

**Product Design and Development**  
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**Lecture - 11**  
**Quality Function Deployment (QFD)**

[FL] friends, so we are going to start our discussion on week 3 that is related to the various design tools that are used for product design and development. Let us have a brief review of what we have already discussed in the previous 2 weeks. In week number 1 we have discussed the basic concepts of product design in which we have seen the need of product design, we have seen the product life cycle, we have seen the various steps involved in the product design process and the other aspects related to the importance of product design.

In week number 2 our focus was primarily on the functional aspects of product design in which we have seen the concept of value engineering, we have also seen how value engineering can be applied in various divers' fields of engineering as well as in service industry. We have seen the functional analysis approach, we have seen functional analysis and cost evaluation approach, we have seen the fast diagramming approach and if you remember in the last lecture we have taken case study of the functional cost evaluation of a furniture item that was a home divan.

So, right now we are prepared enough to understand the concepts that go into the product design. Today we will start our discussion related to the design tools, as you know that if we have to design successfully we should be aware of the various design tools which are used for the product design process. So, now, our focus is more from theoretical point of view to the application point of view, in the last class also lesson number 10 we have seen the application of concepts of value engineering for solving a real life problem that is solving the cost issue related to the cost of the divan.

So, we have seen that application base learning is much more relevant and important for short courses like 10 lecture courses or 10 hour courses. So, it is important that we apply our concepts to the application point of view and today also we will try to understand the concept of quality function deployment with the help of an example, in which we will see a comparison of the pizza manufacturing companies or pizza delivery companies and

see that how the concept of quality function deployment can be used for improving or for benchmarking or for comparing the quality of 2 companies.

Let us now start our discussion on the quality function deployment. First we will just have a brief overview of the historical aspects of quality function deployment, the history goes back to the year 1972 when it was first introduced at Mitsubishi's Kobe Shipyard in Japan. So, this is technique which is maybe now approximately 40 years old maybe more than 45 years old it is a method of structuring customer requirements and translating into technical specifications as a basis for a new product development. So, this is the technique which will be helpful for the development of a product or for the design of the product.

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**Quality Function Deployment**

**History**

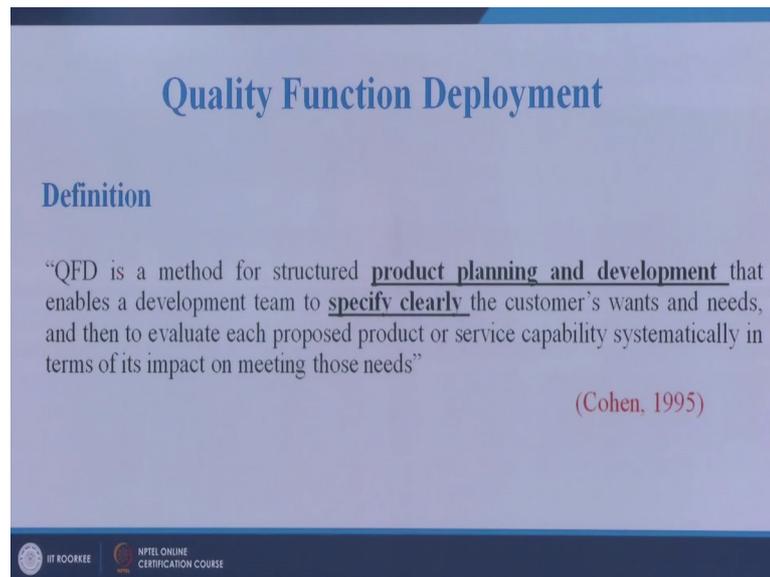
- It was first introduced at Mitsubishi's Kobe Shipyard, Japan in 1972.
- It is a method of structuring customer requirements and translating into technical specifications as a basis for new product development, "HIN SHITU KI NOTEN KAI".
- It has been translated into English as "Quality Function Deployment (QFD)"

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So, it is you can see 2 important terms have come in this sentence, first term is customer requirements. So, we will see how we can make use of the customer requirements in our design process as well as the technical specifications, here you can see technical specifications. So, when we will see the application of quality function deployment we will see these 2 things are the most important things customer requirements and the technical specifications. So, these 2 things will help us to make our decisions.

