Product Engineering and Design Thinking

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Module - 03
Design Thinking and Concept Development
Lecture - 15
Quality Function Deployment (QFD): Example

Welcome back to this session of Product Engineering and Design Thinking and we were continuing with the module 3 that is Design Thinking and Concept Development. Here as we had discussed about QFD in the context of function breakdown structure, we will take this discussion forward here because here we need to discuss it a bit elaborately and with an example covering the its aspects in four phases.

We will discuss that and then we would solve one example problem for one of the phases. The identical will be in subsequent phases. We will discuss that.

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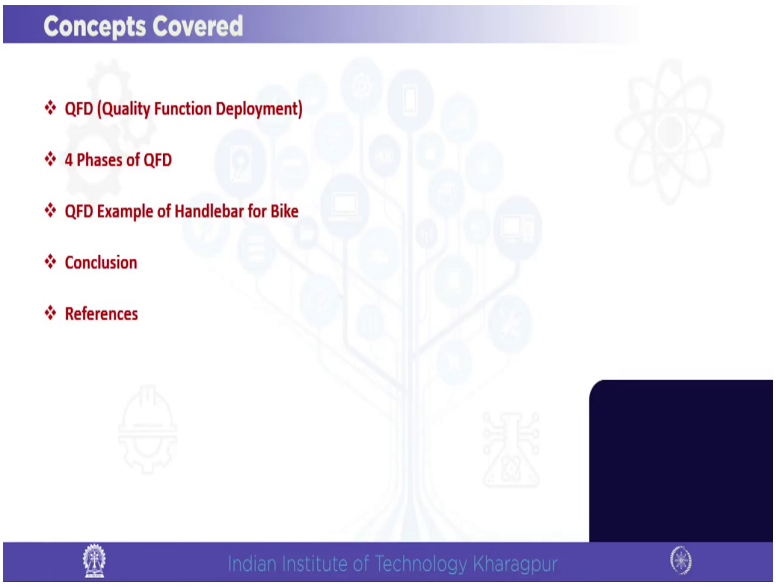

So, here what we will do is we will talk about the QFD modelling details with the with including its four phases that we just now have discussed. I will tell the four phases, but these four phases actually would cover from the start to end that is start to end means from the voice of the customer that is from the catchment of the information about the need and requirement of preferences or desires.

And that then will be finally, through those four phases will be translated into the product. In between there would be the product planning part, product structure part that is the component characters and then process and then its quality, controlled or process controlled or the production process controlled. So, through that this entire production process is reached.

Hence the entire value chain will be under QFD and so, these are the four phases that we will discuss. And as I said we will discuss with an example and that is a handlebar of a bike, we will discuss that and then we will go to the conclusion reference sections.

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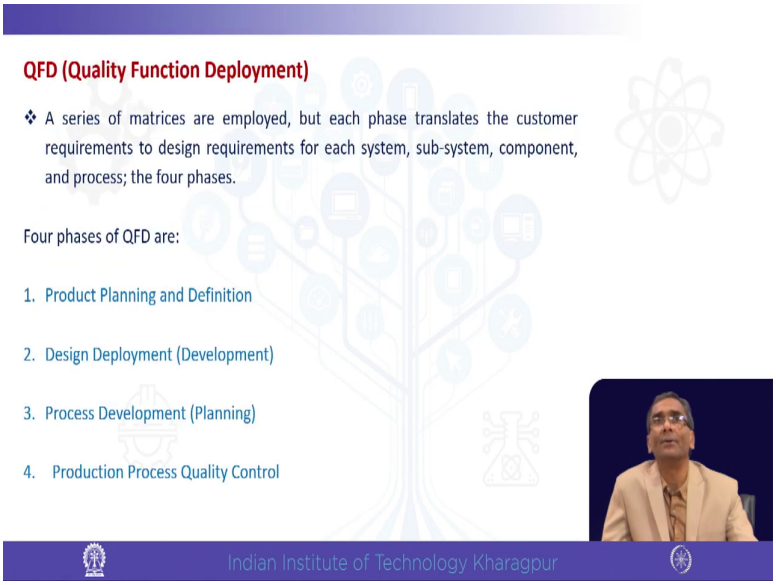

Having said that what we will do is just to for a recap it is a this four phases as I said, these are series of matrices. Each as you had seen earlier it is basically a set of it is a matrix and there are four such matrix, then it is a matrices four matrices. Each will have its configurations which we will discuss now, and basically we had examined the intersections of these customer requirements versus the engineering requirements or technical descriptors.

