Product Design and Manufacturing

Prof. J. Ramkumar
Dr. Amandeep Singh Oberoi
Department of Mechanical & Design Program
Department of Industrial and Production Engineering
Indian Institute of Technology, Kanpur
National Institute of Technology, Jalandhar

Lecture - 03
Engineering Design Process

So, welcome to lecture three. In this lecture, we will try to see the product design morphologies.

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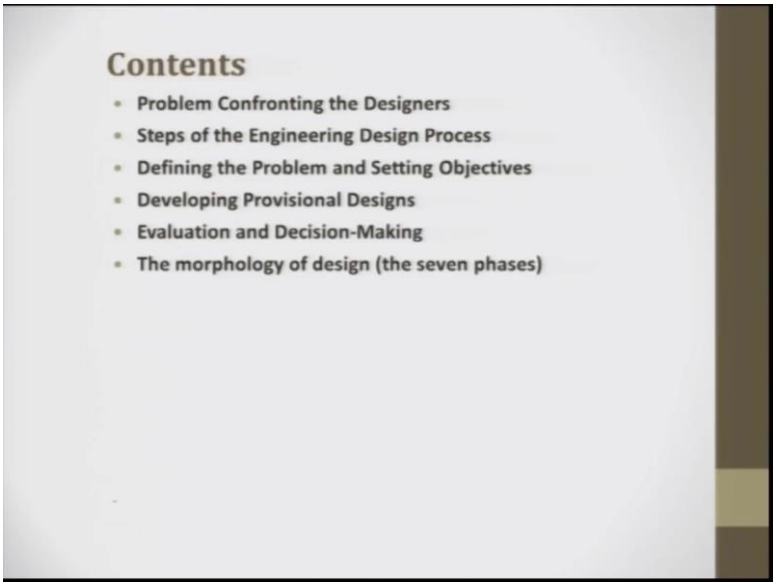

The content of this lecture is going to be problem confronting the designer, next the steps of the engineering design process, the third one is defining the problem and settling objectives setting objectives, then developing provisional design, evaluation and decision-making, and the morphology of design the seven phase. So, all this topics will be covered in this lecture.

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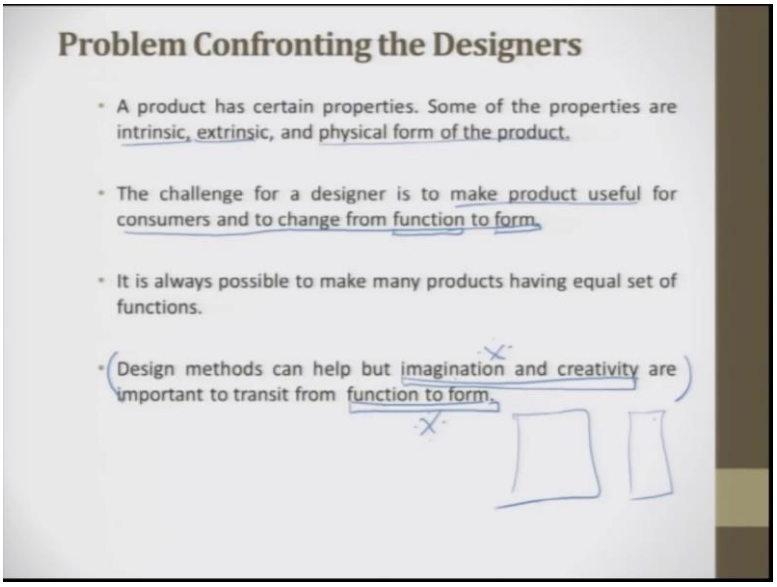

Problem confronting the designer; the product has certain properties. We said it has to be it has to be functionally good, it has to be quality, it has to be reliable, it has to be economical. The product has certain properties some of these properties are intrinsic, some are extrinsic, and physical form of the product. So, these are some of the properties intrinsic property, extrinsic property, and physical form of the product.

The challenge for a designer is to make products useful for customers for and make change from function to form. So, function is one, and form is the other ok. These two are different terminologies. So, the challenge for a designer is to make product useful for customers and to change from function to form. It is always possible to make products having equal set of functions ok.

The design methods can help but imagination and creativity are important to transit from function to form. So, this skill is also very important for a product designer. So, a design method can help but imagination and creativity are important to transmit from function to form. So, this is a very important statement. So, imagination and creativity are important to transit from function to form. Function is; what are all the functions which a product is supposed to make. A form is; what is the shape which has to be incorporated into the product. For example, we have majority of the phone flat, Smartphone's as flat why do not we have a cylindrical phone wherein which it is something like your pen which can which can be kept inside pocket which has a which has a cylindrical circumference.