So, it has been translated into English as quality function deployment and more commonly it is called as the QFD technique and in Japanese they call it as [FL].

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The slide features a light blue background with a dark blue header and footer. The title 'Quality Function Deployment' is centered at the top in a bold, dark blue font. Below the title, the word 'Definition' is written in a smaller, bold, dark blue font. The main text of the definition is in a standard black font, with the phrases 'product planning and development' and 'specify clearly' underlined. The citation '(Cohen, 1995)' is positioned to the right of the definition text. At the bottom left, there are two small circular logos: one for 'IIT ROORKEE' and another for 'NPTEL ONLINE CERTIFICATION COURSE'.

## Quality Function Deployment

### Definition

“QFD is a method for structured product planning and development that enables a development team to specify clearly the customer’s wants and needs, and then to evaluate each proposed product or service capability systematically in terms of its impact on meeting those needs”

(Cohen, 1995)

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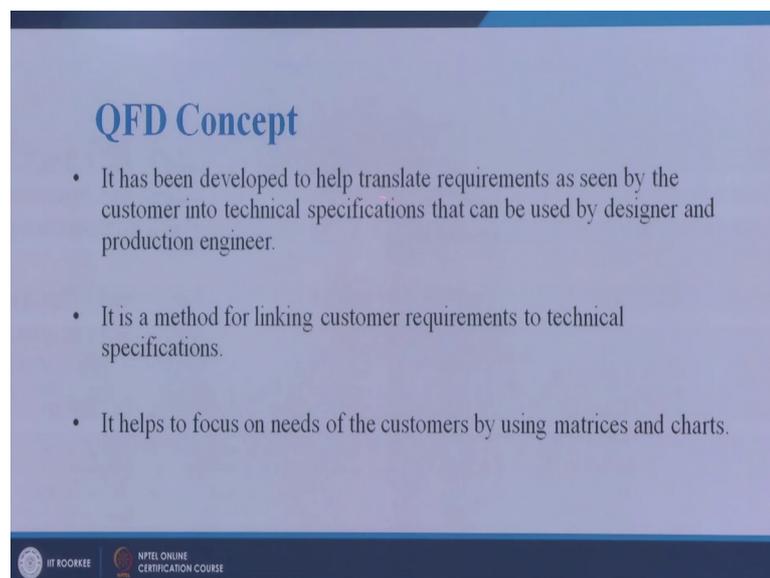
So, this is a Japanese name for this technique of quality function deployment. Now the definition you can see QFD is a method for structure product planning and development that enables a development team to specify clearly the customers wants and needs, and then to evaluate each proposed product or service capability systematically in terms of its impact on meeting those needs.

So, basically we have 2 things here, we will take input from the customer that what a customer wants for example, we, we can say if we are doing our quality function deployment for a design of an automobile. We will ask the customer that what are his requirements, maybe we may say, he may say that he needs a 4 seater vehicle. what should be the bhp, what should be the efficiency, what should be the we can safety features in the car or the automobile or we can say what can be the type of drive it can a manual drive or a gear drive. So, we will take all feedback from the customer and then we will document it properly, we will give equal maybe equal or maybe relative weightage to the various demands or the needs or the requirements of the customer and then we will try to map these or try to correlate these with the technical specifications. And then after we will after we have the matrix we will compare the designed products with the already existing products in the market or already existing automobiles in the market and benchmark our product that how competitive that product is going to be once it is launched in the market.

So, basically our focus here is on 2 important aspects, aspect number 1 is the input from the customers and the aspect number 2 is how to meet those customer demands and requirements technically or how the technical you can say specifications will be able to match the customer's requirement. So, same thing has been highlighted in this definition also, in the product planning and development process we need to specify clearly the customers wants and needs and then finally, we have to evaluate each proposed product or service capability systematically in terms of its impact on meeting those needs.