So, these four phases would cover start starting from the broad system, then to subsystem, then to component and then to the process as I just now have said. The phases of QFD are these following four – the product planning and definition, design deployment, development,

process development or process planning as we are saying here and production process, control or product process, quality control.

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Now, we will check each one of them like say product planning and definition. It actually is the during this phase it the following functions following activities are done – collecting requirement details that is the voice of customer VoC in short we say; translating this VoC into engineering requirements. Including evaluation of competitors products.

Well, in most of the you know QFD diagrams that is considered because if we consider with the competitors then a good benchmarking happens and we know where we are. So, that is the aspect that we need to consider. And, the initial design concept is created based on the product performance and the product specifications requirements.

The phase 2 would include or during the phase 2, the following activities are performed that is identifying critical parts and assemblies or sub assemblies. That is in streaming down critical product characteristics and translating into part and assembly specifications or characteristics or part and assembly characteristics in short or part and assembly specifications.

Then defining functional requirements or specifications for each functional level that is defining specifications. I would give example then it would be more clearer, but now please understand that these are the steps which diagrammatically I will be presenting soon. But, before that these are the you know documents or slides should be studied by you later also so that you know the concept is completely clear.

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Then the third phase process development or planning phase: designing processes based on product and component specifications. So, what the specification is? According to the specification suppose this specification is saying the upper from a dimension as you already have heard something called tolerance, and in the tolerance the upper limit and lower limit suppose they are very close or rather tight then we will have to use a process or a machine or a system which can provide for such close tolerances.

Similarly, if the specification is allowing a bit of you know wide range that the upper control limit, upper specification limit and lower specification limit is having certain you know leeway, then we can consider the process which may not be so does not have to be so precise, does not require to be so precise.

Like I will give you examples. Somewhere your you know regular length or any turning machine will work can deliver the goods, but in some cases high precision CNC machines would be required. That is just one example. From that you understand that the process it is not only for turning it is for other processes also and it varies from application to application and not necessary it is confined only to the mechanical process.

After all the manufacturing is done mechanically no doubt, but then the process one might consider is a something which is in the say for example, chemical industry there are some processes happening. So, and that is required for the manufacturing. So, in the paint section of a car manufacturing company the processes are also to be controlled, but they are again the same question the specification limit upper and lower to be considered. So, if you are learning this then we also can apply it there.

Now, so, that is one component specification designing manufacturing assembly process. Developing process steps and identification of process characteristics. What will be the process steps? How something will be manufactured? Production process quality control as I said that once the process are established and determined that ok these are the process then the question is what is the parameter. Say as I was talking about turning you all know that in a turning process what are the process parameters.

Say here as you all perhaps in your first year workshop itself you studied the lathe and there you learned that the three process parameters speed feed and depth of cut is there. So, similarly there are for other processes; somewhere it is a temperature, somewhere it may be a pressure, somewhere it may be viscosity whatever the parameters are, somewhere it may be speed. So, these are the things to be controlled.

So, now, if I go back from here if I control properly the production process of the quality parameters then the correct part will be produced. And, the correct feature therefore, we will be incorporated in that part and if we in incorporate the correct feature that component or the sub assembly will function properly and if it functions properly then it will contribute proper functioning to the main assembly.

So, we are doing the backtracking to test how we proceeded from the forward to forward end now we if we go from the reverse end we see the logic is full-filled.