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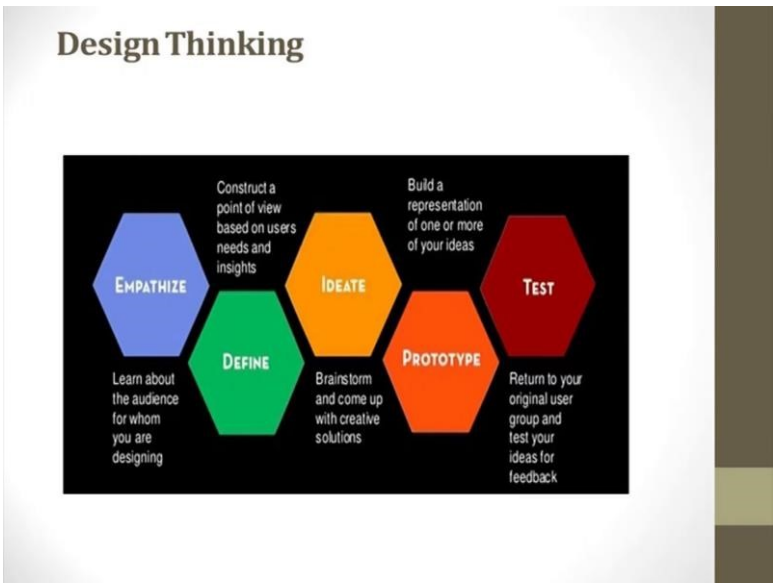


Design thinking has five steps. One is called as the empathy study. Empathy study means you just go to the customer, ask the customer what problem he faces, and you become the customer him himself or herself and try to understand the problem from the customer point of view. So, it is learn about the audience for whom you are designing. So, first you go get into the shoes of a customer himself, understand what all problems he faces, and then you come out and look from the designer prospective how can you solve the problem. So, empathy study is very important. Empathy and sympathy are two different terms. A designer should have an empathetic feeling.

So, he should get into the feelings of a customer, look at the problem, and then note down all the problems what he faces and then start looking for solutions. Once you look at all the problems, you note down all the data. You note down you note down all the information whatever note down all the data, then on this data you try to rearrange the data such that you get a proper information and then what you do is you define the problem exactly.

For example, I was talking to you in the last lecture, I feel cold, so that is a problem statement. You cannot say that I need to buy a sweater. So, when you say I need to buy a sweater, you are almost finalizing a that you do not need a jacket and sweater is one solution towards solving the problem, but what is the customer facing I feel cold that is

it. So, moment I say I need a sweater, then naturally your further processing of the problem goes around finding out alternative sweaters to keep you warm. But moment I say I am I am cold, I want to protect myself from cold. So, you can look at a jacket, you can look at a sweater, you can look at a shawl. So, all those other alternatives are there ok.

So, moment you do the empathy study and then you get the information now you clearly define the problem what is that a customer wants. So, I feel cold, the customer needs something to protect himself. The next question comes is whether it has to be light or heavy. Then the next question comes is should it be should it be only matching fitting to him or he is also looking for his friend also that means, to say is he is he interested to go for a matching fit a shirt or is he looking for something like a shawl. So, now, you see I have defined properly that I need something to protect. So, construct a point of view based on user needs and insides you start defining the problem statement ok.

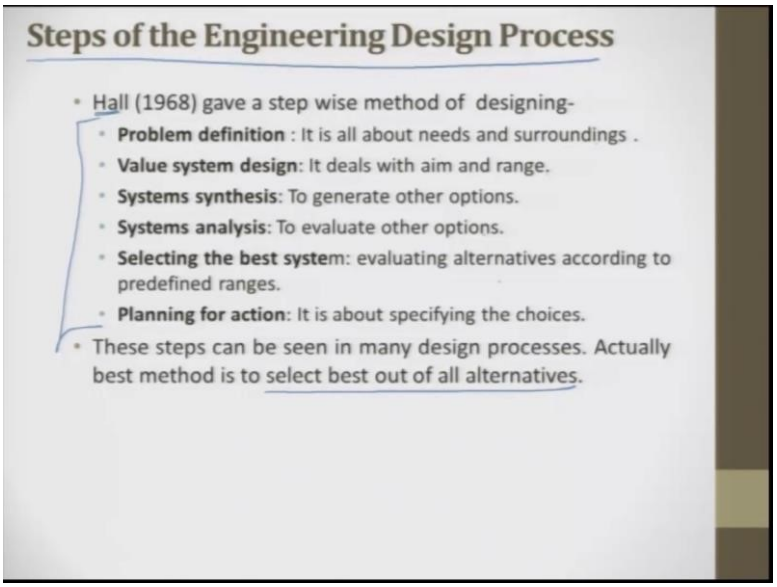
The next one is this ideation. In ideation, what we do is we try to develop several alternative ideas in trying to meet out the solve the problem. So, here what was the problem, I feel cold, he has to be protected from cold. The alternative solutions are sweater, jacket, shawl whatever it is. So, these are ideations. So, brain storming and coming up with creative solutions is nothing but ideation.

