, what is happening in between or what is inside it is happening, we need to find out.

And that can be done by following the flows. So, we will take electrical energy and then see what is happening to electrical energy inside, and at what stage it is actually getting converted to heat, noise or vibration. Similarly, at what stage the tool bit is going inside and what is happening and how the tool bit is helping to fix a screw and then come out as a tool bit itself. So these are the things that we need to look inside the product, in order to identify the functions. So, let us look at that and then see how we can represent it.

(Refer Slide Time: 29:39)



Okay, so we will get this as loosen or tighten screws. So, electricity and human force as the inputs. And then screw the tool bit and hand, okay hand also as a material will be going inside. And then loose or tight, or on or off will be the information. And we will be getting the tool bit screw and hand heat, noise, vibration and loose or tight, or on or off as the material.

Now, we need to see what is happening inside. So what will we do? We will try to explore this box and then see each input. We will see, okay, this is the electrical energy. So I will try, start with electrical energy and try to find out what is happening to the electrical energy and the forces, human force, electricity, screw, bit tool etc. Then I will try to see what is happening to the electrical energy.

So now, I can identify, okay I take the electrical energy and if I assume there is a storage power, battery storage, then I will say that okay, I need to store, store electrical energy. So first I will store in the battery, and then I will supply electricity to it, so I am using the functional common basis, store electrical energy, supply electrical energy. And then I will say that I need to actuate it, I need to switch on or off in order to make the product work.

Basically, I am actuating the electricity. So what I will say, I will actuate electrical energy. And then I will say that okay, I switch on or off, but then I need to control the energy or control the motion of the tool bit. If I have to go in a forward or reverse direction, I want to change the speed, increase the speed or decrease the speed. I need to have some kind of control over the power. So what I will do is regulate electricity.

So I will be regulating it. And then what I will do after I regulate, I can actually convert this electrical energy to mechanical energy. So, I will convert the electrical energy to mechanical energy and then I will transmit, transmit the mechanical energy. Okay? So the electrical energy is coming and then it passes, going through all these functions and getting converted to mechanical energy and transmitted as mechanical energy. So that is what actually happened to the electrical energy.

When it is converting to mechanical energy, then there will be something called generate heat or generate noise, so these are the unwanted functions. And then the noise goes as an output, heat goes as an output. So you have the noise as an output and heat as an output. If you have a cooling mechanism, then there will be transmit heat also because you are transmitting the heat to outside the product, so there will be transmit heat.

Normally, in the screwdrivers, you do not have any special mechanism for heat transmission, so we will say that just heat is just coming out. You know that now the electrical energy is converted to noise and heat because of these functions. That is what actually happens here. Similarly, okay, now this has to happen, now we have to see the, okay the next one is basically the material. So we consider the material going inside. Assume that the tool bit is considered here.

We assumed that there was a tool bit going inside. So we need to do this tool bit so the tool bit is taken, and then we will be using our hand also, so the hand also has a material which is going inside, so the hand will be coming. You will say, using the hand, so you will be using the hand for many things one is basically to actuate electricity and regulate electricity, we will be using this, because we need to have the human hand to do this. So we will actually say that there is a connection here.

Similarly, we use the tool bit. So we need to couple the tool bit. So we will say that we coupled the bit. So couple basically, you connect the tool bit to the screwdriver. So that is the couple, the tool bits or we call say coupled solid, because it is, these are two solids. So we will say that coupled solid to use the functional common basis. So coupled solids and then when you couple that, you are actually connecting them but it is not only sufficient you need to secure it also, you need to lock it otherwise it will come out.