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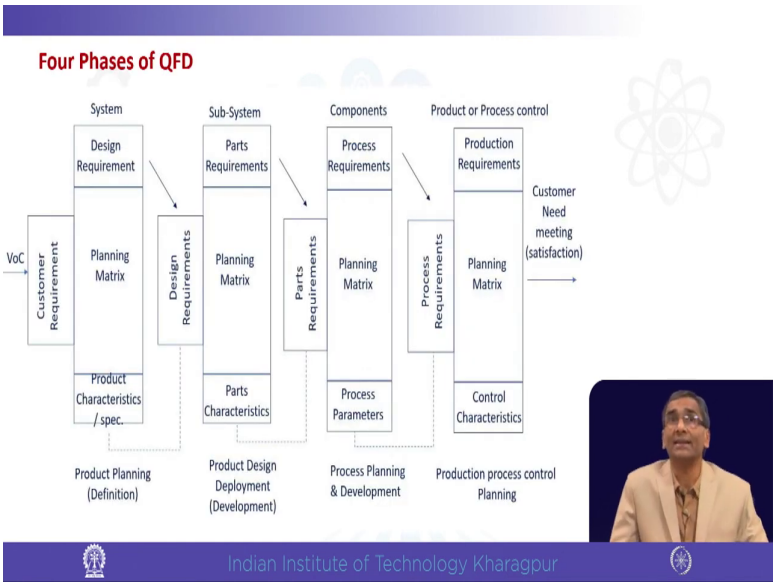

Now, as I just have said these are the four phases here pictorially you can see those 4 phases the voice of customer or the which from which we actually extract the customer requirements. And, on top as we had already discussed in our earlier session that the design requirement is attempted to match.

So, when we are trying to match the customer requirement and the design requirement obviously, because the requirement has to be met in an engineering way that is the engineering requirement or design requirement or technical descriptors. So, that will form a matrix. That matrix here is our major concern because from the matrix will tell us which should be our priority or which actually we should be taking forward.

Now, the design requirements that we have specified say by now from the first matrix that will now put on the second matrix and then the that the design matrix will now will be

attempted to be achieved through the parts requirements. So, it would give through this matrix some kind of part characteristics and like this part characteristics or parts requirements will be part requirements will be put in the input or and the process requirements will be attempted to match and the matrix will be formed.

Now, the matrix will be formed that matrix will give the process parameters. Now, as I have just now said once we have the process requirements, then the production requirements will have to be interfaced with that and then all these parameters control characteristics all these things will come out and then it will meet the specification on the product that it was intended to produce and ultimately it will generate customer satisfaction by meeting their need customer need meeting and that is giving satisfaction.

So, here from the left hand side you see VoC or the voice of the customer and the right hand side the output is the satisfaction of the customer. So, from the voice ultimately it has been translated into satisfaction through this four intermediate stages or phases.

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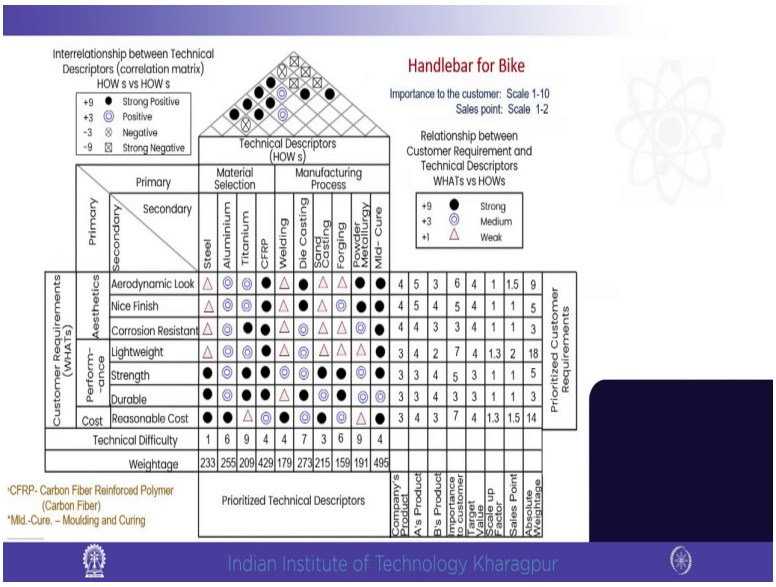