The next one is you make prototype. See as far as buying is concerned the problem ends there he chooses one and then he goes, but if you want to make a product. So, next what you do is from this ideation you start making prototypes. So, you try to whatever the customer wanted, and whatever you have understood, whatever alternative ideas you are generated with that you try to pick one idea, make a prototype and show it to the pub show it to the customer that is this idea or is this product happy for you. Do you feel satisfied with this solution for your problem, so that is nothing but making prototype. So, build a representation of one or more of your ideas, show it to the customer, it can be one it can be n. So, you show it and then ask the customer to pick ok, this solution is much better. So, then what you do is you start working on engineering design problem solving. And then finally, what you do is you start making it to the requirement and then you start doing testing.

So, return to your original use so user group and test your ideas for feedback. Suppose, here you made a prototype. Prototype can be in terms of functionality alone, it need not be in terms of form. So, after that what you do is moment you have understood all the things what you require in a prototype, you take that idea and then put form also to it make it as final and show it back to a customer, get his feedback and start doing it. So, here this is the testing phase.

So, this process is called as design thinking. You should do an empathy study and then you should define the problem. You should develop several ideas then after that you will develop prototype. Prototypes can be in terms of functionality alone; it need not be in terms of shape, size, form it can be only in terms of functionality then from there you pick it and then you go. So, here it will be almost like your final product, almost like your final product you show it to him and then get it.

So, what you develop after testing is also not the final product. You show alternatives and then you make it make it to a final state. And after this what you do is you start looking forward for design for manufacturing design for and then productivity, manufacturing capability all these things will be thought of after this. Before this it is more towards accepting the idea. And here till here you do not work on economics. After this you start working on optimization then you start working on economics. (Refer Slide Time: 09:52)



So, steps involved in engineering design process which we saw problem definition it is all about needs and surroundings. Then value system design it deals with aim and range. System synthesis to generate other options system analysis to evaluate other options. And then select the best system evaluate alternative according to the predefined range and then planning for action it is about specifying the choice. So, this are the steps which are involved in engineering design process which was put out by Hall in 1968. These steps can be seen in many design processes actually the best method is to select best out of all alternatives. So, this is very important.

So, whatever I said here design thinking, it is almost the same which is on engineering design process. So, problem definition is a first step, value system design it is the it deals with aim and ranges, then system synthesis to develop to generate various options, then to evaluate those options, then choose the best out of their options then plan your actions for making the proper choice.

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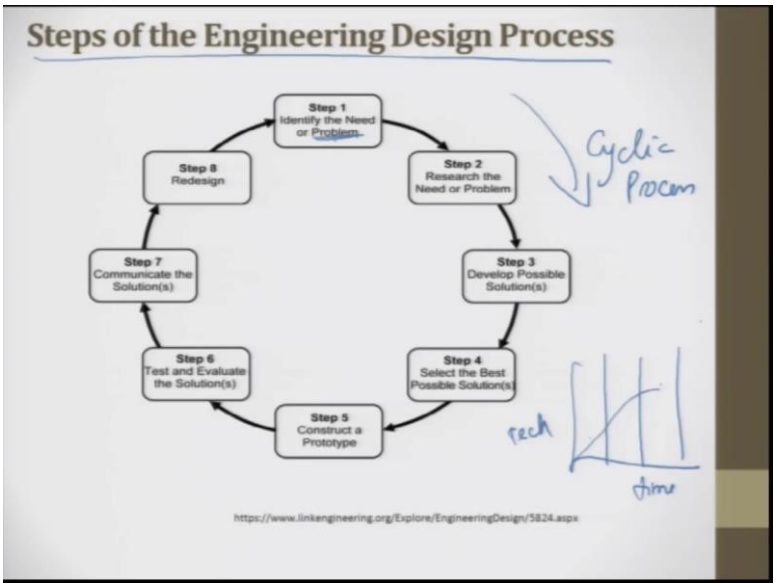

These are the eight steps which are involved in doing it. So, first step one is identifying the need or the problem, research the need or the problem. So, this two this is just overlapping design thinking, engineering design process, all these things are just overlapping which are which here is put in a much micromanagement step. So, research the research that need or problem, develop possible solutions, select the best possible

solution, construct a prototype test, and evaluate communicate the solution and if there is a need you redesign, and then you keep continuing.

