Product Design using Value Engineering

Prof. Inderdeep Singh
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture - 10
Functional Analysis System Technique

Namaskar Friends! Welcome to session 10 of our course on Product Design using Value Engineering. So, as you are well aware that we are discussing the functional analysis part of our course. Just to have a brief review of what we have covered till date, because today we will be winding up the second week discussion and the course is a 4 week course having 10 hours of discussion that is 20 sessions of half an hour each. So, today in our way we are midway through our course.

So, what we have covered it till date? We have tried to cover the basic aspects of product design, maybe 1 or 2 sessions the product life cycle the different stages, steps, phases of the product design process. And we have tried to emphasize the importance of a concept that is value engineering which is not usually covered in most of the UG curriculum.

So, we are trying to integrate the concept of value engineering with the product design process because it helps us to achieve a product with a design which is competitive in the market. So, basically the target is to help the designers with an additional skill set that they can focus on the cost of the product also during the design stage.

And we have seen the basic aspects of value engineering, what value engineering is all about, the definitions of value engineering, the role of creativity in value engineering, then we have seen that value of any product can be represented as a ratio of function by cost. And cost structure or the costing process for a product is almost taught in the in the courses. As all of us know that the cost of any product will be made up of the inputs that are being used, the infrastructure that is being used to create that product.

So, the costing part is not that difficult, but the functional part is an important aspect because if you focus on the function of the product, our product design may change completely and as we have taken few example, even the design may become redundant the function of a product can be integrated with some other product which we are already using or possessing. So, therefore, it is important to understand the function of a product.

And product as all of us know that they are the assembly of a large number of sub components or sub parts. If we take an example of a bigger product, let us take, an example of an aircraft.

So, the aircraft is made up of so many different elements, different sub parts, different sub-assemblies, so we have to see that how these sub assemblies, how this sub parts, how these components play an integral role in defining, the overall performance of the product. And how the functions of each and every product or each or every sub-assembly or part are interacting with each other, whether the functions are independent of each other or the functions are interacting with each other. And then we can try to eliminate some of the components or parts by integrating the functions that they are achieving with the already existing part or more important parts.

So, therefore, we have to analyze the functions of the product, very systematically logically and we have to identify the function first create a alternative and then finally, refine the alternative and finally, we have to integrate that modified design into our product. So, basically, we will try to understand today an important technique which we call as the functional analysis system technique.

So, functional analysis system technique is a systematic approach of finding out maybe the redundant functions or finding out the basic function and the higher order function of a product, and to redesign the part by focusing on some of the non value adding functions that that are integrated into the product because of n number of reasons. And as this topic is also quite exhaustive we have not been able to cover that what are the reasons for the poor value into the product.

Now, if I ask you because here we are trying to find out some of the elements sub parts components in assembly or in a product which are not adding any value to the product. How you can say that these parts sub assemblies do exist in the product? Now, value engineering is a very old approach. Now, some of you may counter question, and may challenge that once the value engineering concept was used while designing this product, how these poor value functions have come into existence in the product?

It means that designers have failed in their approach, while they were designing this product. So, the answer to this question is, no, the designers have not failed, but the

designers have so many constraints when they are designing the product and the most important constraint is the time constraint.

Today, the company decides to come up with a new product, they will set a very tight deadline, a very stringent deadline that by such and such date the design must be ready, by such and such date the manufacturing must be completed or must start and then the product has to be lost on a particular day.

The day may be sacrosanct or the day maybe auspicious for the company or maybe that maybe the raising day of the company. So, that day normally justifies or normally you can say is the deadline for the designers, and the product team or the project team to launch the product. And therefore, the time constraint usually hinders the creativity of the designers.

So, they are not going to look at large number of alternatives, they will focus only on the existing knowledge and the standard practice of design, and we would like to come up with the design within the stipulated time frame. And therefore, while doing that without looking much into the other aspects of design or the other aspects of alternatives they come up with a product which is definitely going to satisfy the functional requirement of the product, but may not be the best product from the value point of view. And therefore, once the product has been launched again the concepts of value analysis are used to find out, to locate the poor value functions, and try to eliminate them in due course of time.