So, technical content is has to be there in order to map this customer needs with the actual products. So, let us see now the concept of QFD maybe 2 slides we will discuss in order to understand the basic concept of QFD.

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### QFD Concept

- It has been developed to help translate requirements as seen by the customer into technical specifications that can be used by designer and production engineer.
- It is a method for linking customer requirements to technical specifications.
- It helps to focus on needs of the customers by using matrices and charts.

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It has been developed to help translate requirements as seen by the customer into technical specifications that can be used by the designer and production engineers. Now it will relate the 2 things the customer requirements with the technical specifications, it is a method of linking customer requirement to technical specifications.

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**QFD Concept cont..**

QFD is a systematic approach of translating customer requirements into appropriate requirements at each stage right from:

- Research and development to engineering
- Engineering to manufacturing
- Manufacturing to distribution and sales

The complete journey of the product is covered right from conception till it reaches the customer.

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It helps to focus on needs of customers by using matrices and charts, usually we do it with the help of house of quality and we will try to understand this house of quality in today's discussion. Now, QFD concept is a systematic approach for translating customer requirements into appropriate requirements at each stage, right from first stage you all of you know research and development to engineering, engineering to manufacturing and manufacturing to distribution and sales.

So, you can see first stage is research and development from there we go to engineering specifications of the product, from engineering specifications of the product we go to the manufacturing of the product and then from manufacturing the product goes to distribution and sales. So, QFD is a systematic approach of translating customer requirements into appropriate requirements at each stage or appropriate specifications at each stage right from the conceptualization that is research to the final sales in the market, maybe automobile designed at the R and D center of any big automobile organization or company and finally, it is sold in the showrooms and the customer can go and buy the automobile.

The complete journey of the product is covered right from the conception till it reaches the customer.

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**The Phases of QFD**

Comprehensive QFD may provide four phases:

1. **Product Planning (House of Quality):** Translate customer requirement into product technical requirement to meet them.
2. **Product Design:** Translate technical requirement to key part characteristics or systems.
3. **Process Planning:** Identify key process operations necessary to achieve key part characteristics.
4. **Production Planning (Process Control):** Establish process control plans, maintenance plans, training plans to control operations.

Source: Garg and Kumar, Quality Function Deployment (QFD): A Case Study, 2014

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Now, the phases of QFD, comprehensive quality function deployment may provide 4 phrases we can see, phase number 1 is the product planning that is how also called house of quality, today we will see how this house will look like what are the various rooms in this house and what is the significance of each room of this house that we will try to understand today.

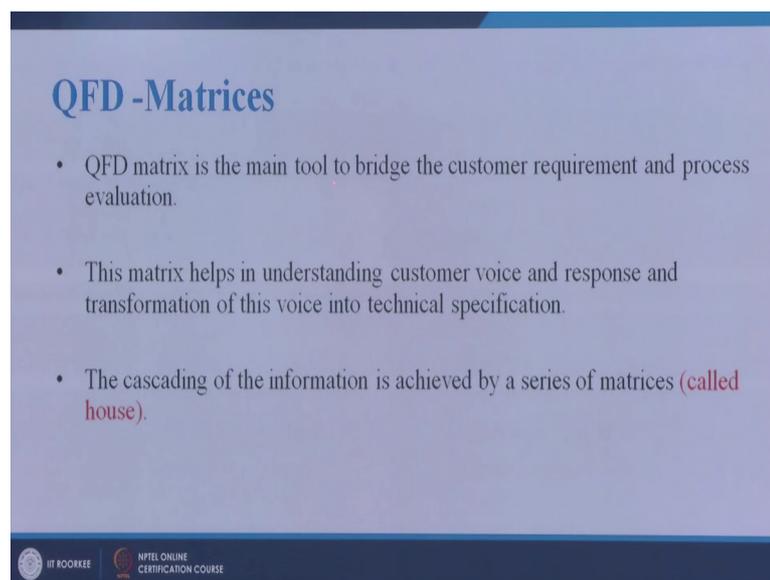
So, the first phase of quality function deployment is product planning, it will translate the customer requirements into the product technical requirement to meet them. Product design translate the technical requirement to key part characteristics or systems, in part characteristics we can says the dimension the specifications the tolerances and other parts. Process planning identify key process operations necessary to achieve the key part characteristics, now we have already you can say done the house of quality, it is now for example, for this pointer we can say the technical specifications of each and every part, what is going to fit? What will be the dimension of this thing? What will be the size of the slot all that is fixed that the product design stage.