So, design is a cyclic process. It keeps all these and no product which comes to the market is the ultimate one. For example, if that is the case then every way everybody in this universe should use only a same or a same Smartphone, but depending upon the choice of the customer and the application, there are several Smartphone's available. So, what am trying to say is in design there is nothing called a unique solution. At that point of time to this customer might be a unique solution. So, you there is alternative solutions for the same problem, so that is what we are trying to say here. So, in problems whatever you understand.

So, there is a possibility that you you communicate and then you if there is a need base you redesign and meet out to a new customer. If you go back and match for your different stages of technology development with respect to time we had four stages. So, whenever it comes to that matured stage we will always try to reiterate, push it back, and then do redesigning and come back to this early stage and start doing it. So, these two are linked. So, if these are the different steps which are involved in engineering design processes.

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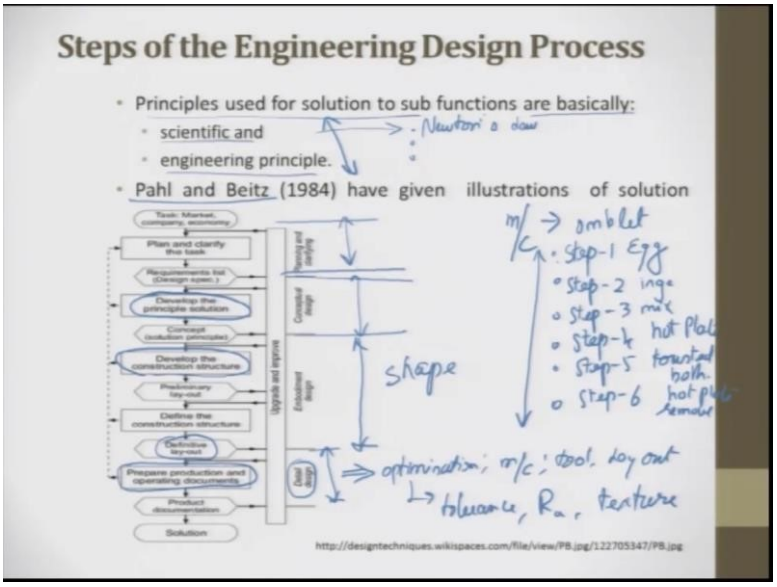

So, the principle use of the solution to sub function are basically scientific and engineering principles. So, it is not just like here say and you randomly do. So, it is it is more focused towards these two. So, the principles used for for solution to sub functions are basically scientific and engineering principle will be there. So, scientific means you Newton's law, Archimedes principle whatever it is. So, all these principles are used and then you try to go ahead with a solution of doing it.

So, Pahl and Beitz have illustrated this illustration of solution is first what they said market company task is market company economy they say, and then they get into a planning and clarifying the task. Then required list of that is design specification they do, this is called as the planning and clarifying operation. Then what do they do, they try to develop conceptual design. So, develop the principles solution, concepts you have developed several solutions. So, you build up a concept. Then after that what you do is develop the construct the constructions structure. You do preliminary layout and then you defined the construction structure, define layout and then preparation production and operations document. So, this is this is what is this is detail, this is detail.

So, here in which we do optimization. And we try to come out with what is the machinery machine to use, what is the tool to use, what is the layout of the factory, all those things small, small things come out with the detail design when you start doing it. Or if you try to take a product then we talk about tolerances, we talk about finish, we talk about texture. So, all these things detailed design of the particular product comes into. And then product documentation comes and then you talk about solutions ok. So, so this is what is it.

So, you would according to Pahl, so you will have a planning and clarifying conceptual design, and then this is called as embodiment design wherein which you try to give a shape to the products. So, till here it is concept. So, develop the construction structure, the preliminary layout and then define the construction structure. So, it is giving shape, shape to the complete project whatever it is. So, before that what we did was we try to do a conceptual you look for solutions ok.

Let us just take another example. I want to make a machine which is used for a egg omelet. So, here what I do is. So, what is so first step is step one, I have to break an egg. Step two, I have to add ingredients whatever it is. Step three, I have to mix the ingredients. Step four is I have to pour in a hot pan hot plate; and five is I have to decide whether it has to it has to be toasted both sides, and then six I have to remove it from the hot plate hot plate remove ok. So, these are the steps involved.

