Product Engineering and Design Thinking
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Module - 02
High-Level Design and Fuzzy Front End of Innovation
Lecture - 07
High Level Design in the Context of Front End Innovation

Welcome back to this session on Product Engineering and Design Thinking. We are in module 2 that is High Level Design and Fuzzy Front End of Innovation. Today's lecture title is High Level Design in the Context of Front End Innovation.

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We would see first the concepts covered in this session, we will talk about high-level design, we will elaborate what it is. For now, we know that is a term High-Level Design which is

HLD. Of course, in our earlier slides, we had discussed what is HLD and what is LLD, high-level design and lower-level design.

And now, this high-level design in the context of design thinking and fuzzy front end this is a very interesting aspect because fuzzy front end where we had already discussed at lathe how fluid the spaces and there in that space when we are developing the product architecture. So, there are many variables which are to be specified precisely determined.

So, some set based design also comes in at this stage. So, this is one important area that needs attention. So, we will discuss it here. While discussing this, we also will discuss this fuzzy front end phases, process phases. And then we will come back to the HLD or high-level design which is the critical area in any design project or product development project or production innovation project. Because as we all have understood by now that LLD takes its guidance from HLD.

So, if HLD is not done correctly or well, then down the line the LLD is bound to be faulty or not successful. So, our focus and importance is on HLD and that is very logical. So, the objective of HLD in the context of product architecture will be discussed and then two very important things in connection with high-level design is decomposition, decomposition of a system or a device or a product. Why this decomposition is necessary?

Because when a complex product is particularly in question then the solution of the complex or the whole may not and is not possible very easily or inexpensively. So, it is always necessary that we break the complex or large problem down into its smaller or basic elements and solve them. And once we solve them and integrate them then the whole becomes a good solution.

Now, so this decomposition has two aspects. One is the functional decomposition, that is what are the different functions this product of the system has to perform or do. And when we are talking of functions how that will be materialized; that means, through which component or element or part it will be materialized is the physical decomposition.

So, two interesting aspect of HLD is the functional decomposition and physical decomposition. And for the logical purpose we will discuss these two in one go. The product architecture therefore, is having these two components the functional elements and the physical elements.

Now, when we are saying product usually it is a family of product now or product family so to say. Like say when we talk about a car we see in that particular car type there are several models or variants we call it variants. And some variants will have certain functionalities and other variants may not have those functionalities may have some other functionalities additional functionalities.

So, there may be n number of variants and that is kind of a product platform or product family. So, we may look at it as a particular product or we may look at it as a product family with n number of variants. If we just take one variant it will be just one product, if we take say variant number 3 that will be just one product. But when we are taking say for example, if we are having a car everything is fine only it has a gasoline system or it has a diesel system.

So, rest all are more or less the same, but here varies in the you know that in the engine or fuel aspect. So, similarly so, but again say there are certain cars where say for example, air conditioning system is there and in some car air conditioning system is not there. So, those are two different variants it means that certain functionalities are there.

And to achieve that functionality the machine that air conditioner machine and their components would be necessary those are the physical parts, which we are talking about and then we will break it in physical decomposition part. Like if we break the air conditioner we will have the compressor and different of the parts is that. So, therefore, product family and product will be discussed together.

Salient aspect of functional and physical decomposition will be discussed why it is so important. That is the question. Why this decomposition is important those are the salient

aspects? And then we will go to the conclusion and references as usual. So, with this preamble we proceed to our discourse for the day.

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Here first we would like to set the context in sense high-level design and its connection with design thinking and fuzzy front end. What we will do here is in the first part in the this initial part we will discuss the relationship between the design thinking and fuzzy front end basically to establish their similarity in different ways. And then we will come back to the high-level design aspect when it will be much more meaningful in terms of its implementation.

So, particularly in the context of HLD we may say many enterprise in the recent past they have adopted design thinking. Because in the HLD process which is actually a very thoughtful process how the functions will be categorized, how the functions will be

segregated and how those functions will be met through the physical entities it is actually a very cognitive analytical and thoughtful process where design thinking comes in a big way.