At third stage process planning now we have to see that how we can achieve this design, which process will be used, how we can cut this portion, how the mold has to be design, so, that is process requirements. So, identify the key process operations necessary to achieve the key part characteristics, now this part has got certain characteristics if you

can see it has got a specific shape you how to generated this shape, how the mold will be designed all that will be covered in third stage that is process planning.

And in the last production planning or process control establish process control plans, maintenance plans training plans to control the operations. Finally, we will do the quality check of the product that we are producing, but in today's lecture our major focus is on house of quality these are the 4 stage is of QFD which will help us in a successful product design. Let us see the QFD matrices because here we will do we will use different types of matrix operations where we will give different weightage to different types of requirements which will be the voice of customers and the technical specifications we will try to relate them using a matrix system and then try to do some decision making based on the data that we generate out of this different matrices.

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**QFD -Matrices**

- QFD matrix is the main tool to bridge the customer requirement and process evaluation.
- This matrix helps in understanding customer voice and response and transformation of this voice into technical specification.
- The cascading of the information is achieved by a series of matrices (called house).

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Now, let us see what are the different matrices. QFD is a main tool to bridge the customer requirements and the process evaluation this matrix helps in understanding the customer voice usually call it many books you will see it will be written as VOC that is voice of customers. So, this matrix helps in understanding the voice of customers and response as well as transformation of this voice into the technical specification. So, we will try to understand with a very simple example. I understand that all of the learners for this course or all of the students are registered for this course may not be engineers

therefore, the problems that we are considering are not actually engineering problems they are more of day to day problems.

In value engineering also we covered the problem of a divan. I could a very easily taken a case study related to mechanical engineering, but my focus was that everybody should be able to have a basic fundamental understanding of the process of value engineering and therefore, divan was taken as an example. Today also all of us relish pizzas. So, we have taken an example of a pizza which is in your day to day life. You see pizza and you will be able to relate the concept of quality function deployment with the application of a pizza because everybody quick and relate to that product.

So, the different matrices as I have already told customer voice will be correlated to the technical specifications. The cascading of the information is achieved by series of matrices which is therefore, we club it into the form of a house. So, there will be individual matrices and when club together maybe there are individual rooms and when these rooms get connected together you build a house and that house is called as the house of quality. We will see what are the individual matrices and how these matrices are interrelated to each other and how we can make a house and how decision making or what decision making can be done based on this house.

So, let us try to understand the individual you can say matrices here. QFD is known by the house of quality I have told you individual matrices combined together a house is conceptualized or it is made and that house is called the house of quality it is called the house of quality because of its triangular roof structure we will see in the next slide. The house of quality is a kind of conceptual matrix that provides the means for inter functional planning and communication.