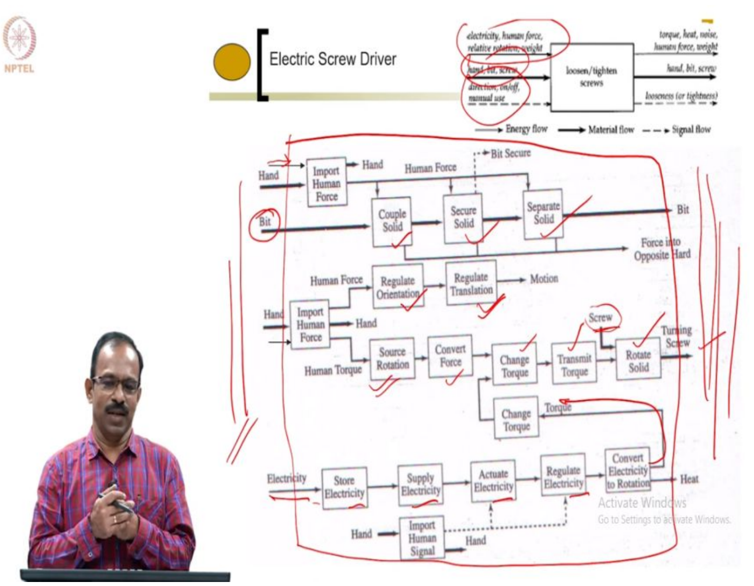
You need to secure solids. And these are done using the human hand as an input. So without human hands you will not be able to do this. These are materials, so secure solids. And then we will have separate solids, so you need to separate it later. So after the function is over, you need to separate it, so you need to separate, separate solids. And then, the solid will actually go out. You are getting the tool bit coming out because it is already separated from the solid, separated from the machine and then it got, and again you need a human hand to do this.

So this is the way how the bit comes out. So your tool bit is coming out after separating from the machine. And this way you can actually look at each one of the inputs and then see what happened to this input, so you can actually look at the screw also, you have the screw. And then we need to okay, we will be identifying all those functions connected to this, and then how the screw is coming out. That also will, can be identified as something similar to this.

In between we have to see, oh what actually happened to this transmit torque. So we already transmitted the torque. Now, what actually did we do with this? So we need to have a rotate solid because the solid needs to be rotated, so there will be a parallel function coming from here to rotate solids and these rotate solids will be connected to transmit. So the transmit power will come and then this solid will be rotated and that will actually move the screw in or out.

So we will be able to identify the functions by going through each flow and then identify what is happening to this flow as it passes through the product and coming out. So this way we will be able to identify all the sub functions needed within the product in order to convert the input flow to the output flow. And if you are not able to see the output flow this side, that means you have missed some function and you need to go through it and then try to identify the function inside. So this is the way how we get the, or do the function decomposition in the flow methods. I hope you understood this.

(Refer Slide Time: 37:41)



Then I will take this as a more detailed one, I would like to show you the detailed explanation. So this is the inputs, as I showed you the input going and then output. As I told you the tool bit is coming and then coupled solid, secure solid and separate solids, okay? We will be using the hands, using hand and human force to do this so we need to have the hand and human force to do the solid, coupled solid, secure solid and separate solid.

That is where the human energy is coming as an input. So, human hands and energy come together to help these couple solids, secure solid and separate solids. And again we will be using the human force for regulating the orientation of the tool. So we need to, because we are holding the drill, this screwdriver so we need to orient it as per the requirement of the operation, because we cannot simply always have the same orientation. We use our hand and the hand force to orient it, that is basically regulate orientation.

Then regulate translation, because we need to move in and out in order to tighten or loosen the screw. So that basically regulates translation. And then the human torque will be used for source rotation and convert the force, because we need to rotate it and then that is the source rotation, convert the force, then you change torque that is for the clockwise or anti-clockwise direction. Then transmit torque and rotate solids.