And therefore, you will see that many times companies are coming up with the extended version or the modified versions or the updated version of their product. Why? Because at a later stage they realize that there are better alternatives in terms of materials, in terms of processes, in terms of shapes, in terms of sizes, which can be even update or even help us to create a new product which is better than our existing product. So, that is the basic concept, that there are definitely some poor values, poor value functions in our product and we have to locate them, identify them and try to eliminate them from our product.

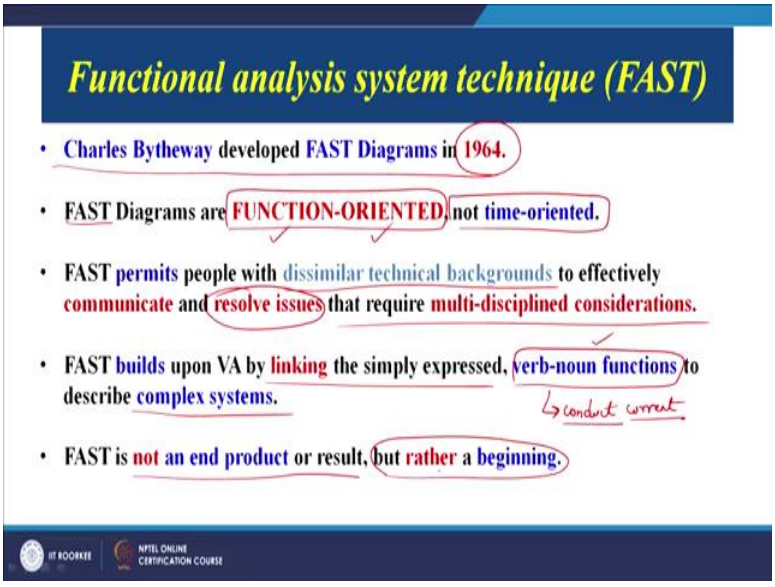
And functional analysis system technique normally helps us in achieving that target because here we blast the product into the individual components, and then try to see what is the function of each and every component. Up to that we have already covered in our previous sessions also, where we have taken an example of a lamp post where there are different parts of the lamppost each and every part is accomplishing one or the other

function. So, we have seen that for each part there are primary functions and there are secondary functions. So, that is what our objectives. So, we try to find that these are the basic functions of this product, these are the secondary functions.

Sometimes, we may like to combine two secondary functions of two different parts together and then maybe even able to combine the two parts together into a single modular part. So, functional analysis system technique will also work on the similar principle as we have seen in our previous session. We will try to find out the basic function or the lower order function, the higher order function and then finally, try to see that what can be eliminated.

Now, let us quickly see the question that every learner must be able to answer is that why we are using a FAST diagram. So, here if you can see that two parts are there functional analysis which we have already covered in our previous session, and the second is the system technique. So, here we will try to analyze the whole system using this technique. So, we will draw a FAST diagram and try to understand that how the functional analysis can be done in a more systematic manner, analyzing the system as a whole.

(Refer Slide Time: 09:59)



Now, just to have a brief review of what does this technique mean and how it originated. So, Charles Bytheway developed the FAST diagrams in 1964. So, it is more than 60 years old technique. FAST diagrams are function oriented, so this is very important. Normally, many diagrams like we have seen a product life cycle, on x axis we have time.

So, here in the FAST diagrams we do not have time; time is not an important ingredient. Yes, we have when also in the FAST diagram, but that is related to the functional analysis part. So, normally the focus area in case of FAST diagrams are the functions being achieved by each and every part, each and every component of the product.

So, FAST permits people with dissimilar technical background or from diverse technical backgrounds to effectively communicate and resolve the issues. So, we have to resolve certain issues, we have to make our product better, make our product more valuable. So, those issues we have to resolve, that require multi-disciplined consideration. So, here different people can communicate, different people can come together, coordinate communicate and come up with a product which is better than the existing product.