And it is interesting therefore, to note that since we are working and discussing in that direction that there are many large big world class companies are adopting these design thinking methodology. There is a list I just would like to read some of them because these are certain companies which are known to most of us even at all starting from GE Healthcare, Netflix, Procter and Gamble, Apple, Amazon, Google, IBM, Tesla, Oral B of Braun, PepsiCo, Toyota, Nike, Uber, SAP and several others many others.

So, you can understand the companies that I named are the world class companies. And world class companies set examples and it is followed by other companies over the time. Therefore, if these companies have adopted design thinking in a big way so, we understand we can realize that how important it is going to be in the next few years and in maybe in next couple of decades. So, those who would be learning and studying this would have a great advantage in professional and industrial career.

Of course, these are the companies I named, but we should first name the company who actually is promoting this. In fact, the IDEO is popularizing it a lot and the genesis of this IDEO design thinking model goes to Stanford University by David Kelly and his team that we had discussed earlier also.

Now, DT aims to manage creativity. And channelizing this creativity towards innovative solutions and it bares similarity with the NPD that is New Product Development process if that is used in scores of industrial enterprises. It is reported that fuzzy front end stage in NPD notably uncovers a significant correlation with design thinking.

Based on the analysis of literature on DT and FFE it can be inferred that not only do both have the similarities between them a lot, but they feed each other and there is a symbiotic growth. This is derivable from the work on design thinking by Brooke M Davis and on fuzzy front end by Yung-Ching Ho and Ching-Tzu Tsai.

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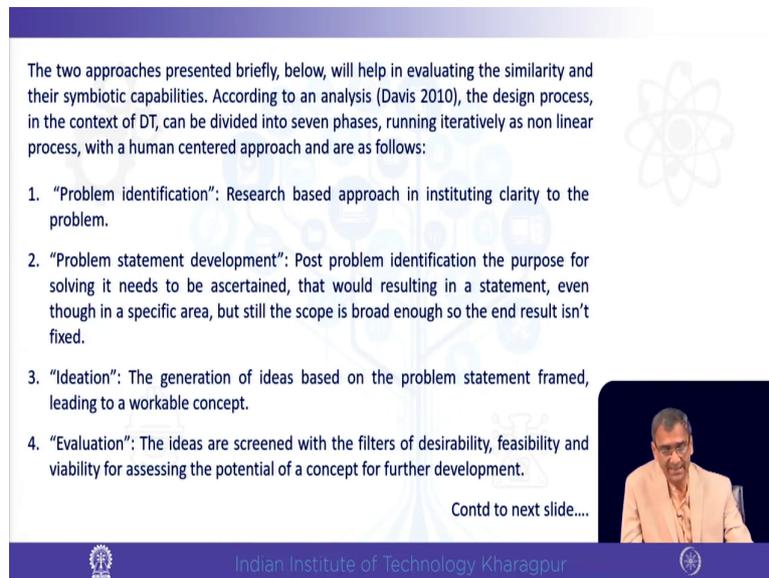
The two approaches presented briefly below will help in evaluating the similarity. These two approaches that we just have mentioned is the design thinking and fuzzy front end. The design process in the context of DT can be divided into seven phases according to Davis and those steps are listed here below. It is in the slide as well as in the next slide total seven four here and three in the next slide that will appear. The "Problem Identification": research based approach in instituting clarity to the problem.

That means to find out what exactly is the problem research into the customer, research into the need, research into the requirement, research into the pains and potential gains. From that what is needed is although we had discussed this, but in this context we are refining it. So, that now we can make an alignment more clearly with FFE and then from that as we said is the creation of development of problem statement.

That is post problem identification. Once the problem is identified then the problem statement is written it is created. It is created in a way that it is not very or overly precise. It is relatively broad. So, that work scope can be extended or pivoted or modified a little here or there to come up for it or with a good solution. Then comes ideation which we had already discussed when we discussed this phases.