Yes, now we have discussed quite a few things, but it was I understand was a bit abstract because unless we see something with an example it does not get very clear, but one thing I would like to tell you at the beginning you have to bear with me is that the font size unlike all other slides here is a bit smaller. But you can zoom out and see zoom in and see that that what would be the you know what is the letters or the transcripts you can examine.

The thing is that we had to keep the entire diagram in one page, otherwise the connectivity would be missed and possibly it would hinder your understanding. So, in order to improve the understanding we had to keep it in one page and therefore, the fonts obviously, I hope you understand had to be made smaller. But, do not you please worry I will read it out column by or row by row or that way so that you will not have any problem in understanding the concept.

So, what is this? This is here you see that on the left hand side that the customer requirements or we call what is what is required? What? So, and what will be made when say what is required then how it will be made? So, what and how is the name of this game? So, on top you see that these are HOW's quite a few HOW's or which are known as technical descriptors or say you can call it as engineering requirements or design requirements.

So, I would like you to see that on the left hand side, extreme left hand side the customer requirements and on top just below that triangle you would see that the technical descriptors or HOW's or engineering requirements. Now, for both the customer requirements as well as for the engineering requirements, we can if you want we can break it into sub parts like say primary requirement and then secondary requirement and also maybe if required tertiary requirement and so on.

But, then by and large mostly from our experience as we see that within the secondary requirement most of the problems are well addressed. And, in many literature you would see the explanation only with the primary requirement phase. So, we are reasonably in depth and judiciously we can say we have gone up to the secondary level.

So, what is the primary one? The primary requirement for the for customer would be say here as an example of the handlebar of a bike would be say 3 – one is the performance, then the aesthetics, the look how it appears the form; one is the function, then is the form and the third one is the cost. So, these three things what has been understood from the voice of the customer and the these three broad things.

Now, if we try to understand what aesthetics means or what performance means, then we have to go to the next level that is called secondary level and where we are saying oh aesthetics means the three things as we have understood from the customer interview and that is the aerodynamic look, that is the nice finish and it is corrosion resistant.

So, these three if was satisfied will give aesthetic value. When we talk about the performance, then these three thing appears the lightweight strength and durable. So, these three things are

important and cost is standing out as a very important criteria. So, it has been also put in an one of the requirements.

Now, and similarly for the technical descriptors, if we go to the top we will break it in two broad groups which is in the secondary level. So, when you are saying HOW, HOW basically here is being answered with two questions. One is what material to be used and what the how the material will be processed.

If I say I want a pin to be developed, then I will say ok we will steal and then we will be turning it. If we are saying ok we want to have a bolt, then we will say ok we will have steel and then we will do the threading and milling and whatever the processes are, turning threading milling on whatever.

So, here if we are doing something with plastic, the material is plastic, then what we do? Plastic is normally molded either through injection molding or compression molding or some kind of a molding etcetera. If we are using say aluminium, we perhaps use die casting. So, usually so, material and process this goes like this.

Here for this particular product we have found in the market there are four types of materials used and there are six different possible processes which can be used to process these materials to give the product. Now, what is the next step then? We have established that part.

Now, the main work revolves around creating the main matrix that is the at the intersections of the What's and How's that is the customer requirement and engineering requirement, where the each cell the intersection will form a cell and each cell or the intersection characteristics is either strong or medium or weak.

For example, molding for plastic is very strong relationship and say for steel and die casting is not strong at all. So, those relationships are expressed as either strong or medium or weak. On top right hand corner you will find that the legends that they symbols are placed as dark circle solid dark circle in black which is strong.