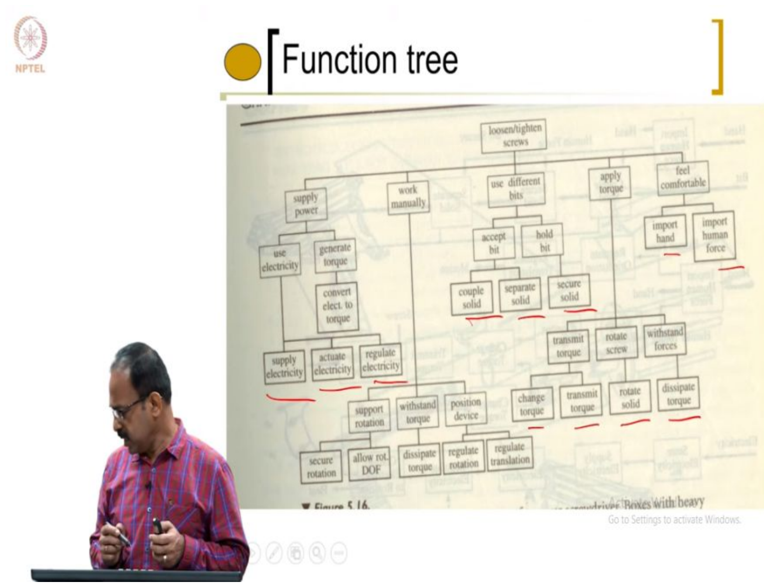
The rotate solid is basically you have a screw and that screw will be attached to the body and body of the surface where you want to screw it, and then you rotate the solid, then the turning screw will happen. And this electricity store, supply, actuate, regulate, convert to rotation and this torque will be coming and this change torque and then you will be getting a transmit torque and then rotate solids.

You will see that this bit is already attached to the machine and then when you rotate that, you will be getting the required torque to move the screw in or out and you will be getting the screw, either it going into the system or coming out of the system. So, this is the way you will be able to see all the functions within this box. So these are the inputs and these are the outputs that you can see and you will see that heat and other things are coming out as an output from here.

So, this shows the functions can be identified by following the flow, each flow can be followed and then try to identify what happens to that flow and from the starting to the end and till it comes out if you are able to follow it and then identify all the functions needed to convert that into the output, then you get all the functions needed in the product. So that is the basic principle of functional decomposition using flow methods.

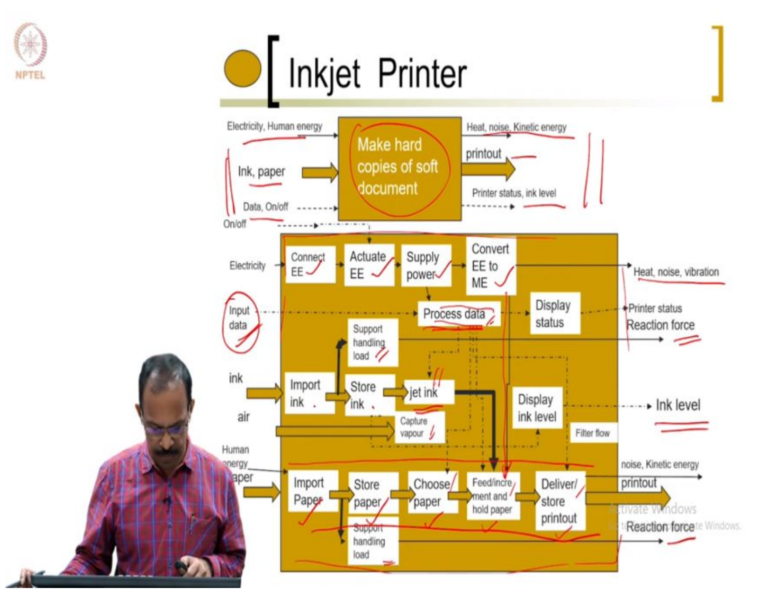
I hope you understood this and using this you will be able to decompose any complex product, because you are not worried about what the product is, you are worried about what is going in and what is coming out. If you know these two, then you will be able to identify what happens inside, and that actually tells you how to get the sub functions within a product. And once you have this, you can actually create the function tree and then see how the functions are arranged as a, in a proper way so that will get the top-level function, and the sub functions and the sub sub functions can be easily identified. And that helps you to design a product also.