The generation of ideas based on problem statement framed. That problem statement that how might we solve a problem and then the ideation for that is necessary and would begin. Then the evaluation part; obviously, for screening those ideas which idea is good and that is to be taken forward. There may be few good ideas which are very closely analyzed and evaluated. And finally, the best one of that is taken forward. So, that is the step.

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Then comes the "Visualization": making the select concept tangible and testing the potential target groups to with potential target groups to ascertain if such is valuable enough. That means we need to observe. We need to observe whether the solution actually caters to the need solves the pain or adds to some kind of gain of the user or the customer. "Analysis": after turning the concept into viable solution a validation of the same is accomplished usually through a SWOT analysis.

SWOT analysis is an analysis where SWOT this four letter that is strength, weakness, opportunity and threat are analyzed. Strength and weaknesses are internal to the organization. Like it is concerned with an individual. A person can have strength not only physical, but may have other strengths say one is good in mathematics or one is good in physics or one is good in say drawing, one is good in music.

So, that is the strength. There are weaknesses also, individual weakness. I mean; obviously, we know the weakness some people not very risk taking kind of propensity, some people get depressed a little easily. So, I mean it is individual level strength and weakness we are talking about, but similarly for an enterprise there will be strength and weaknesses.

Weaknesses may be the shortage of resources, strength may be that they have developed a very good technology and it is patented and it has huge potential. So, those are strengths. Opportunity and threat these are external things; that means, it is outside it is in the environment.

If say for example, there is an opportunity being created by government or the environment or the society for something, like people have become the very conscious about health now, people have become conscious about environment now. So, we are talking about renewable energy. So, that is an opportunity being created. Now, those who are working or developing their products in the area of say renewable energy or green energy that is an opportunity for them.

Threat comes in when there is a potential competition coming in or some regulation is coming that is forbidding or preventing something to happen. So, those are the things like I like in old days to kill pest people who would spray DDT, but now that is revert because it is not hygienic. So, those who are doing that using those components or products is a threat, competition new competition substitute product is a threat if some substitute is coming in the market is a threat.

So, SWOT analysis is important. So, that one understands finally, what is the going to be the prospect or in other words you may say the fate of the development. So, final concept direction is presenting the final concept to the user or the market and proceeding with the final prototype. So, after all these analysis etcetera I mean we choose that ok, this we will take it forward then we move ahead and these are those several steps that we were talking about.

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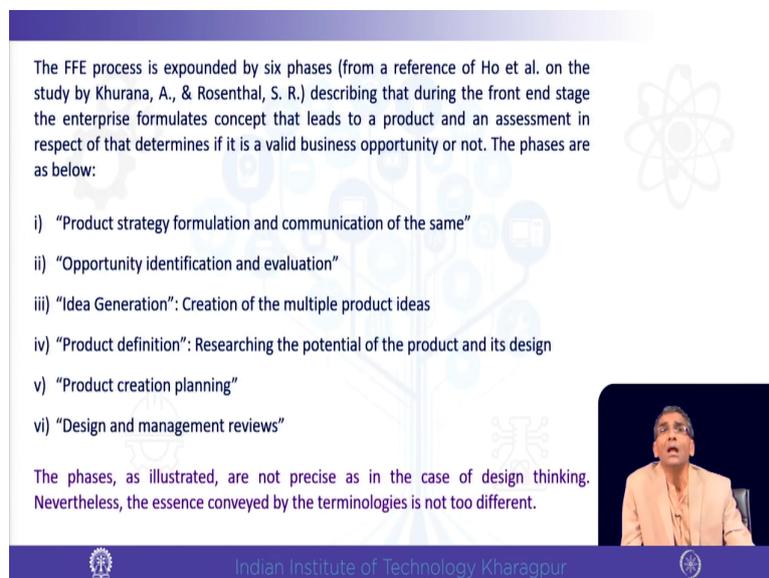
The FFE process is expounded by six phases (from a reference of Ho et al. on the study by Khurana, A., & Rosenthal, S. R.) describing that during the front end stage the enterprise formulates concept that leads to a product and an assessment in respect of that determines if it is a valid business opportunity or not. The phases are as below:

i) "Product strategy formulation and communication of the same"

ii) "Opportunity identification and evaluation"

iii) "Idea Generation": Creation of the multiple product ideas

iv) "Product definition": Researching the potential of the product and its design

v) "Product creation planning"

vi) "Design and management reviews"

The phases, as illustrated, are not precise as in the case of design thinking. Nevertheless, the essence conveyed by the terminologies is not too different.

