RAC Product Design

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Lecture - 01
Introduction to design

I welcome you all who have taken this opportunity to have some learnings from my experience in industry.

The journey from an aspiration for design to delivering a product reliably is kind of the way I connected to product design when I went for my first job. I wanted to do something new, and I thought it is all going to be fun. But in reality it is a mix of fun and discipline. Aspiration begins when you want to create something new, and then from there you take on, you look for what is the new need or an unsatisfied need that you are going to satisfy with the new product design. We are going to cover that.

The spirit of adventure exploring unknown constraints is key to product design. If you are looking at a profession in design then one of the ways to be sure is do you like exploring the unexplored; it is there that there is a bit of inventiveness, and also an ability to take some risk. Ability to face failure, what might happen, and then can you face failure, learn from it and start all over again. Draw inspiration from people who you know for inventing something, like for electromagnetic induction, someone struggled; as you may know, was it Michael Faraday? And finally, when he threw his magnet that he discovered that there was some galvanometer movement that led to him discovering the interrelationship between magnetism and electricity and the first ever dynamo. So, some kind of perseverance.

And then, of course, if you want to make it your profession you look for an opportunity where you get this opportunity to design new products, and you are valued for that and then you earn management confidence. If you do it once it satisfies customer needs, you kind of get the confidence of management for you to continue investing more of company's resources and time in new products.

Finally as you grow you want to master the whole process from a concept to market. Can you visualize and reliably deliver repeatedly, so that is as you gain experience, as you learn more processes, as you learn from your own successes and failures you get there.

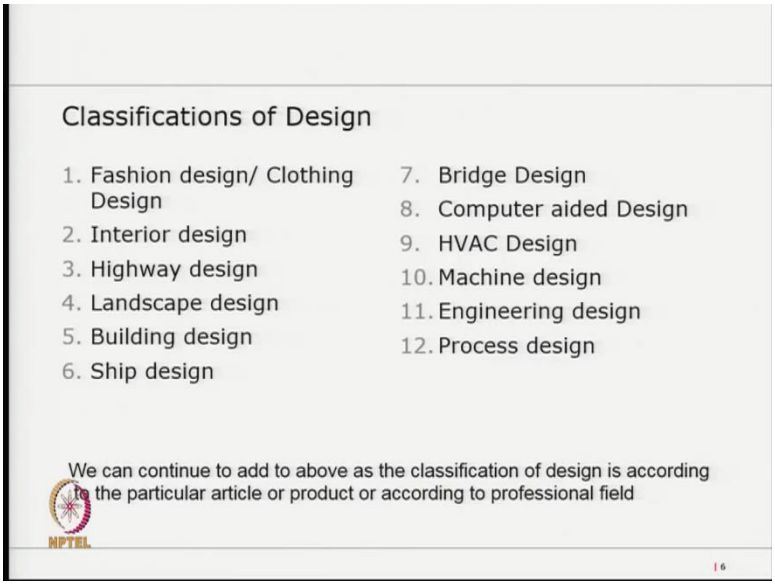
Now, let us understand what is design? Design is to formulate a plan for the satisfaction of a human need, and the obvious question then is how to identify this need. The human need may or may not be well defined. Let us take some examples. How do we satisfy India's energy needs without burning fossil fuels? And we do it in a safe manner and in an affordable manner.

This need, if it is taken as a requirement for design leads to something very clear. It says what is it that we will not do? We will not burn fossil fuels. At the same time we will look for something affordable and something which is safe. So, we are not going to suggest that people start using their gas cylinders and start generating electricity at home, it has its obvious hazards, but something like solar seems to be coming in and if it becomes affordable then that is one solution. But this need kind of straight away drives the design process in a particular way, there is nothing not specific about it.

Say, compressors in the air conditioner used for the computer science building are failing once in 2 months, again it is a well-defined problem to solve. So, these are two examples where the need is clear the human need is clear, someone wants a solution and it is pretty much straightforward how to translate it into some specifications, requirements and start working on that.