There is a the symbols can be chosen by you, but then here we have taken the symbols as this that the circle within a circle is the medium and the triangle is the weak that is the symbol which then will be actually converted through the numerical values which is equivalent in some literature is the line (Refer Time: 22:20) one is very common distribution that we see but other distributions are also possible.

Now, the values we will be using later. We have used the symbol here because this helps in visualization. With the digits we cannot visualize what is the distribution of the intersections characteristics. How the requirements are connected to the technical descriptors that comes very clear with the use of symbols. So, we have used the symbols first and then we will convert into numerical values.

Now, the next is that what we do is that the company's performance that is the organization of the team, team that is going to study this. Now, as the team we are talking about in QFD like all design processes the team normally would constitute the design people, engineering people, manufacturing people also to give the customer requirement of preferences the marketing people and also the quality people.

And, not to forget when we are saying manufacturing I am also including the procurement because the quality of material that is coming in is very important. So, in some case you call it supply, some it is called it purchase or procurement. So, they those team actually determines what should be the position here. So, is a team that does this assessment.

Now, the company's product you can see that in a scale of 1 to 5 that we have mentioned here in a scale of 1 to 5 that the company's product are rated. So, 4, 3 are the various values. Here though it is not mentioned that it is in a scale of 1 to 5, but I would tell you that please note that it is from 1 to 5 in a 1 to 5 scale these things are presented.

Now, compared to the organizations there are two competitors that we have taken which we think are to be benchmarked with and they are called best in class. In that particular class of product they are the best and that is considered. So, A's product and B's product are compared

and against each say for aerodynamic look for example, our company or the company's product is 4 and A's in comparison is 5 and B's is 3. So, we that this company we are talking about is midway.

Another one the next one say for example, nice finish. Here the companies or the company we are talking about is 4, another competitor is 5, the other is 4. What is the purpose? I will just tell you that very soon, just after the next column I will come back to this again. So, these are the; these are the first listing that how in a scale of 1 to 5 these requirement fairs. How companies are meeting different requirements and that is the scaling are rated.

Now, here the next column is for importance to customer the thing is when we are talking about customer requirements there may be multiple requirements, but all requirements are not equally important to the customer something is more important. So, in a car the power steering may be more important than say for example, leather cover on the back seat. So, that is the issue.

So, importance to customer it is done in a scale of 1 to 10 which is mentioned on the top here. Important to customer is in a scale of 1 to 10. Now, having said that now coming back to the question of earlier three values in the three columns the companies A's and B's now from that what we what the team the design team will said now is a target value because when we are setting target value you are considering several different aspects.

And, then the target value is chosen say for example, the companies is 4, another is 5, the other is 3. But, judiciously if we feel the team feels that no we should need not go to 5 right now, we can stay at 4 for this particular requirement say aerodynamic look then here it is 4 it is mentioned target value. So, what target we are taking that we will compete for.

Similarly, if we take say for example, the strength it is 3, 3 and 4; the present is 3, the another company is 3 the other company is 4, but way, but suppose it is decided that the company will continue with 3. So, it is 3. It could be otherwise also I mean it could be enhanced also depending on the given situation.

Like say for I can tell you the cost aspect of it as is here, the here the companies rank rating was 3, where another was 4 and the other was 3, but it is thought that it is better to be cost conscious and so, it has been put as 4. So, now we have realized the importance of the comparison because it helps us to decide on the target value.

Next column if you see scale up factor, what is the scale up factor? Scale up factor is the ratio of the target value and the present performance. So, here the target value is 4 and for the aerodynamic look if we see the first row target value is 4, the present performance is 4. So, what is the scale up? There is no scale up. So, 4 by 4 is equal to 1. So, here in the scale up factor is 1, clear?

Similarly say for example, the light weight – in the light weight case where the present rating is 3, but the target value is 4. So, it is 4 by 3 that is 1.33 which is rounded as 1.3 here. So, it is 1.3. So, like that we set the target values sorry, which says the scale of factors.