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FFE Fuzzy Front End, well it has six phases in the slide you can see that this reference is taken from the Ho et al. on study of Khurana and Rosenthal etcetera. So, the phases are as you can see are product strategy formulation and communication of the same. Opportunity identification and evaluation see the closeness, idea generation and as we said that in idea generation the idea the objective is quantity in the beginning, quality comes later, quality comes at the concept development stage.

But idea generation is the quantity is important where more ideas means more possibility of good solution creation. So, that is then apparently there may be some very wild ideas, but so be it not a problem, but that should be there. Product definition: researching the potential of the product and its design, product creation planning and design management reviews.

These are the steps where you would find that there is a there is a there is a there is a congruence with DT. The phases as illustrated are not precise. As in design thinking the stages are more precise, but then the essence conveyed by the terminologies is really not too different that you can see.

Now, we will enter in the domain of HLD to be more closer to the architecture of a product. The HLD constitute construes the product centric architecture of the system. This architecture fixes the subsystems to be built. So, once we decide which kind of car or what will be developed then the subsystems accordingly will be developed.

If we choose to develop a conventional car with IC engine the components will be petrol or diesel engine. If we choose to do a electric vehicle then it will be a electric power train with battery. If we choose to do with hybrid electric vehicle then it will be a combination of IC engine with the motor and battery as the controllers etcetera.

So, the subsystems will depend on the system that we are going to design and build. So, the architecture will depend on that and the interfaces naturally both internal and external

interfaces also to be developed. Say external interfaces we understand different components and different modules, they would have interface among themselves.

When it comes to external interface we need to also find say for example, EV charging at a charging station. So, that compatibility etcetera becomes the issue and where design may well refer to the characteristics of a system or components that are decided upon by the product developer with regards to the requirements of the user.

Now, so, here be we have said what design is and we have said what the architecture is, then we would talk on the architecture saying it would be defined as the organizational structure or composition of a system as embodiment, distinguishing its components, the interfaces, and the logical construct of interaction among them.

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Objective of HLD (High Level Design) in Product Architectural Context:

❖ The HLD is the stage where the sub-system requirements are determined and it also identifies, the principal or key components that may be used in the product-system that particularly is available as off-the-shelf items, and constitutes the configuration design.

❖ 'Requirements' is expressed as the comprehensive consideration with regard to what it has to accomplish or specifically what functions it has to perform, how well the performance should or has to be and under which conditions it has to operate, be that environmental oriented or even not directly associated with the functional aspects.

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Having said that the objective of HLD therefore, the HLD that is high-level design is the stage where subsystem requirements are determined and it also identifies the principal or key components; that means, two things we are telling. That one is this subsystem requirements and the key components which will cater to that. That may be used in product system that particularly is available of the self.

So, here we are talking of two things. One is the distinct design or distinct component or product or customized product, there is something that is to be built uniquely and there are some components, which are to be used in a product, but those are available of the self, bought out components. For example, a car manufacturing company do not manufacture tires; the tyres are procured from other companies as standard tyres.

Similarly, a company who is manufacturing fans or other electrical gadgets or other mechanical gadgets would be using components like say bearings for rotation. And the bearings they do not manufacture themselves they are selected and they are of the self. And the more standard components we use in the product the better because they are proven, they are time tested.