Then there are some not so well defined needs and there you have to probably apply some more thought and look at what is the real need. A lot of people are killed in train accidents. Now, it straightaway relates to a need for safe travel by trains. But what needs to be done? Are we going to have elevated tracks throughout the country or are we going to improve our signaling system, what needs to be done is not very specific. Some people need to get together and look at what constitutes safe train travel, before anyone can translate this into a design problem.

And then in Delhi roads if you want to cross the road it is not safe. Now, is an underpass the answer? Is it making some elevated pedestrian path or something else or managing traffic better? Even I don't know. This is just to let you know that a human need may not always lead to a straightforward design problem; it may, it may not.



Now, we can classify design. We are just building the whole thing towards refrigeration and air conditioning. When we talk about design, fashion design is design, someone is busy designing clothes or interior designing, where someone is making the interiors nice and cozy and comfortable for someone as per his or her choice

Highway design and you can look at the whole list in the slide. Now, there is nothing great about this whole classification. So, you look at a particular professional area or you look at a particular need and you classify them and then you can say that. What happens with mechanical design? When you say mechanical design you normally will look at mechanical component design its more to do with strength of materials, it is more to do with shapes and the moment you say mechanical engineering design then the whole thing translates into a much bigger domain, it includes the thermal sciences and therefore, air conditioning.

The other part, and this is and this is a big one, is that when there is a design problem there is no correct answer. If you have a mathematical problem there is one correct answer. People are given the questions, answer sheets come in and then it is either right or wrong. Similarly in physics you will have a right or wrong answer, mostly, unless you go into advanced quantum physics and look at those uncertainties and stuff.

So, a good answer to a particular human need today may not be good enough 2 years from now, or 10 years from now, and we can see how technology has been evolving. This

actually occurs due to change in expectations of people, new discoveries on ways of doing things, etc. We are not using the communication tools say, telephones the same way as we used to 20 years back. The expectations of 2 wheeler have changed so much over a period of time. The way we interact in classrooms has changed. The overhead projector was a big deal, it satisfied a human need at a certain time, and today it is kind of obsolete.

Design problems by their very nature are characterized by one or more constraints. A large group of interrelated complex factors are involved in arriving at a design. To give you a flavor of that we say there is an air conditioner here. Now, what all does this air conditioner need to take care of? Varying loads. We are more than 50 people in this room today, another time there could be just 5 people. Some means of controlling the cooling is needed. It also needs to relate to the environment, it may be very warm inside this room even though it is cold outside (Winter). So, it needs to operate in a temperature like 5 degrees centigrade in winter and right up to maybe 48 degree centigrade in summers and have some means of reliable operation. These are a few examples.

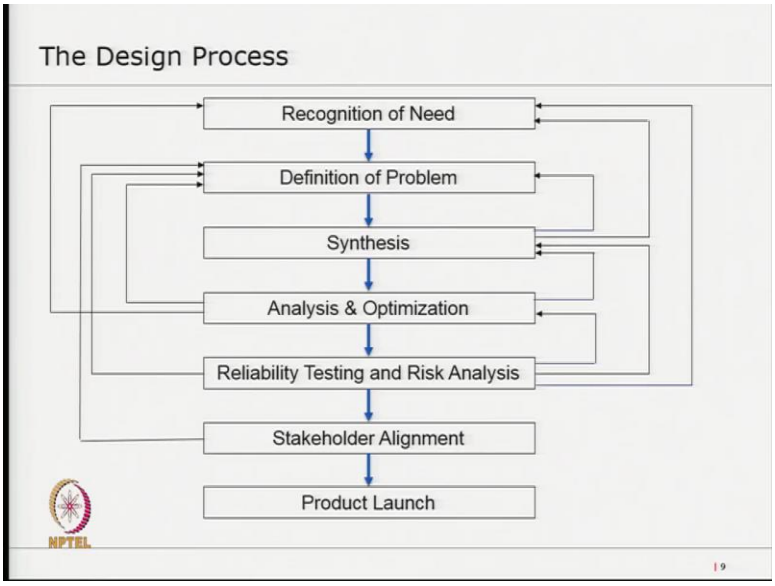
When we look at a design problem we need to have the ability to fathom all that there is in solving that problem, and our success in delivering what is required by the customer depends on how well we understood, whether the customers said it or not, we made it a point to capture it and put it in a design specification document. A few common constraints for designs are: cost, people are willing to buy a product if it is affordable, they may be a luxury product but still there is a there is a cost at which it will be making a business sense for the company to sell it, as a premium product. And then size, form, how much time it is going to take to deliver.

