Quality Control and Improvement with MINITAB
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Lecture - 03
Quality Function Deployment

Hello everyone and welcome to the 3rd sessions of this Quality Control and Improvement using MINITAB.

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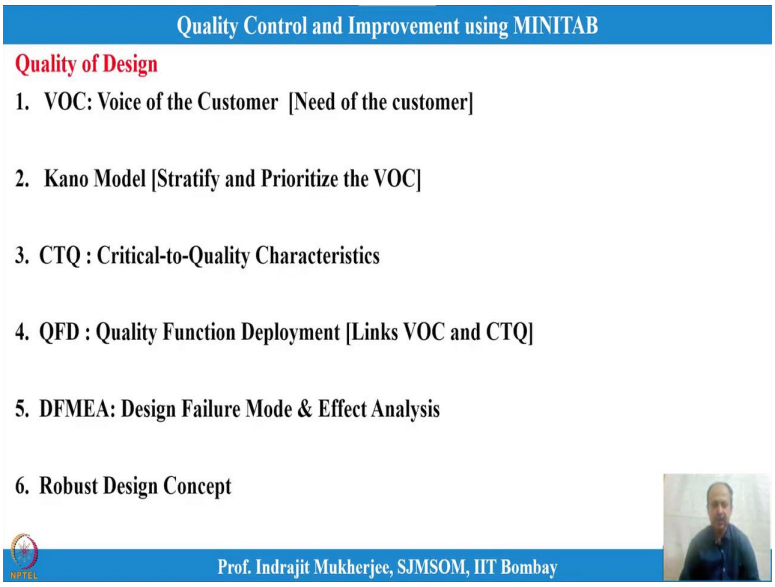

Last session what we have done is that we have discussed about voice of the customer and also how voice of the customer is related to technical specifications. So, CTQ how we can convert the voice into technical specifications of CTQ and we have also discussed about how the voice of the customer can be stratified using a Kano model and stratification and prioritization of the voice of the customer that we have discussed.

So, today what we will do is that we will try to discuss about quality function deployment or which is known as house of the quality that relates between voice of the customer and CTQ that will link between voice of the customer and critical to quality characteristics. So, how it is done we will try to give an example out of that. So, let us start our discussion from there and so, this is session 3; is session 3 what we will do. So, this is session 3.

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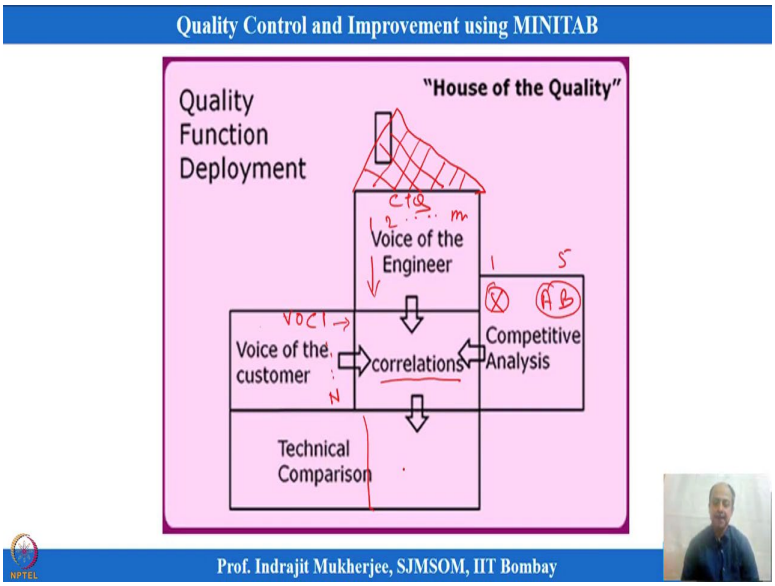

So, voice of the customer over here. So, quality function deployment, basically which is known as house of the quality. What does it consist of basically? So, you will find that on one of the box over here you will find that the voice of the customer. So, there will be voice of the customer 1 like this.

There can be N number of voices over here and the CTQ will be written that CTQ dimensions will be written over here 1, 2. So, this will be done by the engineers and they understand that if these voices has to be translated in the products in that case what is the characteristics that has to come out of the products basically that will basically link the link to the voice of the customer basically.

So, voice of the customer N number of voices will be addressed by m number of CTQs. Let us try to think about that scenario ok. So, these two box will show you the CTQ and this box will show you the VOC. And the correlation between VOC and CTQs will be shown in this box what you see over here. So, they can have strong relationship.

One voice can be addressed by CTQ, but relationship can be strong or weak or medium relationship can exist over here. And this will be shown in this matrix over here and relationship between the CTQs that how CTQ 1 and 2 are related. This relationship will be shown on the top of the mats of top of this house of quality and this is known as roof of quality we can think of.

So, what you will see is that there will be a roof of the matrix which will show the correlation between the CTQs also ok. So, how CTQ 1 is related with 2 ok and then you will find that each voice of the customer will be evaluated by the customers and the average rating will be shown over here.

So, if our company is X and other company is A or B, so, where we stand in a scale of 1 to 5. So, average rating may be for a particular specific voice over here can be we are rated as 1 as the lowest rating over here and they are given a high rating over here. So, then this is a concern for us.

So, the way we are addressing the voice may not be sufficient and we need to improve our ratings. In that case we have to follow what A and B is doing basically ok. So, we have to improve that one in whatever way that is possible, so, ok. So, similarly so, this will be done by the competitor.