So, what was the problem statement first I have to identify how do I want to make a omelet making machine, so that was a clear problem statement, then what did I do I did all the steps are involved I did. I have not gone in depth. So, I just put down all the steps. So, now, for these steps I would try to develop a machine. So, in this machine, what I will do is I will try to apply principle solution. For example, should I use microwave, should I use induction heating, should I use a coil heater, so all these things I try to put the concept.

Once I do this concept, I put all these things and construct how it should it be in a cuboidal shape, should it be in a cylindrical, should it have several induction stations should, it be only one station. So, all these things are construction the shape, the size, the steps involved all these things are construction structure we do. And finally, what we do is we defined the layout and after this we prepare the product a documentation why did we do it, and then product documentation is done and the solution is given.

So, these are the steps which are involved for one simple example which came to my mind. So, first you try to do it scientific and then engineering principles are used. So, no product can come just out of the moon or out of the blue it cannot come. There has to be some scientific backing, there has to be some engineering principles, and then only you can start developing a product which is worthy and which is functional and which has quality in it.

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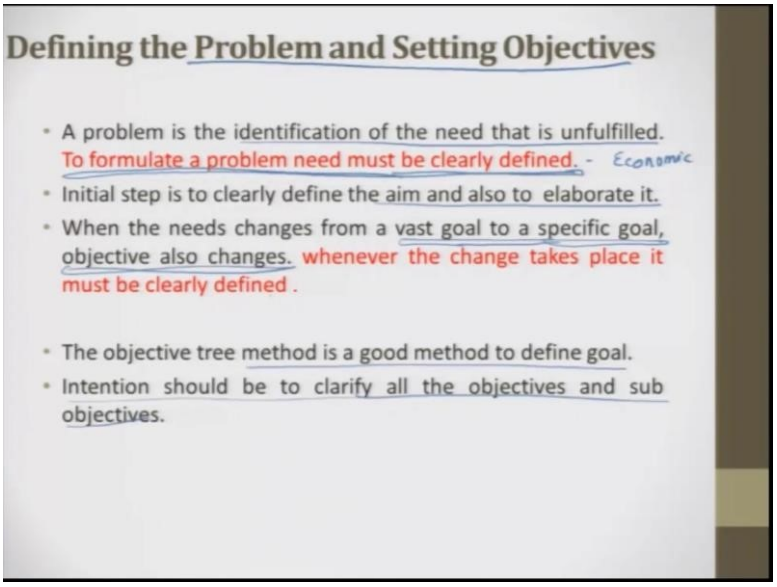

So, defining a problem and then setting the objective, the problem is the identification of the need that is unfulfilled. To formulate a problem need must be clearly defined. What was my need I need to make an automated omelet making machine, but before that students I did not address will this be economical or not. I wanted to make an automatic machine, true, I wrote I wrote down all the steps true I came out with the wonderful product true, a very reliable product true, but I did not work the economics of it. If I buy a machine worth of 25,000 rupees, and the output is I have I can make every 30 seconds 1 omelet.

So, the consumption rate of omelet is 30 per day my production cycle time is 30 seconds I can make 1 omelet, but my consumption that means, to say I will have only 30 customers a day what is the point in developing or buying such machine. So, that is something which is very important it did not explain to you, and I did not put the economics to you, if that situation is there, then no point in developing a product.

So, you just be happy on appointing a person and he is multi tasking fellow, he does this job that job you can optimize and get the job done. So, that is what am trying to say to formulate a problem need must be clearly defined. And when you define economics also should be one among them. What is the costing we can do? Is it truly justified that we should automate it, ok. Initial step is to clearly define the aim and also to elaborate it. First you have to do all those things. You have to write it down what is the aim will be

very elaborate and when the need changes over from a vast goal to a specific goal the objectives can change. So, first is ok.

So, when you go back I need to make an omelet. So, why did I go for this omelet making machine, I thought that maybe it is it is a dirty process may be it is a dirty process I do not want a human to do it, I want a machine to do it, so that is what was my goal. So, first thing, but now I realize after putting all those things I realize, maybe I need to make a beating station, I need to make an induction station where these two are the dirty process I want to just make them clean. So, when I had a vast goal that was completely different. Now, I have specific goal what I have to do is look for only a very efficient heating technique, and then this heating technique should be also should be also something like universal, so that other processes can be used by the same heater.

So, when the need changes the vast from the vast goal to a specific goal, the objective also changes. Whenever the change takes place it must be clearly defined or you are supposed to redefine your objective is that clear. So, you are supposed to redefine your objective. First you have to clearly formulate a problem then when you go detail study more and more, more, now you try to see this entire thing is not required I do only partial of what is automation that is fine. So, whenever the change takes place the definition must be redefined clearly. The objective tree method is a good method to define a goal. Intention should be to clarify all the objectives and sub objectives which is there in the problem.