And lastly design always has an authentic purpose. It will satisfy a human need and it will be because it is a new product or process that is created. For example, you can look at Uber, now there is nothing physical about it, it is an app but it connects with people's want or need. And there could be a physical product like an iPhone which addresses the need for people wanting to communicate as well as have fun, listen to music and all those things using apps and same goes on for any other product that you using.

Then who do we consider as a designer? If you had come to any of my offices you would see draftsman and they were given work. They could be making a drawing, and that could be a component drawing.

So, do we call him a designer? Or someone is making a complex communication system work, is he the designer? Is design system engineering?

Instead of getting stuck on specific words, let us look at it as a complete approach towards satisfying a human need. Whatever you call it and whatever form, right from you know something very irrelevant for our course here, fashion designing to something which is very relevant like designing an air conditioner. The design intent is always to satisfy human need, and if you want to define it as an engineering design function and the design function is still a process in which you make use of scientific principles and engineering tools. And some of the engineering tools you will use are modeling, simulation software, CAD tools, Pro-E, Catia, any other software and you will make use of the knowledge that you have out of material science, out of whatever you learnt on thermodynamics and many other disciplines.



If you look at the whole process from concept to product launch then we can split this into: recognition of need, definition of the problem, synthesis, Analysis and Optimization, Reliability and Risk Analysis, Stakeholder alignment and Product launch. Let us begin by recognition of need and let us pick up an example. And I am willing to look at any input from you. You want to pick an example, just so that all of you are actively engaged.

Think of a design problem, think of an unmet NEED. Do you encounter things that are not to your liking and you want them changed?

Student: “I have a need to walk through a door without having to open it”

Alright, so, you would like to walk through a door, right? Like you approach it and it opens up for you and then it closes. Perfect! Yeah it is it is something that bothers you and it is a want, and most people will connect to the need the moment you state it and we also see some demonstration of it in products already available, sliding doors for example, in many large offices you will find them move automatically, it satisfies that need.

Every day you are interacting with the environment in a way that somewhere you are not happy with what is and you want it a different way. Not always are you acting to create that new design to satisfy that need, but if you want to look at being in the profession of product design, developing this ability is going to be helpful. You can start practicing, you can start practicing from today's lecture onwards.

Once you recognize the need and let us continue further on the problem that you said door opening. What do you then do? You want to specify, we cannot solve a problem just saying that when we walk to a door it should open. We need to say what size of doors, what time it will take before it opens, how far should the person moving to the door be when it opens. So, all that is the definition of the problem phase, it is not always straightforward, but it is needed. Before you invest your time and resources before you commit to a time in which you will complete that design you will need a specification document and that specification document is: "Definition of the Problem".

And then what are we going to do is synthesis, analysis, optimization and we will cover some of this in the next few slides. But before I go there notice that there are a lot of interconnected arrows between different steps, each time you go to the next step there is a possibility you will go back, because you may discover that the door does not move fast enough. So, ideally when you first formulate the problem you will say fine as I approached the door it should open, and the moment you look at the whole weight of the door the time required by the motor, the cost of the motor you could well end up saying that, fine is it if I open it 30 seconds before. So, there is an iteration happening there. Similarly, when you analyze, when you optimize, you will experience cost overruns and you may want to go back to the customer or to the stakeholder that is it OK if I compromise one parameter, but reduce the cost by half.

The recognition of the need and phrasing the need often constitute a highly creative act. There is no law, no theorem that I can give you on that act. It is pure creativity, it comes

out of your interest, and out of you not being satisfied with “WHAT IS”. When sleeping in the air conditioned room has any of any one of you being distracted by cold air falling on your body? You have, right.