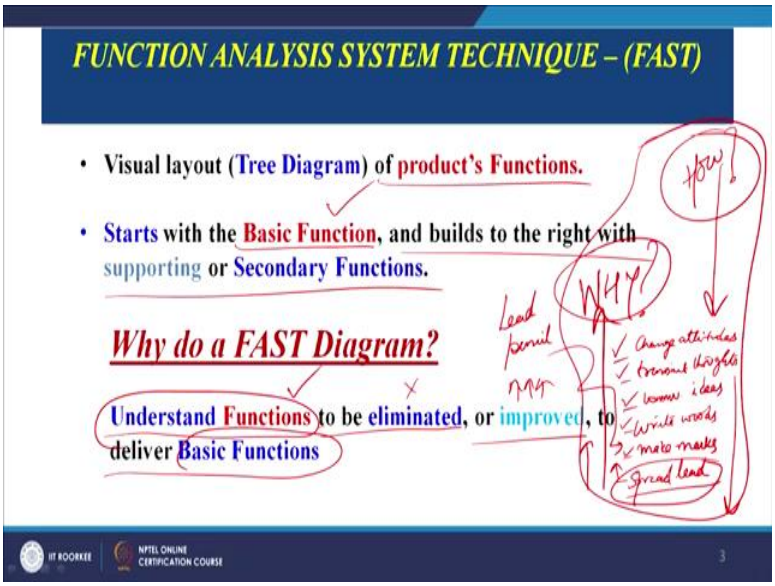
So, FAST builds up the value analysis by linking the simply expressed this already you know verb noun definition. So, one example those who are listening to this session only, conduct current. So, conduct is verb, conduct is a verb and current is a noun. So, this is a verb noun definition of a function to describe the complex system.

So, we will take one example today, so that you are able to assimilate the knowledge about the FAST in today's session only. So, here we for every function we will use a verb noun definition. So, verb noun definition will help us to blast our bigger system into the individual components and each component we will like to write a verb noun definition or the definition of the function.

FAST is not an end product or result, but rather a beginning. So, first and foremost we have to see that FAST, we have to analyze at a later stage. First thing is to put all the information together. We have to put all information together for each and every part, we must identify the basic function of that product, we have to write that part or sub assembly, and we have to write verb and noun definition for that.

Once that is done, then we have to sit with a multifunctional team and see that what are the areas of improvement, where there is a scope of improvement, what are the parts that we can eliminate, what are the parts that are not adding any value to the overall product function and how these can be combined or eliminated. This is the basic background of the FAST diagram.

(Refer Slide Time: 12:59)



Now, this is a visual layout of products function that we will try to see. Starts with the basic function and builds to the right with the supporting or the secondary function. So, right from the basic to the secondary function, we would like to go.

For example, if we take example of a lead pencil that we used to use, when we were in school. So, we can say what is the basic function of a lead pencil. So, it is supposed to make marks. Even, we can go a step lower we can say to spread the lead, so this is a basic function. Then next level is make marks.

Why to make marks? To write suppose words. Why do you want to write words? To communicate ideas. Why do you want to communicate ideas? To transmit thoughts. Why do transmit thoughts? To change attitudes; so, you can see that from this direction, we are asking why type of questions, and we are getting to the next level of the function.

So, what is the basic function of a lead pencil? Spread lead. Why? To make marks. Why do we need to make marks? To write words. Why do we write words? To communicate ideas. Why do we communicate ideas? To transmit thoughts. Why do we transmit thoughts? To change the attitude. So, we are moving in this direction and asking why type of questions.

Now, if we move in the opposite direction that is this direction, we can ask how type of questions. You can start asking. How the attitudes can be changed by transmitting the

thoughts? How the thoughts can be transmitted by communication of ideas? How the ideas can be communicated by writing words? How the words can be written by making marks? How can we make the marks by spreading the lead?