(Refer Slide Time: 41:39)



Okay, so this is the function tree, which actually from the previous functional decomposition, you will be able to identify all those functions. Now you can see all those at the bottom level, you can see coupled, separate, solid, import hand, import human force, torque, rotate, transmit, etcetera, all these can be identified using these methods.

(Refer Slide Time: 42:00)



Okay? So this another example for the inkjet printer. So we are talking about the printer, and in the printer, we will see that the main function is to make hard copies or soft copies of the product, of document and the inputs are the electrical, electricity, human energy, ink and paper. And here you have this heat, noise, kinetic energy, print out, printer status and ink level. So these are the inputs flows and these are the outputs.

You can see the energy express using a, using a single arrow and this has a thick arrow and a dotted arrow. Now if I go through this decomposition, I can actually make the products, so within this box, all the functions can be represented within this box, and we will follow each one, each input one by one. So look at the paper, so you take paper, so import paper and store paper. Okay, if there is a storage facility you can store paper in the printer, if not, there will not be the store paper will not be there.

And then choose paper, so depending on the paper and the number of copies the paper has to be chosen. And then feed or increment the paper and deliver the paper or store the print out. So that is the, these are the functions that in, these are the things what happens to the paper when you put it inside, when you give it as an input to the printer. Now, there is a feed and increment of the paper, so we need to have some input to do that. Okay? So we will see what happens there.

So, when we are storing paper then there should be something to handle the load also. Then we will see the ink, so import ink and store ink. If it is an inkjet printer, you need to have some ink stored. That is imports, import is bring in the product ink and then store it. Then jet ink, that means you have to convert that into a jet. And then you have to display the ink level also, so that is an information that you need to see based on the store ink, you have to display the ink level.

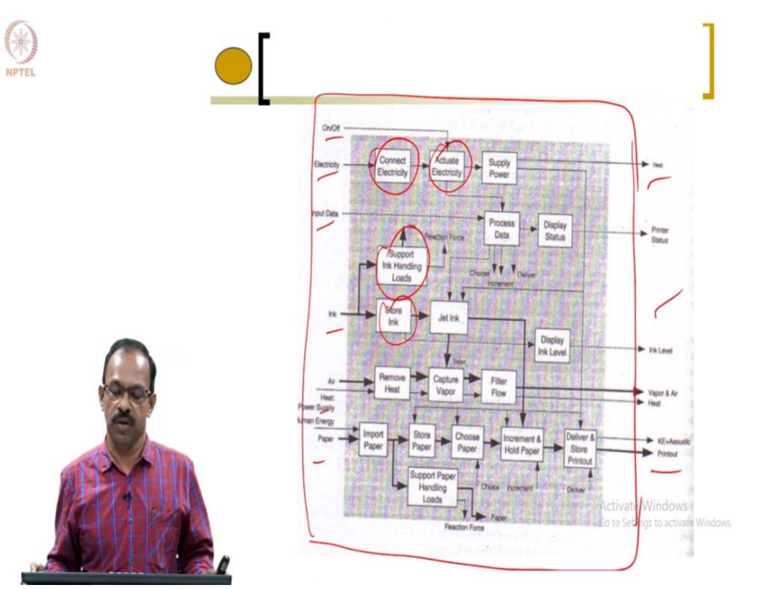
And that will be going as an output signal or the information. And if there is a storage, then you need to have a handling load also, support handling loads, and the reaction force will come as an output, here and here. Then electricity, connect electricity, actuate electricity, supply power, convert electricity to mechanical energy. Okay? And that mechanical energy is used for, here for incrementing the paper. So now we know what is happening to the paper and what is happening to the electricity.

When you convert the electrical energy, there will be noise generated and there may be heat generated also. So heat, noise and vibration may happen depending on the type of conversion. And then you have the process data that is the data that is coming as an information. So you have the input data coming as an information or a signal. You have to process this information and that will be given to different functions in order to make it possible for that function to happen.