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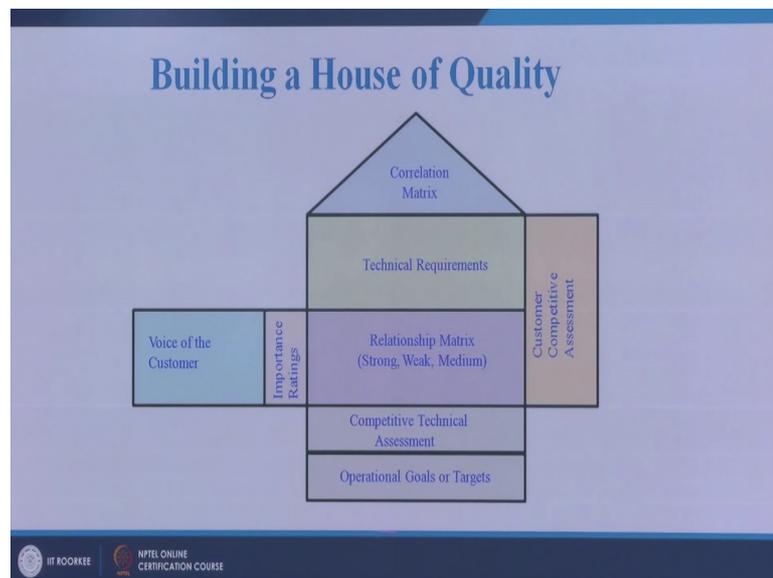
## House of Quality

- QFD is known by the **house of quality**.
- It is called house of quality because of its **triangular roof structure**.
- The house of quality is a kind of conceptual matrix that provides the means for **inter-functional planning and communication**.

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Now, maybe a product may have different functions. So, here we will do the analysis of inter functional that is how one particular function is you can say related to the other function and how it how the different functions influences each other. So, that we will try to understand.

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Now, this is you can see a house of quality. All the matrices are shown here top let us start from the top it is a correlation matrix, then the technical requirements relationship

matrix, competitive technical assessment, operational goals or targets, voice of customers importance ratings, customer competitive assessment.

Now, here we can see this straight if we move horizontally this is related to the customers only. You have voice of customer as I have taken an example of an automobile. For an automobile the customers may have certain requirements which can be the fuel efficiency, the safety, the comfort, as well as the break or spar or the sitting capacity all those or the weight of the automobile with different relative weightage. So, all that will come under the voice of customer that what the customer actually wants.

Then the importance ratings - the weight of an automobile may not be to relevant for various you can say customer. So, the weightage will be less, but as we see in different advertisements on the television we see our people or maybe in India we have a huge fantasy towards the fuel efficiency whenever we buy a car our focus is what would be the fuel efficiency. So, may be fuel efficiency is one requirement of the customer and which may get the highest weightage here.

So, that weightage is also assigned and there are standard statistical techniques to calculate this importance ratings also, but right now we are not going to go into that detail that how we will calculate the importance ratings, but we will try to understand the overall house of quality in detail. So, we have voice of customer we can have 4 inputs here then we have relative importance of this voice of customers and then as we have seen in the all the previous slides that we try to establish a relationship or interrelationship between the technical requirements and the voice of customer.

Now, if suppose one is fuel efficiency here we will see how technically we can achieve that fuel efficiency maybe redesigning of the engine or redesigning of a particular fuel injection system. So, that will come here as the technical requirement. So, you have voice of customer fuel efficiency and a technical requirement which will help to achieve that customer requirement and then we have the relationship matrix and this relationship matrix usually we will have 3 ratings for the relationship matrix. Suppose fuel efficiency is directly related to one of the customer one of the technical requirements we will say they have a strong relationship and in other case one of the voice of customers may not be that related to a particular technical requirements we will say they have a weak relationship among them.

So, we have a technical requirement matrix, voice of customers and this is the correlation matrix between the various technical requirements because one technical requirement may have a positive influence on the other technical requirement or one technical requirement may have a negative influence on the other technical requirement. So, based on that we will fill this correlation matrix also. So, we have understood correlation matrix, technical requirement, voice of customers, importance ratings and the relationship matrix all these will be filled and then from customers competitive assessment way this is kind of an output that we get based on this analysis.

So, here we can put 2 or 3 competitive companies and try to relate or benchmark, our particular output with the relative companies that what the other companies are doing or what are there you can say targets or how they fair on the voice of customer maybe we may be better than them in 3 of the options are 3 customer requirements. But maybe may fair poorly for the fourth customer requirement or 2 2 or sometimes it may so happen that we are not competitive on any of the customer requirement with the competitive company.