So, these two why and how type of questions if we start asking for each and every product, we will be able to find out that what is the basic function of the product, what is the secondary function of the product, what is the tertiary function of the product. So, how and why type of questions are very useful. And once we are able to make this type of an analysis of a product we will be able to understand.

Now, from this diagram we can see that our basic function comes out to be to spread the lead. And this is now a challenge for the designer to find out means mechanisms techniques of spreading lead on a piece of paper. So, the lead has to be spread by a painter also for making the sketches, it has to be used by an engineer also to make the engineering drawings, it has to be used by a child also to write alphabets or the numerals.

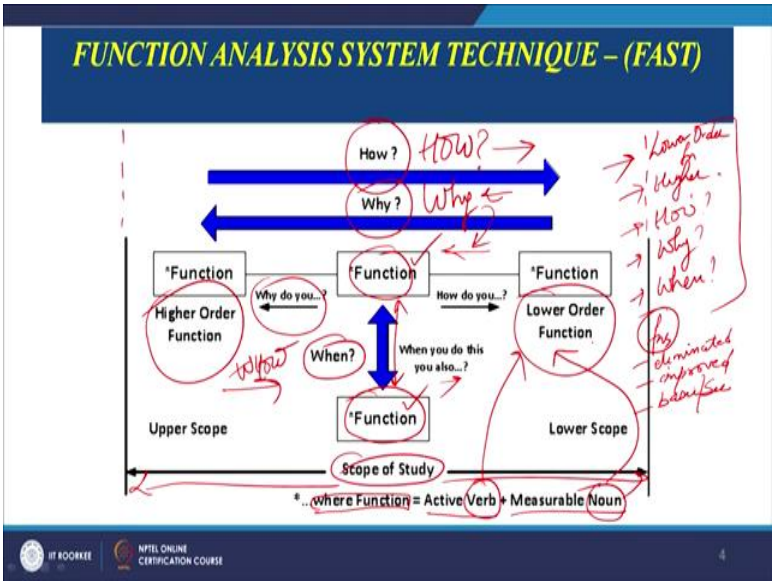
So, spreading lead is the basic function now, and it has to be used by a diverse background or a diverse set of people. So, as a designer he has to see that how this basic function of spreading lead has to be achieved by the product, and the product has to be a pencil. It can be different type of pencil you can see around you, you will find different types of pencil each having the basic function of spreading lead. So, that is, you can say the basic background of FAST diagram, why and how type of questions have to be asked.

Now, why do a FAST diagram? Why do we need to draw FAST diagram? Because it helps us to understand the functions you can see here one example already I have taken it has helped us to understand the functions; so to be eliminated or improved. Now, these functions once we have understood we may like to eliminate the functions, we may like to improve the functions or how to deliver the basic functions, even our product design we may like to change in order to have a better product.

So, we can see that once through the FAST diagram, we are able to understand the function of our product, function of each and every component of our product, we will definitely be able to use our creative skills to come up with a better alternative design which will be having improved functions, which will be able to satisfy the basic function in a better manner, which will be able to eliminate the unnecessary or redundant

functions, which are not adding any value to our product. So, that is going to be the final outcome of representing the functional analysis of our product as a FAST diagram.

(Refer Slide Time: 18:05)



Now, this is what I have already explained, basically we asked how and why type of questions. So, this is how type of question, we are asking in this direction and why type of questions we are asking in this direction. And in the previous slide I have just explained with the help of a pencil or example of a pencil. So, when we asked how and why type of questions, we will be able to find out the basic as well as the higher order functions of the product.