And, then the next column is the sales point; that means, all features are not equally attractive to the customer and people would not pay extra price or premium price for that. So, which does not attract that is one category and which attracts more say a if a car is painting it is body with some very bright exotic unusual color there will be demand.

Although cost of the paint is not very high, but then the cost of the car may be escalated to a significant extent which customer will be ready to pay for. So, that is called scale up factor. So, scale up factor again as on the top here you on the right top you will find that scale up factor is mentioned as between 1 and 2. So, either it is 1.5 or 2 or something like that that is decided. So, here say from the judgment of the team the scale up factors are presented here.

So, if we have done this our main understanding part is more or less complete. Now, what we have to understand the computational procedure; also that is also part of the method. Now, what we do is we will show in the next slide the calculation procedure, it is all there. Now, I am telling you how to calculate you will find in the next slide all these things are presented, the calculation procedure are presented.

So, now here we would say that the calculation for the weightage is the 3 that is the importance to customer multiplied by the scale of factor multiplied by the sales point. So, let us take this example that say for aerodynamic look the importance to customer is 6 the scale up factor is 1 and sales point is 1.5. So, 6 into 1 into 1.5 is 9. So, you see on the first row in the absolute weightage, it is 9.

Now, like that all these columns all the rows are filled up. Rest is easy because now we what we will do is, we will multiply each cell. Now, in when I am saying each cell that now the symbol will be converted to the numerical value. Triangle means 1, the circle within circle means 3 and the solid dark circle means 9.

So, now if we are multiplying 9 into a triangle that is 1, then 5 into the triangle that is another 1, 3 into the triangle another 1, 18 into the triangle is 18 into 1, 5 into the solid dot that is 5 into 9, 3 into solid dot that is 3 into 9, 14 into solid dot that is 14 into 9 and so on and so forth, ok.

Here one thing I would like to tell you that on top you what you see is here that technical it is how versus HOW's that is technical descriptors are compared among themselves. Like say which goes with what and that gives the feasibility. Like say for example, the CPRF or the carbon fiber reinforced polymer, that goes with the mold curing or molding curing process. It does not go with the steel or aluminium or titanium.

Similarly, titanium goes with the power metallurgy; they steel does not go with die casting; aluminium goes with the die casting. So, if you look at those intersections you will find a solid black dot there. It is only for technical assessment, but it does not come as such in the calculation. Here for this particular work.

Now, we have explained the computational process and that the bottom the weightage values are here. What you see that here 429 is the highest or here in the process 495 is the highest. So, here you see this two highest values 495 and 429 this corresponds to CPRF and the mold

curing process; that means, it is asking the is preferring that the handlebar is made with the carbon fiber reinforced polymer with the molding curing method.

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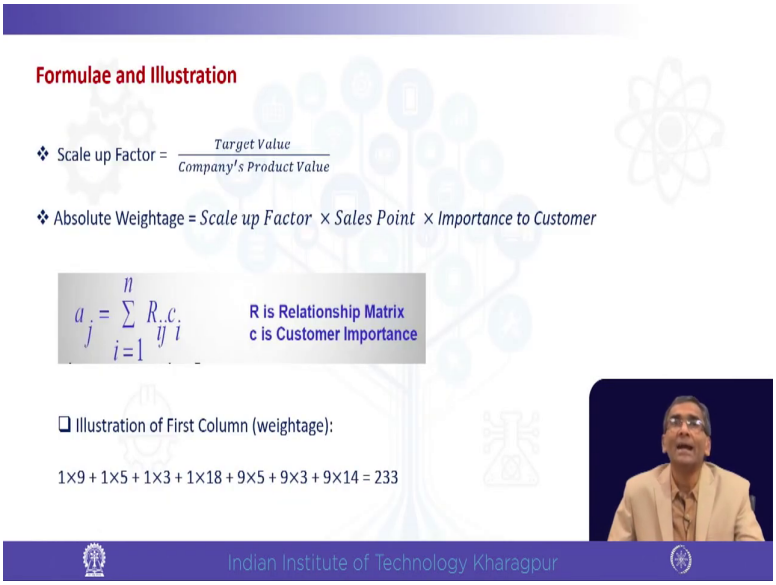

In this slide we are presenting the formulas that we have used and as I had explained the value of 233 the first column, it is also explained here as I said 1 into 9 plus 1 into 5 and all that. So, you can check that later and a j is that the cell values which is the summation of the products of relationship matrix sales values and customer importance and earlier these those things I have already explained.