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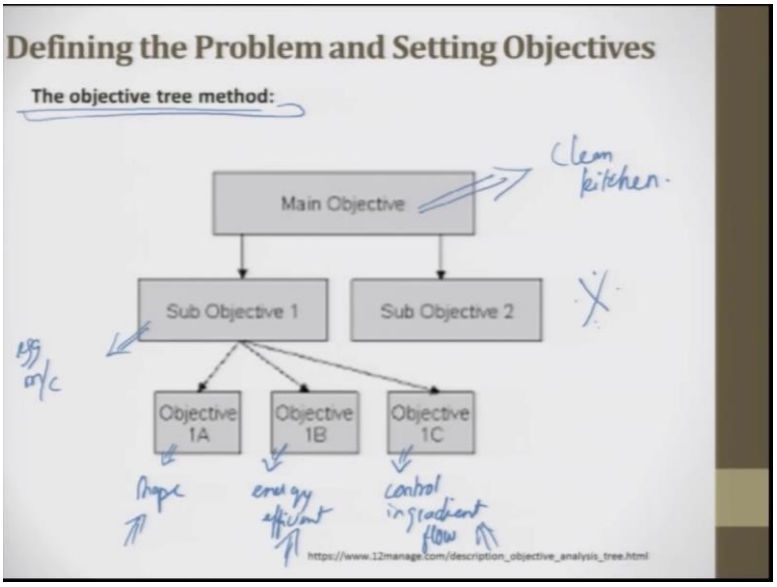

So, this is the objective tree method. What is your main objective? My main objective is in the omelet example is to make a clean kitchen. Now, in this clean kitchen I have several things to do. So, one of the objective is make to make a machine for this egg omelet ok. And then what are the objectives? So, objectives are it should occupy minimum shape, it should be energy efficient, it should have a control over ingredients, ingredients, and a flow or addition. So, these are some of the objectives. So, this is the tree method. So, you are always expected the tree method will give you a good way to define your goal.

So, now, once the goals are defined; so now, you start tackling each goal and start looking for solution for each goal. So, when you try to have solutions, these solutions will be clubbed, and they try to give a sub objective; from the sub objective you go to the main objective ok. So, this is a method which is used which is called as objective tree method. It is it is also very important. And if you start following this maybe in your dayto-day life also if you start following the objective tree method, you will see that you define the problems very clearly your objectives are set very clearly and you start going towards your goal.

So, many a times what happens in your day-to-day life you are try you try to give more importance to small events and you miss out your objective, but always try to keep the objective as a primary thing for this objective is this action going to help if it is. So, please do that action. If not, please drop that action and do other things such that you

meet out the objective. If try doing this in your day-to-day life also you will see that things are becoming much more efficient. But every time what you are supposed to do is you have to clearly define the problem ok. This is for life, this is for product designer anyway please use this you have to be very clearly define. If you do not clearly define you will never be able to reach out to the solutions.

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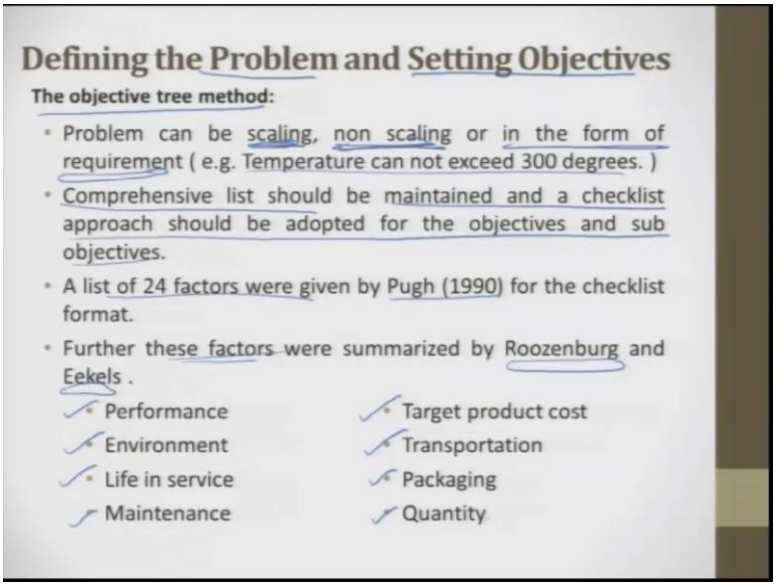

The objective tree method the problem can be can be scaling, non scaling or in the form of requirements ok. So, the problem can be scaling, the problem can be non scaling or in the form of requirements. Example temperature cannot exceed 300 degree Celsius. Let me tell you interesting problem which I am currently working on. Today, there is a peculiar problem when the new born baby is new born baby comes into existence, we always see that when the temperature goes high there are problems.