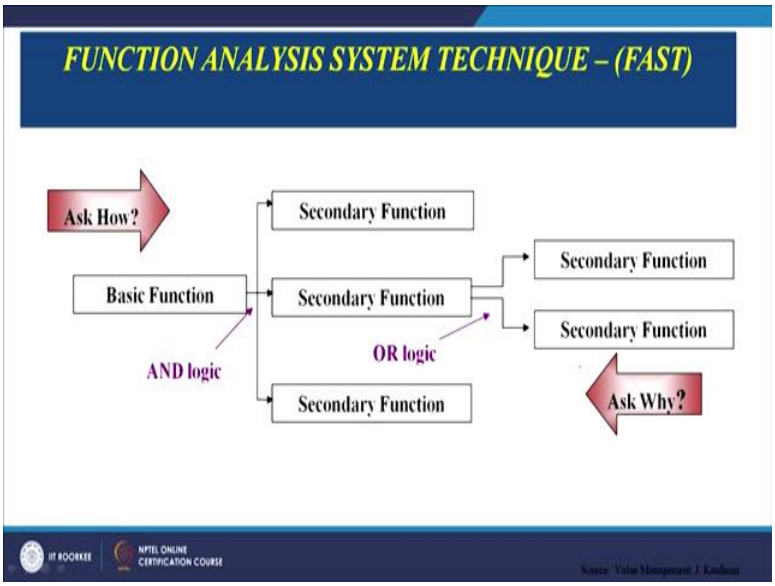
So, this is basically the boundary line for our FAST diagram, and this total is the scope of study. It will represent all, from lower order function this you can see a lower order function to a higher order function. And we will say why, why do you do this? Why do you? So, in this direction if you know, if you see here, we have to ask why type of questions. And in this direction, we have to ask how type of question. So, lower order to higher order.

So, we can see that with the help of a pencil you can try to draw a diagram or functional analysis system technique FAST diagram for a pencil. And if you try to find out on search engines over the Internet, you will get definitely number of figures or number of diagrams where you will see a FAST diagram has been drawn for different types of products.

So, I have also taken one example where the function is represented by action verb plus measurable noun. So, verb and a noun definition has to be given for the function. So, function will be represented by a verb and a noun definition. And another thing that is coming here is when. When you do this, you also do this. So, this is also, when this function is being achieved this function also is achieved. So, when we are doing this function at the same time we are doing this function also. When you do this, you also do this. So, this is basically when type of analogy that is drawn.

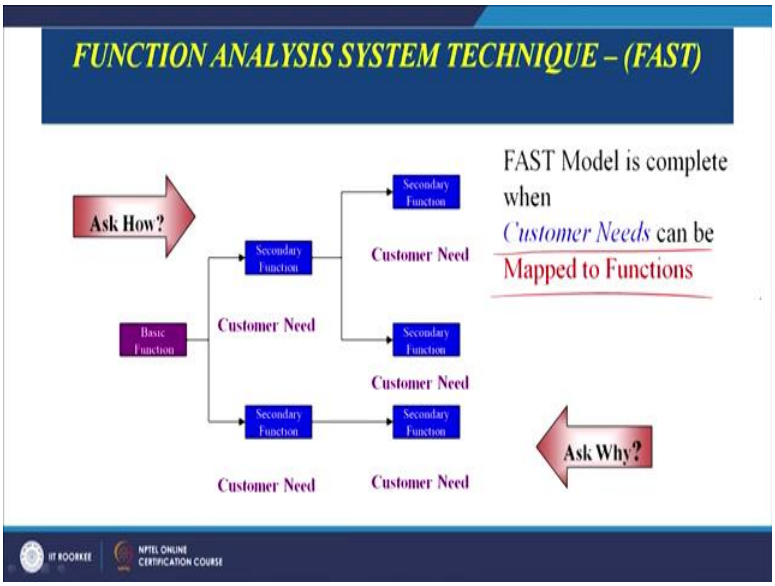
So, let us now try to understand all these 3 things. What we need to understand from this diagram once we go to an example is the lower order function, we need to look at the higher order function, we need to look at how type of questions, we need to look at why type of questions, we need to look at when type of questions. And then we will try to see that what are the functions which can be eliminated, what are the functions which can be improved, what are the functions, which can be classified as the basic or the secondary function. So, this is a functional analysis that we would like to do.