So, as we can have more such components which are standard in the product its reliability will be high, robustness also will be influenced in a positive way. Cost certainly will substantially go down because see for example, a bearing manufacturing company would be manufacturing the bearing for many companies and its mass produced and in the large quantities.
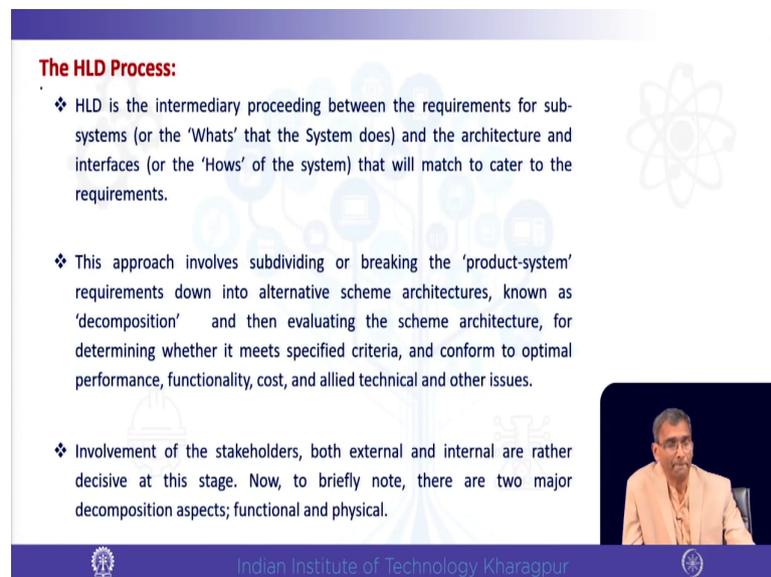
So, naturally what happens is that the cost per unit goes down because it is mass manufactured. But if the company wanted to manufacture the bearing then the cost would be exorbitant and therefore, in the configuration design that means, in the design in the design how much would be customized and how much would be the bought out is the configuration design agenda.

So, in the there the bought out components play a very important role. If say for example, nuts and bolts; for example, rebates; for example, diodes and many such things which are taken of the self. Requirements, as we just now had said which is based on the requirements, the subsystem requirements, the customer requirements.

Requirements is expressed as the comprehensive consideration with regard to what it has to accomplish, what it should do, what it should perform what it will do, what the purpose? And how well the performance should or has to be that is the consideration. What it will do and how nicely it will do, how what will give time, how accurately it gives time is the how well it performs. Similarly a refrigerator, how it has to cool, how well it cools or etcetera so, similarly for car, for fan, for any product so, that is the thing.

And the last, but not the least is under which conditions it has to operate. That is the environmental condition under which, it may be under fluctuating temperature or fluctuating power or load or it may function in a dusty environment or in a situation where huge noise and vibration is there. So, these aspects are important from that perspective.

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The HLD Process: HLD is the intermediary process between the requirement requirements of the subsystems or 'Whats' as we had said 'Whats' and the architecture and the interface or rather 'Hows'. So, it is basically an interconnection of 'Whats' and 'Hows'.

Now, I hope may maybe if you know you would recall if you do not know I will discuss that later. Of course, I will discuss that later is a matrix of what and how there is a model called QFD or also is known as house of quality and colloquially it is also known as voice of customer catchment. So, this we will discuss that it is the matrix what versus how.

This approach involves subdividing or breaking the product system requirements down into alternative scheme architectures known as decomposition and then, evaluating the scheme architecture for determining whether it meets specified criteria, and conform to optimal

performance, functionality, cost and allied technical or other issues. Involvement of the stakeholders both external and internal are rather decisive at this stage.

Now, to briefly note there are two major decomposition aspects functional and physical. We would take up these two aspects in our next lecture.

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So, in conclusion we would say that this session brings the context of high-level design and its consequences on FFE that is Fuzzy Front End and along with the congruence of design thinking DT. This is one very interesting area that we have ventured in because these three things together is not always very commonly discussed, but those are the common requirement.

This explicates the FFE process phases, the objective of high-level design in product architectural context and also the HLD process. Namely the functional and physical decomposition is addressed here as well.

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So, I will now suggest that the lecture material may be considered as for study and with this I thank you very much for your patient hearing and I would hope that this session actually helped you in understanding.

Thank you once again.