So, doctor comes and attends to the problem, give medicine and tries to reduce the temperature. There is another problem the temperature can go below the normal temperature which is very alarming. So, when it goes below the normal temperature, today the state of art is you have so many thermometers which measure normal and above we do not have a temperature thermometers which measures normal and below ok. So, this is what am trying to say.

So, when you talk about scaling and non scaling and all, so it is completely different you have to look for new, new, new solutions right. So, the problem is what is that you have to look forward, it is normal and below the normal ok. So, then you start looking at suppose if I say the the objective the objective is to give a solution for temperature then if my sub objective is to now only I say that it is less than normal temperature, now you see the objective itself is changing. The problem can be scaling, non scaling and in the form of requirements the so this is one thing.

The comprehensive list should be maintained and checklist approach should be adopted for the objectives and the sub objectives. Whenever you try to develop a solution, you have to look at whether sub objectives meet if the sub objectives meet whether I have meeting the main object. So, this is the second thing which there has to be a comprehensive list which is to be maintained. List of 24 factors was given by Pugh in 1980 for the checklist format. Further these factors were summarized by Roozenburg and Eekels.

So, they said performance, environment, life in service, maintenance, target product cost, transportation, packaging and quality, these are some of the factors which are to be considered while trying to define the problem and set the objectives. So, there are 24 factors was given by the Pugh.

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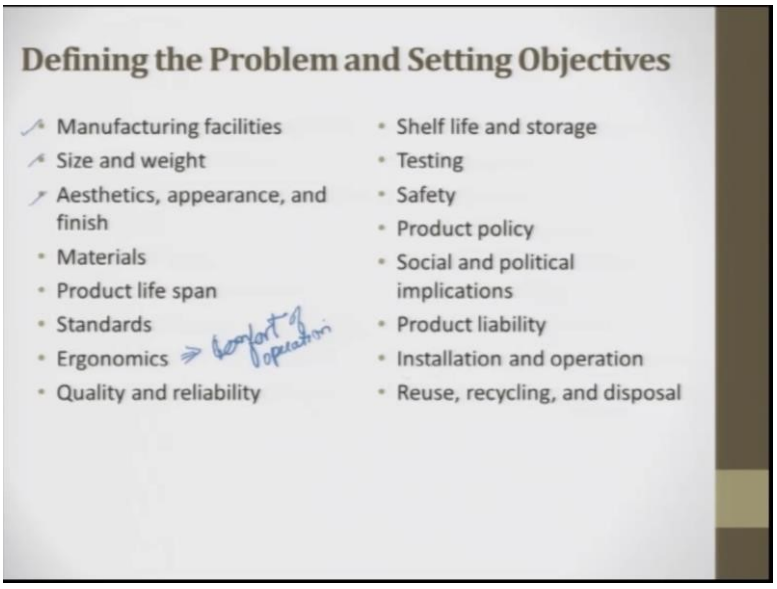

But, the next gentlemen Roozenburg what he did was he packaged all these things into eight, manufacturing facility, size, aesthetics, material, product life span, standard, ergonomics. Ergonomics is more towards comfort it is separate topic we will read it in detail. So, it is more towards comfort of operation I would say call. So, should I keep the what should be the size, where should be the switch all those things. Then quality and reliability, shelf life and storage, testing, safety, product policy, social and political implications, product liability, installation and operation, reuse, recycle and disposal. These are the factors and which was summarized by Roozenburg and Eekel. And these are the things which are to be considered while defining the problem and setting objectives.