For example, to choose paper or the feed the paper, you need the information from the controller. So that is the process data will generate the signal, necessary signals for the ink generation, inkjet ink, paper choosing and feeding the paper as well as delivering paper. So this is the information flow taking place in the product. And you will be able to see as I capture vapour.

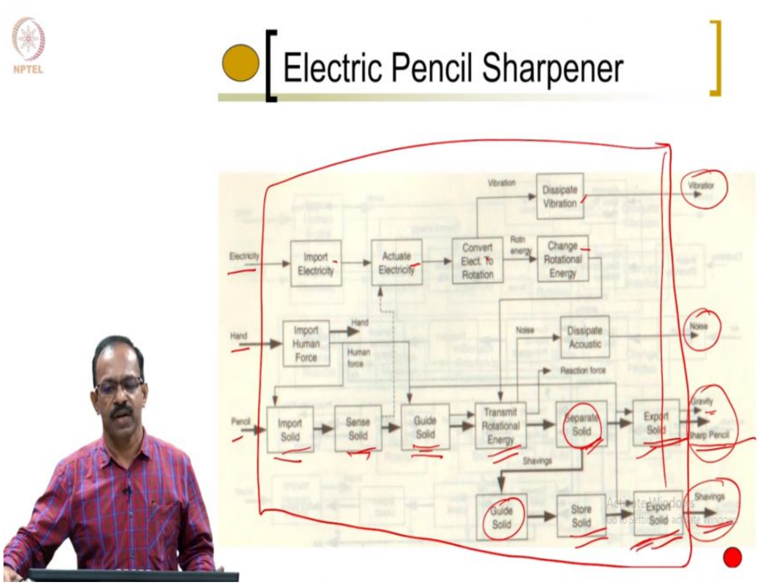
Suppose you want to have a system where the jet ink produces some kind of vapour, so you need to have a capture vapour as an additional function. Okay, so air will be used as an input in that case. It will capture vapour and then it will filter the flow, and then hot air and vapour will be coming out. So, that is why you are getting hot air, because you are taking air inside and then use it for some purpose inside, and then the hot air is coming out.

(Refer Slide Time: 45:46)



Okay? So this shows the detailed diagram of the same inkjet printer and you can see that the inkjet printer has got many functions inside as you can see here, and all these functions can be easily identified by looking at the inputs that are going into the product and the output coming out of the product. And this method of looking at the flow and then trying to understand the functions inside the product is the functions structure method of functional decomposition or sometimes known as flow method of functional decomposition.

(Refer Slide Time: 46:22)



The last example for today is the electric pencil sharpener. As you can see here, electricity is going inside, the hand is there and the pencil is there. And you get the vibration as an output, noise as an output and then the sharp pencil as an output and some gravity forces will be there and the shavings of the pencil will be coming as an output. Now what is happening to electricity?

Import electricity, actuate electricity, convert to rotation and change rotation energy, because you can change the direction of rotation if needed. And then, if the since its vibration is generated, you anticipate vibration also. And hand, sorry pencil, import solids, send solid, guide solids, transmit the rotation energy because you are generating rotational energy, you transmit the rotational energy here and then, separate solids.

You are saying that you have to separate solid from another solid. So pencil is taken and pencil is sharpened by removing the material from the pencil that is the separate solid and then export solid. The shavings, the pencil is exported, the pencil after the sharpener, sharpening, it is removed. And this shavings or the dust coming out of the sharpener will be guided to store somewhere and later on, it will be exported or sent out.

That is the coming out of the shavings. This way by, okay the last one is the hand, how the hand, the human hand is used. So, the human hand is used for holding the pencil, importing the pencil and then guiding the pencil. And similarly, for exporting the solids we will use, exporting the pencil and exporting the solids, we used the human hand. So you use the human hand and hand energy and use that one to hold the pencil, remove the pencil as well as remove the shavings also.

That actually explains the way in which we can use the flow method of functional decomposition to identify all the functions within the product. So I will stop here. We will take a few more examples in the next class and then see how we can use the functional common basis and the flow methods to identify all the sub functions in the product. Okay, thank you.