So, this will help us to benchmark our performance with in context of needs and requirements of the customer our company as compared to the competitors company and finally, this is competitive technical assessment that which technical requirement has got more you can say importance as compared to the other. This is the inter technical requirement competitive assessment we will try to understand this with the help of an example. And then we can have the operational goals or target this is one standard house of quality which is used maybe by most of the companies for accessing their product.

Now, this is the customer matrix as we have seen, this one this straight line horizontal line all the rooms here are represented again here the matrix evaluate the voice and response of customer on a particular product.

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## Customer Matrix

- It is the horizontal part in the house of quality.
- This matrix evaluates the voice and response of customer on particular product.

Voice of the Customer	Important Ratings		Complaints	Customer Competitive Assessment
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So, you have voice of customer here importance ratings, this is a relationship matrix in previous slide you can see, this is relationship matrix and then you have the sometimes you can also add complaints here and then the customer competitive assessment that how the customer rates the competitors product as compared to you are product.

So, this is a horizontal base for the house of quality or the horizontal rooms and then next class this we can see what we have to fill in this already I have explained just quickly we can read the various details of various rooms.

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## Customer Matrix cont..

1. Voice of the Customer: It is an input to QFD. This implies actual needs and wants of the customer and it is referred as the heart of the matrix as further evaluation depends on this matrix.
2. Importance Ratings: It shows the importance levels from customer point of view.
3. Complaints: It represent the dissatisfaction of the customer.
4. Customer Competitive Evaluation: It refers to the fact that how customer rates the product of the company in relation to its competitors.

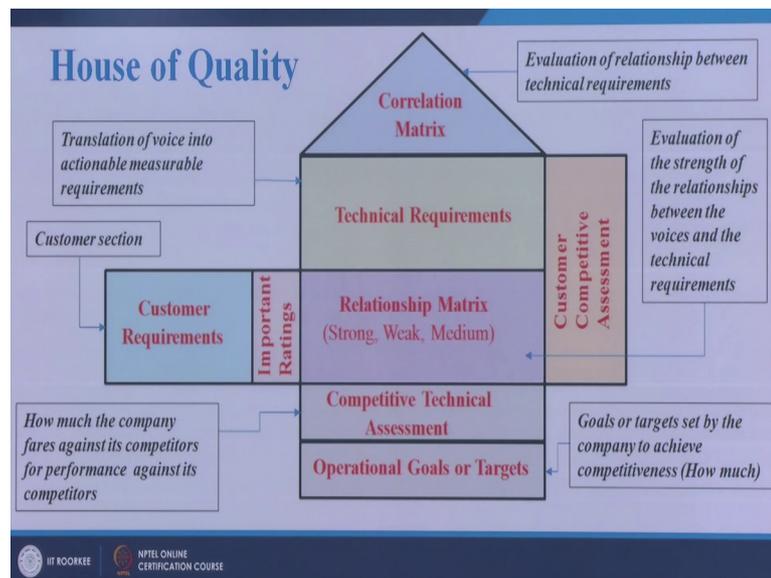
Voice of the Customer	Important Ratings		Complaints	Customer Competitive Assessment
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You can see voice of the customer it is an input to quality function deployment this implies actual needs and wants of the customer and it is referred as the heart of the matrix as further evaluation depends on this matrix because we are going to design a product based on what the customer actually wants.

So, this is the most important part of our house of quality. Importance ratings it shows the importance level from customer point of view. Complaints it represent the dissatisfaction of the customer. Customer competitive evaluation it refers to the fact that how customer rates the product of the company in relation to its competitors. So, whatever product we are designing this will help us to compare our performance as compared to the competition or the competitors or the performance of the competitors.