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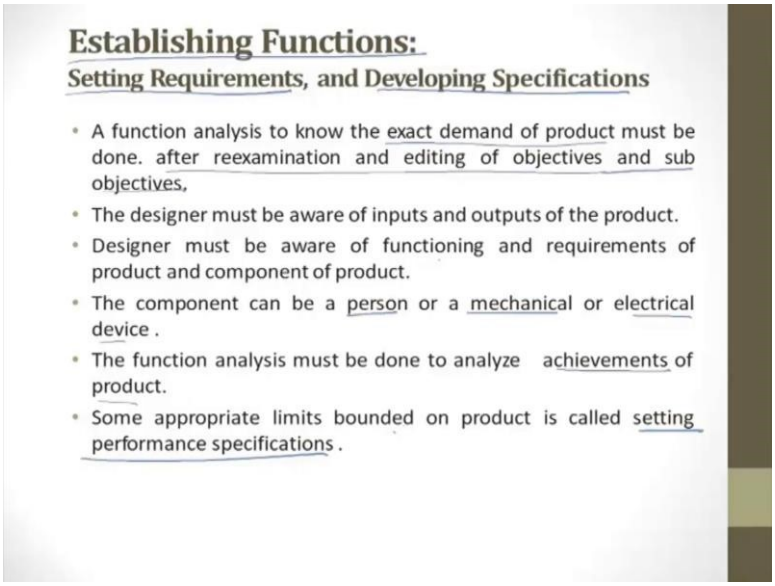
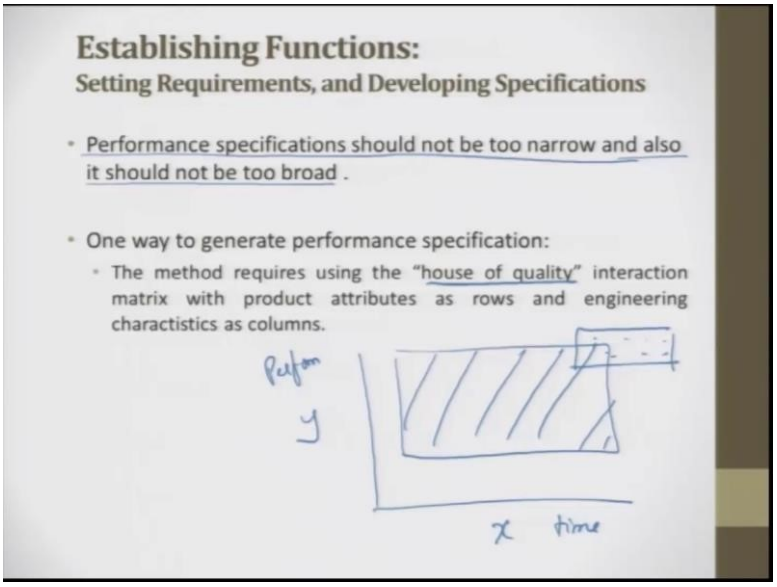


So, next thing is establishing function. So, in establishing function is setting requirements and developing specification is the next one. A function analysis to know the exact demand of product must be done. After reexamination and editing the objectives and sub objectives, this will be done setting your requirements. The designer must be aware of input and output of the products. Designer must be aware of functioning and the requirements of the products and components of the product. The component can be a person or a mechanical or electrical device. A function analysis must be done to analyze achievements of the product. Some appropriate limits bounded on product is called as setting performance specification.

For example, I try to make a sub assembly which gets into a full product. So, now, in that sub assembly the dimension, shape, size, weight is all the setting performance specification a limits bounded on product ok. So, what it cannot be more than 100 grams, it cannot be more than this, cannot be more than that cannot occupy more than 20 square 20, 20x10 millimeters whatever it is. So, these are all the setting requirements and developing specification. First problem identification; then after identification, you have to fix your objectives; then in your objectives, then you go to sub objectives. When you try to fix this sub objectives, you will all try to have quantitative a quantitative specification such that it helps a product designer to make the product easy. (Refer Slide Time: 31:07)



The performance specification should not be too narrow and it should not also be too broad. For example, so this is y and this is x. So, this can be time and this can be performance whatever it is. So, if you say that I would like to develop a product in this zone, this is a very broad specification. If I say I would like to develop a product only in this zone, it is too narrow ok. So, so then it is always better to it neither be too broad nor be too narrow, try to be little generic such that you can try to cater to multiple customers. One way to generate performance specification is the method required is house of quality, interaction matrix which product attributes as rows and engineering characteristic as columns will be used to come out with performance specification. We will discuss house of quality in the forth comings in the forth coming sections of this course. So, house of quality will be dealt in one of the lectures. So, do not worry about it.

So, here basically what we talk about in house of quality is there will rows and columns, so we will try to see there will be rows there will be columns ok. So, what we do is we try do a mix and match and we try to give a ranking for it, and then sum up we get into some values, and then we come up with the performance specification.

A weight or a reliable in a relative importance is assigned to each attribute. The value of the strength of the product can, can be got through multiplying weights and the relationship course. The target value of each parameter is set on the basics of its importance and competitor products. So, we will see more in details about house of quality later down the line.

So, the next is developing professional design. So, when you talk about professional design, so here what do is we look at association methods, creative confrontation methods, analytical methods are the main methods which are used in developing this design. So, this is important association method, creative confrontation method, analytical methods are main methods of design. So, I will stop here.

Thank you.