When I say that a lot of you start thinking when did this last happen? Did you have to cover yourself while you were sleeping and the AC was on? And why did this happen? The moment I formulate this and state it, a lot of you start looking at it, and if I said there is a product which will not let this happen, you will be inclined to consider buying it if it is affordable.

Let us take another example something where a person is not satisfied and there is a human need which is not even stated. When you pick up your trouser from a hanger what do you notice? You ironed your trouser or someone ironed it for you and it is on a hanger and you pick it up and maybe it is a week since you last used it. There is a crease right, where it is hanging there is a crease and then if it was a heavy trouser like a jeans you will also see that it is crumpled a little bit at that fold. So, there is a line and then it is crumpled because the weight the hanger bends and this happens. Now, how many of you really stopped and said no this is not acceptable we need a new hanger?

We put up with it, right? However a person who is sensitive will at least be knowing this is happening he may or may not choose to act on it because it may not be consequential, right, does not bother, it is fine or manageable. Or the next time you look for something which is sturdy which will address one part of it. The whole idea is you start thinking what are the needs that are there waiting to be discovered and then which of them the customer is willing to pay for.

So, you could have your start up! If you really got this and you validated it and then you got a product and then you know if you had the good fortune of even patenting it, you don’t to do anything rest of you life, you can have fun and do whatever else you want. You don’t have to work for any company. Doesn’t that sound exciting? So far all that I am covering is like very broad it is not just refrigeration air conditioning, any product design that you choose to do you will connect with a human need and the human need is the trigger of something big happening. And now, the big may not happen the first time, may not happen for several years, does not mean you stop aiming for it.

Sensitive people are more likely to be creative does not mean you have to be sensitive to be creative, right. You will pick things, something bothers you. The sound of the laptop fan is bothering me, next time I look for a laptop which does not have this kind of sound. It might interfere with the audio recording also, this is being sensitive. And this I said before, once a need is stated it is very easy. All the examples I gave you, the moment I state the need then it is very easy to connect to that. So, I want this process really to stimulate your thinking. Particularly the part about there being no one right answer, as far as design is concerned and the second part about you being sensitive to human need. I am not going to evaluate you for that. Right now in this room I want you to experience this whole process. So, the two unmet needs that came from this room are not enough because there are far too many and if you are here in a design course you are here to learn about design then I want you to start thinking.

Student: The need is that my screen doesn't crack as often as it cracks. In a lot of phones when the phone falls, the screen cracks.

Right, yeah, yeah, yeah I can relate to it, yes.

But, isn't, one of the phone manufacturers tried to address that?

Student: So, Apple as a patent on it they have some sort of vibrating device which ensures that your phone falls vertical

Student: I read about it I am not sure about.

But good I mean yeah, but right now, I want to do to start thinking. So, this is an unmet need as far as you are concerned. So, great yeah thanks that example is good. But to add to you know your research efforts and everything else, one manufacturer and I will not name it here because it is a brand, has done that part, you drop it and the screen is guaranteed not to break.

So, let us not go with names, but yeah there is. So, this is leading to business. See the moment you state a need like that, the phenomenal thing about it is that you have stated something, out of your own experience and there is evidence that a company has invested design and manufacturing resources to make it available and there is a product available

in the market, so good, OK. So, fire extinguishers, auto in, auto what? Auto energized right we can say that. So, fire extinguishers that will automatically come into action.

Student: There is no foolproof way of waking up in the morning.

Ok, very good.

Student: Alarm clocks don't work

Yeah, and if they do work you know there is a snooze button and then you press it too many times and then it overshoots the design, yes, good. See one thing you will find is that when one person is stating a need, others are able to relate, sometimes within this room, sometimes even outside this room and sometimes there is evidence of products being designed and already in the market to address those needs. So, think!

Student: Lot of time we need to see a particular picture on our phone. I don't think there is an app for it, I tried to search and we want we have to see this very particular picture and you have to go back always to the gallery scroll down pick up this picture.

Ok, that is the need, yes, thank you.