(Refer Slide Time: 21:21)



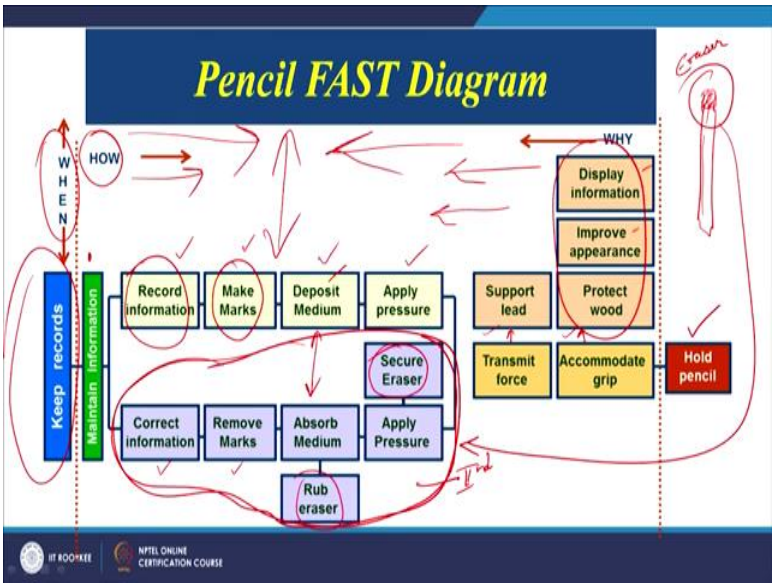
Let us quickly try to understand the diagram. So, here you see ask why, secondary function basic function, ask how AND logic, OR logic. So, this is the same thing that we have written there.

(Refer Slide Time: 21:33)



So, quickly now we can start for our diagramming approach. So, here we can see FAST model is complete when customer needs can be mapped to the function. So, this is the general diagram. So, I want to take an example.

(Refer Slide Time: 21:47)



So, this is a FAST diagram of a pencil. You can see, hold a pencil, this is one and here we are asking how type of questions in this direction, why type of questions in this direction. So, we can see hold a pencil. Why we want to hold a pencil? To accommodate the grip. And when we are accommodating the grip, we must also have a protective

wood coating, appearance also is important and display the information sometimes on a pencil for example, am using this stylus here also, some information can be displayed. So, when we are accommodating the grip all these 3 when, when this function is there all these 3 things are important. When we are holding the pencil, we are accommodating the grip, we have a productive wood coating, appearance is important and the information can also be displayed.

For example, we can take an example of; what example? We can say save trees, save girl child, we can save our environment, save water. So, such type of information can also be displayed. Also, the name of the company, the type of the pencil HB1, HB2 that kind of information can be displayed. Now, first is accommodate grip; now once we have gripped it, we have to transmit the force, whatever force we are applying. So, for that we have to support the lead. So, lead has to be supported because we are applying the force. So, it may not many time if you apply more force, the pencil breaks or the lead breaks, so that has to be avoided. So, there is the hold.

Then apply pressure, after you are applied transmitting the force, apply pressure, deposit the medium. What is the medium? Medium is lead, then make marks. If you remember we have said the spread lead and make marks. Then, once we are able to make the marks, we are able to record the information and then, we can maintain this information which can help us to keep the record. So, we can see when is coming in this direction, why is coming in this direction and how is coming in this direction.

So, if we start now asking the why and how type of questions we can say. Why do we hold a pencil? To accommodate a grip. Why do we accommodate that grip? To transmit the force. Why do we transmit the force? To apply the pressure. Why do we apply the pressure? To deposit the medium. Why do we deposit the medium? By making the marks. And why do we make the marks? To record the information. And why do we record the information? To maintain the information.