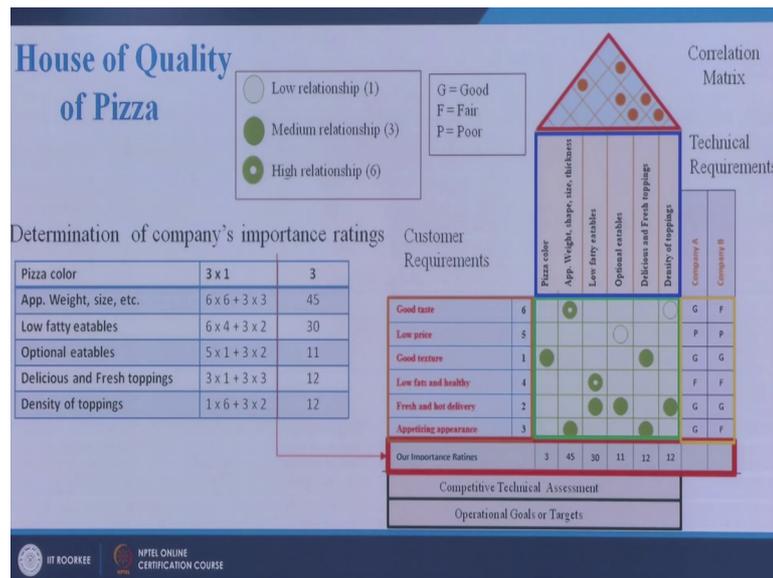
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This is the vertical already we have seen, your correlation matrix which will correlate the various technical requirements suppose we have five technical requirements here. So, this will correlate the all the 5 that which one has a positive influence on the other one or which one has a negative influence on the other one. Then the relationship matrix already this is part of the horizontal rooms also this is related to your voice of customers and the importance ratings and then the competitive technical assessment and operational goals or targets. So, let us now try to see this is translation of voice into actionable measurable requirements, whatever is our voice of customers that room coming here this will help us to achieve those targets technically.

This evaluation of relationship between the technical requirements already I have explained evaluation of the strength of relationships between the voices and the technical requirements; how much the company fares against its competitors or for performance against its competitors. Goals or targets set by the company to achieve competitiveness means this will tell us the target here we will get the assessment and accordingly we can take the decision making this is the overall. This is the customer section customer requirements or voice of customers important ratings and then the relationship matrix this is the overall house of quality in general in most of the books you may find 1 or 2 changes here and there. But in general it would look like this only the major sections will remain same correlation matrix will remain same technical requirement voice of customers importance rating and customer competitive assessment will be same in almost all the books or literature that you find around on internet.

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Now this is one example we are going to take that is house of quality of a pizza as I have already told I think the text maybe little smaller, but I will read it for you. Now if I ask you may be what is this matrix this is the correlation matrix the technical requirement matrix, relationship matrix, voice of customers, importance ratings, competitors assessment, competitive technical assessment and operational goals or targets we are not keeping here because we are just understanding the basic house of quality model.

So, you can see now you will wondering what is 6 5 1 and they will see what is G F P G this we will try to understand now. Now you can see that what are the customer requirements, I will read it for you the customer requirements for any pizza company or for a many pizza company is it should be good in taste price should be low texture should be good, means it should be good looking or the topping texture should be good it should be low on facts and it should be healthy maybe healthy ingredients are used, it should fresh and hot delivery should be ensured and appetizing appearance means you should feel hungry once you see the pizza. So, you can see these are the requirements of the customer .

Again I am reading it for you it may not be clear on the screen - good taste, low price, good texture, low facts and healthy fresh and hot delivery appetizing appearance. So, this is you can say the voice of customer this is what the customers want. Now the relative importance rating you can see here 6 5 1 4 2 3. So, here you can see good texture is not that important less rating highest rating is for good taste.

So, maybe a customer may say that 6 is the rating for good taste which means that it should be tasty, texture and other things may not be these not much bother, but it should it is a food item it should centilate our tasting birds or taste birds. So, we say it should be good in taste therefore, the rating for good taste is higher from the customers point of view. Now how we can achieve this voice of customers technically maybe the person who is preparing the pizza in the kitchen minions this is the input for him and how he can do that he can do it with the help of pizza color weight shape size thickness low fatty eatables, optional eatables, delicious and fresh toppings density of toppings.