Student: There is a need for a book shelf organizer. I pick a book and I read and I want it to go back the shelf automatically, I don't want to waste energy to find the original location and put it back there.

Alright ok, alright. It is a need you know, like we may not always be able to provide a solution but it is its starting there. And when you look at that then the next step is start thinking of what you already know, are there ways to specify it first of all, like what all do you need, what size of books and what do you conceive as ways of it going back. Like when I started thinking, I started thinking after you said it right, I am beginning to think could there be something elastic which hangs from the roof or from the desk you pull it down and it knows and then when it is not used for a certain while it begins to you know pull back like a cord and get it into some position which is acceptable. What? So that is the part of beginning to formulate, synthesize.

Actually today when I was driving for this lecture I came from Gurgaon and I was looking at the IIT security system when you enter the gate and all you require is which department

you are going and then you are in, right. I was wondering if there was an opportunity to look at something which is very robust. Now, our prime minister has been linking the aadhar to various systems. So, this thought came to me (I do not know how it can get executed) is that when a person wants to come to IIT, he makes a request to someone within IIT and then his name is biometrically connected and all that is needed is when person is entering, if he uses his thumb impression which matches what is recorded he can enter, else there is a different path. Like an exception route, which means then you can have someone call and do anything, but it will improve the security manifold. Like no one can take advantage.

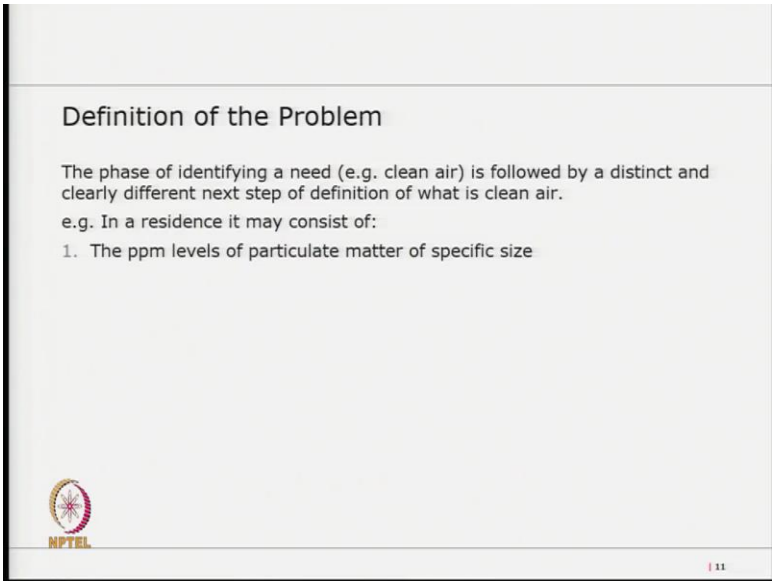
Student: Sir except this might take long

Exactly, so, this is this is the very important part the analytical part. Before we accept a solution is to thrash it out, what all, our networks may not work right? The server can get choked.

Student: The road outside is the outer ring road and we can't afford to have a line outside.

Here is where I want you to further stimulate your thinking. Why would you accept a solution which takes more time than what is right now used? You would accept a solution which is faster. Did you did even read that Japanese the news item where someone is doing the victory sign and the camera high definition camera takes the image, and then that, that resolution is good enough for breaching security. So, I am just saying there are so many dimensions to technology that we need not, not to criticize what you said, but taking value from what you said.

So, you bring in an aspect of how much time it takes and the road outside is busy. So, we cannot have a pile up of cars just because people are verifying; valid point. I am saying why create a solution which is going to be slower than what is existing. We put that into our need. So, like it is a good input and that is the part which is the next step when we looked at this slide "Analysis and Optimization", so what you just said it took me to that analysis and optimization which comes after synthesis. So, the example I gave you was trying to propose a solution, maybe try it out at a prototype level or something and then we see what are the issues concerned with it and then go back, so that is why those arrows which link back to "Definition of Problem", then again "Synthesizing it" and doing all this until we can reach product launch.