Why do we maintain the information? For keeping the records. So, this is why type of questions in this direction. We can now, how type of questions also. How to keep the records? By maintaining the information. How can we maintain the information? By recording the information. How can we record the information? By making the marks. How we can make the marks? By depositing the medium. How we can deposit the

medium? By applying the pressure. How we can apply the pressure? By transmitting the force. How we can transmit the force? By accommodating the grip. And how we can accommodate the grip? By holding the pencil. So, this is the way.

Now, in this direction we have, when type of question. So, when we apply pressure, we can also secure the eraser on the pencil. So, we can have an eraser as well as a pencil. Then when we are depositing the medium, absorb the medium, we can also rub it by the eraser. Remove the marks, because from here we have a secure eraser also, so we have double function.

Though this color is representing the second function which we can achieve that is if we have secured an eraser at the end of the pencil that can also be accomplished by the pencil. So, this pencil can be of this type with a cap here and eraser at the end. So, this eraser, these are the functions in this color, what is the function of the eraser.

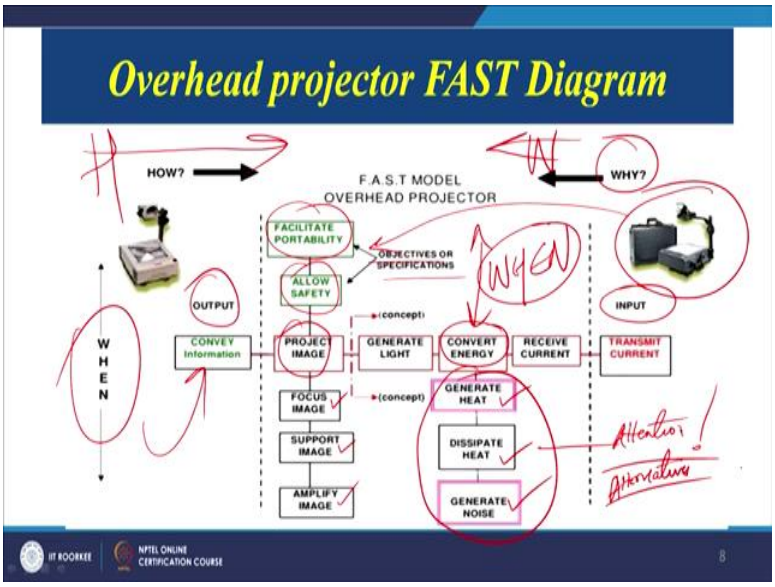
Now, secure eraser, apply pressure to the eraser, it will absorb the medium, it will perform the rubbing action, it will remove the marks and it will correct the information. So, it is not only depositing the lead or making the mark, it is also the pencil is also achieving the purpose of removing the marks also, because it has a eraser at the end of the pencil. So, this is another part of our product that is being analyzed using the FAST technique.

Now, here we can see that this is an entirely different function. Do we really need to have this function? In our product, suppose these pencils are being used in a 5 star hotel for making notes by the executives who are attending the conference in that case; obviously, they may not like to use this pencil with the eraser at the end, we will they would like to use a separate eraser. So, that can be one of the areas where this function of eraser can be eliminated.

But, on the contrary, if we are giving or designing a pencil which has to be used by the school going children, it is always better because there are chances that they may lose the eraser sometimes or many a times. So, if the eraser is integrated with the pencil, it is always better. So, depending upon the needs requirements of the customer, the product will be analyzed, and the decision will be taken that how it is going to benefit or help the customer in satisfying the function for which the product has been bought.

So, here we can see, we have taken an example of a pencil that how and why type of questions will help us and also the multifunction product also can be represented in a FAST diagram. This colour is representing the second function of eraser, secure eraser, apply pressure, absorb medium, remove marks and correct information, functions of a eraser and the light colour yellow background, boxes are representing the basic functions or for the pencil or the lead (Refer Time: 28:26) pencil.

(Refer Slide Time: 28:27)



So, this is another example which is the overhead example of a FAST diagram. This is the product. You can see here again, you can see, here why type of questions from right to left, and how type of questions from left to right. So, first is input transmit current, receive current, convert energy.