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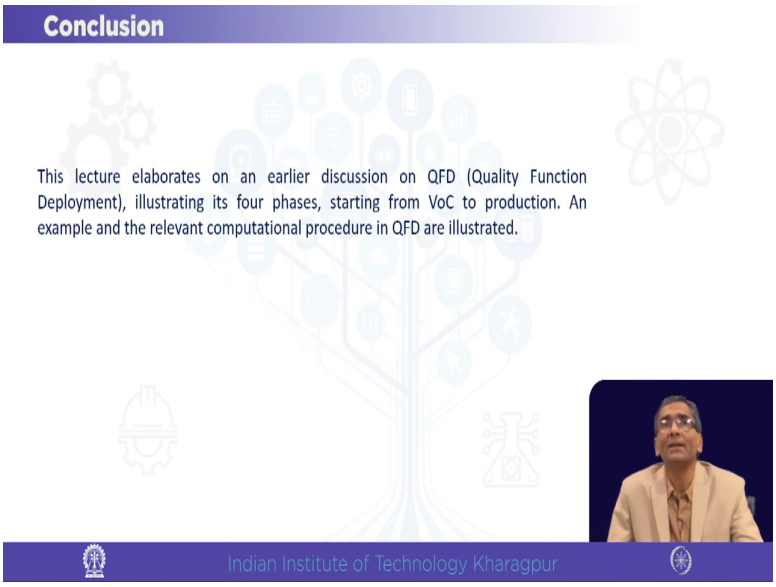

So, you can use that when for understanding later and in conclusion I would say that this lecture elaborates on the earlier discussion we had on QFD illustrating its four phases, starting from VoC to production an example and relevant computation procedure in QFD are illustrated well so that you can apply in real life situations which it gaining huge importance in industry now.

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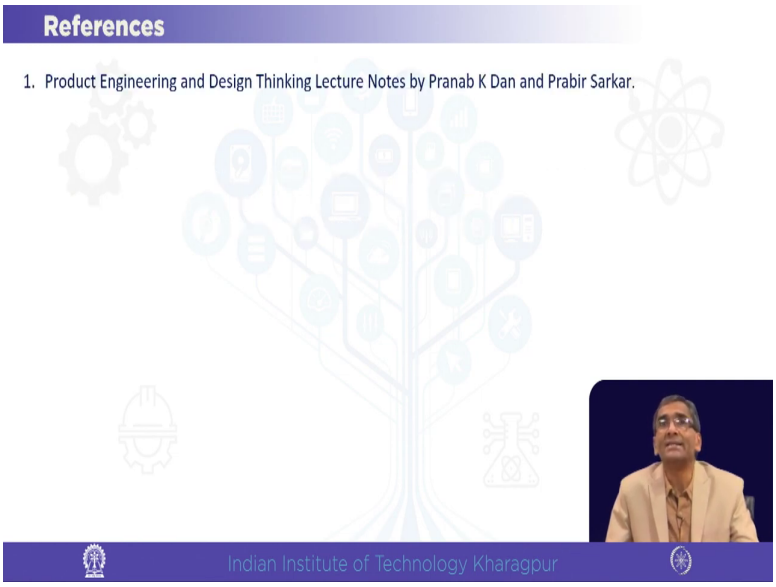

This you can look at the you know lecture notes as reference. So, I am sure that it will you will be able to help this knowledge in your industrial career or your entrepreneurial career and I thank you for listening to the this course and attending this session.

Thank you once again.