Now, let us take another example “Clean Air”. We are all concerned with clean air, in this room, outside, walking. When we say clean air it is a human need. Does anyone disagree? No one disagrees. OK. Now, what do we do with this need? Can we design something which will address it?

Student: Yes, we can.

We need to break it down into requirements which are more definitive. What could those requirements be? So, I am giving you the first one and the remaining ones will come, but I want you to start thinking because that again will connect with your need. The ppm levels of particular matter of specific size. So, there is some medical evidence that PM 2.5 is hazardous beyond a certain level. So, we could use that as an input that, fine in a residence we do not want that to be the case that could be the first requirement with which most of the people in NCR are concerned about. What would be the second thing?

Student: The level of Carbon Dioxide.

Very good; so, it will come in this list and thank you for that, it means, it shows that you are thinking, good. What else?

Student: not just carbon dioxide.

So, what I will do is now, that we have this opportunity to write on this, let me first start writing here and then we of course, go through my list. So, first one you said CO 2 levels, right.

So, you want to say some limit right CO 2 level should be less than some ppm or some percentage we might say.

Student: Not CO2 but Carbon Monoxide.

Ok.

Student: More importantly Nox

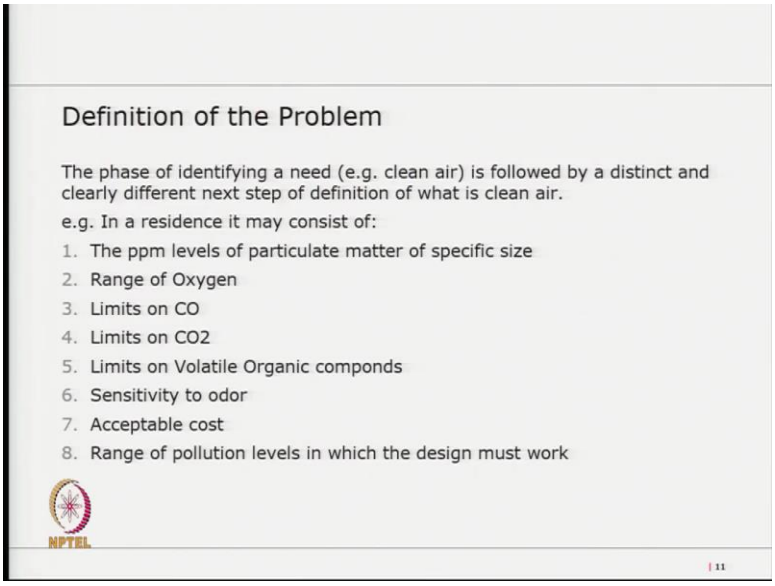
See now I am feeling that I am in IIT.

Student: Sulphur Dioxide.

So, we will have again a limit right, here we will have a limit here, we will have a limit here. Should we look at volatile organic compounds also? Someone said it, right, yeah, right. What else?

Student: We are talking about no Foul smell.

Very good now, if you go through my list see this: limits on CO, CO 2, VOC , sensitivity to odor, so that is what I am saying you covered it all. Yeah, right. Like 10,000, 20,000, 40,000 what level and the other thing is this will need to work in a certain environment.



So, if we go to a place near Nainital, a place called Ramgarh and if you are designing something there, you might discover that nothing needs to be done. You know the indoor air quality well meets most of the norms that you define but in a place which is close to an

intersection a busy intersection, this may not be the case. So, we need to define what is the outside air pollution level and if you see some of the times when there are warnings to stay indoors it is because the outside pollution levels have gone way too high.

Now, under those circumstances how do we get the CO_2 proportion right, those would all be design inputs? Taking further the discussion we had on requirements for the air purifier, if we got AIIMS doctors to say that look what all these guys have put together is just what is needed, it would bring in a certain element of credibility. So, we can involve the health professionals into our requirement planning. They could be the ideal guys to validate after we make the prototype, right.

Now, I went through this as an example, but the whole idea was translating a need into a definite set of requirements creates the opportunities for engineers, developing new designs using scientific knowledge and engineering tools.