Now, once the energy is getting converted in this direction, what do we do, already we have seen. This is why, this is how, and in this direction it is when. So, when the energy is getting converted, we can see it will generate heat. So, for generating heat we have to dissipate the heat and once we are dissipating the heat with the help of a fan, it will generate noise.

Then convert energy, generate light because this energy the current will help us to generate the convert the energy into light that is we have a lamp or we have a bulb there which will generate the light. Now, once you are generating the light, it will project the image. So, once the image is projected what we can do? Once the image is projected we

can focus the image, we have to support the image somewhere, and then amplify the image in case of an overhead projector. And then, we also have to allow the safety and facilitate the portability objectives or specifications for this product. So, we have to ensure safety also, we have to ensure the portability also.

And what is the output? The output is that we will be able to convey the information. And in this direction is again which I have written here when. So, basically, again this is giving you another example of the FAST diagram; previous one was related to the example of a very common product which all of us use that is pencil. This is related to overhead projector.

So, for overhead projector also you can see, what is the input, the input is a current the output is a convey information. So, we are able to understand the functions of each and every part of the product. And here we see generate heat, what will generate heat when we are converting the energy? It will be the bulb that is generating the heat. Now, this heat has to be dissipated.

Now, we can see that once this diagram is ready, what are the focus areas, where we can focus our attention? So, we can focus our attention on suppose one of the attention areas can be this. And how we can focus? We can say that one of the challenging aspects is that heat is generated in the overhead projector, how this can be eliminated.

We can go back, a step back, why the heat is generated when we are converting the energy which means that lot of energy is required to generate the light which will be able to project the information. Obviously, we would like to look for alternatives that what are the alternatives available with us which can generate similar amount of light, but with lesser generation of heat or no generation of heat.

So, we would certainly like to focus on that area that is energy conversion. Now, this why? Because energy conversion is unnecessarily adding these 3 problems into our product. What are the 3 problem? Generation of heat, we have to then find out means and mechanisms of dissipation of this heat and finally, this is also leading to generation of noise. Why?

Because for dissipation of heat we are using a small fan inside our appratus or in our product. So, the fan when it is continuously moving will generate noise. So, we have to

focus on this area and if you see the projector systems that are being used today are much better effective, efficient and performance wise, we can see more reliable as compared to the old overhead projectors. Why? Because this area has been addressed.

Now, the type of bulb used does not get too much of heat. There is less requirement of cooling or dissipation of heat, and since there is less requirement, the fan system also is designed or developed in such a way that it generates very less noise. So, we can see that once, we are able to draw a FAST diagram like this we will be able to find out or we will be able to locate, we will be able to identify the areas which are not adding any value to our product, but are in a way reducing the value of our product.

And therefore, once we focus on those areas, we will be able to find out the technological advancements, the material science advancements, the manufacturing technology advancements, and trying to integrate those advancements into our product, we will be able to eliminate, the unnecessary functions or non-value added functions in our product. So, here we can see that, the fan or the cooling system is a redundant function, because of the change in the technology, we can have a better cooling system which can help us to eliminate the noise that is being generated in the overhead projector.

So, I think we can keep on discussing the topic related to overhead projector on your design of the overhead projector. But our target is to understand the technique of functional analysis system technique or the step by step procedure for constructing a FAST diagram that we have been able to do successfully today. We have tried to understand that what is a FAST diagram, why it is required. We have taken examples of too FAST diagram and I think if you further do self study and look for various other examples of FAST diagrams for different products you will be able to appreciate the importance of this technique.

So, with this we come to the end of the second week of our discussion on this very important topic of product design using value engineering. In our next week of discussion, we will try to focus on another important aspect that is a functional cost relationship. Right now, our focus only has been on the functional analysis, trying to identify the best functions or the basic or the secondary functions of the product. And then we have tried to analyze the function using a systematic technique that we call as

fast. So, we will now try to relate these functions with the cost of the product and try to understand that how we can analyze the functional cost relationship for a product.

Thank you very much.