So, maybe these are the technical things which can help to achieve the voice of customers and then we have to draw a relationship matrix between the two that which technical requirement is related to which customer requirement. So, which technical requirement can satisfy the customer requirement that we will see. So, if this is a representation this is a representation of a scale that scale you can see. So, this is a voice of customers the purple portion is your technical requirements, this is your correlation matrix between the, among the various technical requirements this is your relationship matrix green color.

So, relationship matrix you have low relationship is given a rating of one, this is standard some in some books you will find 1 3 9 also, but they does not make much of a difference. So, in this case they are taken it as 1 3 and 6, so this represent low relationship. Solid represents medium relationship and solid with a dot represents high relationship. So, you can see good taste with this technical requirement weight shape size and thickness has got the highest relationship that is the high relationship then the taste is also related to the density of toppings which has the low relationship. So, density of topping and weird shape size and thickness are 2 things which are related to the good taste.

This is the specific you can say information in many cases it may be low fatty eatables may also have a representation on the good taste, but in this particular case it is not non representational. So, this way 1 3 and 6 rating is given and different ratings are given for example, appetizing appearance maybe this has got medium relationship with delicious and fresh toppings appetizing appearance, this has got a medium relationship you can see here.

So, this relationship is there and G P means you can see this is G means good, F means fair, P means poor. So, we are comparing our product with company A and company B. So, from taste point of view the company A has good and company B has got fair. So, this is a house of quality which we can generate. Now we can do the calculations also and you may be wondering that how these numbers 3 45 30 11 have come now let us try to understand this. This is calculated in this manner the pizza color 3 into 1, let us go to pizza color this is pizza color only one relationship established here this solid means medium relationship 3 and the rating is 1. So, 3 into 1 this comes out to 1 and then the second weight shapes size and thickness of the pizza it has got here 6, 6 into 6 - 36 plus this has got a medium 3 into rating is 3 3 into 3 is 9, so 36 plus 9 is 45.

Similarly, we can do the calculation and for the relationship matrix and establish this importance ratings. Now this can also help us in our decision making that when we have to make a tasty pizza we can say successful pizza successful pizza means it is successful from the point of view of business. We know that where we should focus our efforts 3 is for pizza color. So, color has the least you can say requirement from the customers point of view, but you can say weight shape size is most important. Second most important is the low fatty eatable. So, these days' people are getting more and more conscious about

their health. So, may not like to take a pizza which has got fatty eatables. So, if you are low in fat and we can sell that idea that the pizza is made up of you can say eatables or materials or ingredients which are low on the fat content. The various customers may get interested to buy our pizza.

So, here the relative importance of the technical requirements has been established and we can work on these two parts in order to satisfy the customer requirements and we can benchmark our product with the products of the other companies also and see that where we stand and become and may become successful after analyzing the results in a systematic and logical manner.

So, this is one tool which help us to convert the customer requirements into the technical requirements and then analyzing the technical requirements among each of the different technical requirements among each of them or among each other. So, one thing that sorry I forgot to mention is the correlation matrix. In correlation matrix we do the inter functional analysis. So, we go pizza color you can say going this way and this is optional eatables that is going this way. So, they have a relationship if you get optional eatables they have a influence on the pizza color.

Similarly, density of toppings has a, you can say influence or maybe relationship with delicious and fresh toppings. So, this way we can see that which of the technical requirements are you can say related to each other positively here also we can have positive and negative we are not explained it here because the pizza is a simpler products. So, all technical requirements may not be competing or may not be effecting positively or negatively otherwise we can have here also positive and negative ratings and see that which technical requirement will have a positive influence on the other technical requirement or if the otherwise it has a negative influence on the other technical requirement.

So, I think now I have tried to explain the role of each and every room of this house of quality and this is an important you can say skill if you have as an engineer or a manager you can try to relate the customer requirements with the technical you can say requirements that can be met using your engineering skills or the engineering knowledge.

So, with this we come to the end of our session or lecture number 11 on product design and development course and today our focus was on house of quality. In our next session we will discuss the basic concepts of computer aided design.

Thank you.