Each voice will be survey will be done and each of the voice where we stand as compared to a competitor that will be evaluated in case it is a existing product that we are trying to launch over here and we are trying to improve on that. So, quality function deployment can be done at design stage also can be done at various stages.

So, even after implementation QFD can be done because every time CTQs are keeping on changing because the voice of the customers are. So, this is the dynamic one. So, voice changes, CTQ changes and we may have to replace some CTQs because voice has changed. So, in that case we need to continuously improve on that and then competitive evaluation also changes with time.

So, in this case also and the CTQs also will be evaluated based, the engineers will give you inputs over here. So, in that case if we have defined a values over here for any of the dimensional CTQs, so, which will have specifications. And in that case engineer will say that our specification how it is performing as compared to the other competitor's specifications.

So, this is the technical input that we will get from the engineers or process experts or anybody who is product experts. So, in that case expert opinion will be taken over here. So, in this case what we will; what we will what we can see in this box is that technical

evaluation on every CTQ. So, all the CTQs and what is the evaluation in a scale of 1 to 5 again ok.

So, where we stand as compared to the CTQ that is provided by the competitors. So, this information will be used maybe in reverse engineering. When we are doing reverse engineering this information will be useful over here. So, voice of the customer will be translated into CTQs, CTQ dimensions over here ok.

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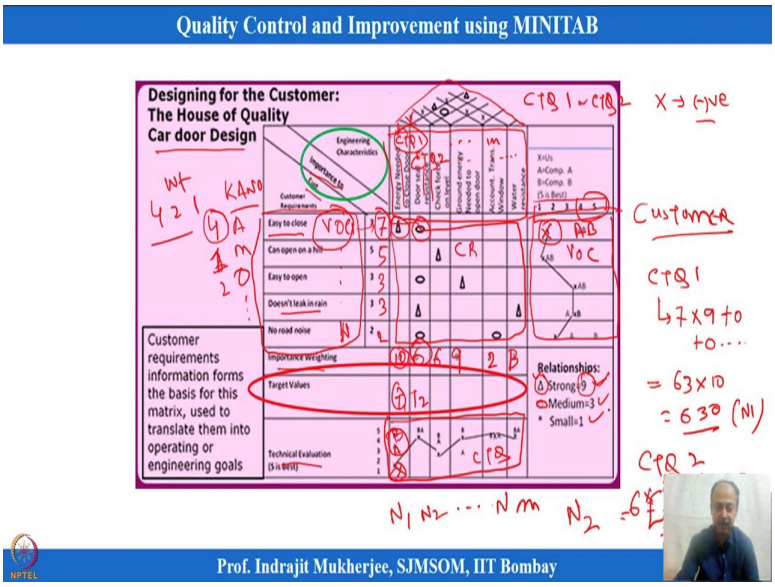

So, now let us take an example to understand this one what is happening over here. So, in this case what we have taken over here is the car door design example over here. So, one of the examples from book we have taken. So, what we are trying to; what we are trying to show over here is that this is the roof of the matrix what you see roof of the house of the quality over here.

So, this is the box where voice of the customers are noted down over here and this is the CTQ box that you are seeing over here and this is the competitor evaluation box that you are seeing over here and this is the correlation box that you see over here, evaluation of VOC and CTQs.

And here we will have targets for each of the CTQs. Target values we will target values will be set over here will be shown over here and the technical evaluation will be in this

box. So, where we stand as compared to what, as in the CTQs basically. So, this matrix will say in terms of voice of the customer where we stand.

This below box will say that CTQ stands with respect to competitor where we stand basically. And this correlation matrix what we will show is that relationship between any voice of the customer 1. Let us say and CTQ 1 let us say over here. So, here one of the voice that is shown over here is easy to close. So, car door design so, customer wants that it should be very easy to close.

So, then technical engineers. So, they have defined that easy to close is highly related with energy needed to close the door basically. And also door seal resistance is another parameter which also influences or that is another CTQ which influences how much easy it is to close the door ok. So, these are the CTQ. CTQ 1 and CTQ 2 we can think of. So, these are the two CTQs what we can think of over here; energy needed to close the door and door seal resistance basically ok.

So, energy needed easy to close is highly related with energy needed to close the door. So, that is why this symbol is used delta and this delta is equals to strong relationship is rated as 9 over here ok. So, we are giving some numbers over here, this is arbitrary over here. So, any company organization to organization this can differ.

So, what we are trying to say is that what is the inter relationship or correlation between voice and CTQs. So, this is shown over here as they have a strong relationship with it. So, energy needed is highly related with easy to close so. Similarly, easy to close is highly is mediumly related over here. This is based on previous evidence or technical literature or something.

They knows that if door seal resistance is high and in that case what will happen? It is very easy to close ok. So, they have a, but they are saying that this is not very strong relationship, but energy needed is highly related with voice of the customer 1. So, voice of the customer that is first voice of the customer we can think of ok.

So, this is based on experience, based on feedback, based on expert opinion, based on literature. So, we will be able to know what is a strong relationship which is having strong relationship which is having a weak relationship over here ok and then they can be given a scale like 9, 3.

Medium relationship is given a scale of 3 and this is 1 equals to number is given as 1 if the relationship is not so strong ok. So, it can be positive or negative any direction of relationship we can think of ok. So, then energy needed to close the door and door seal resistance; you see on the top also there is a matrix which shows the relationship between these two.

So, CTQ 1, how CTQ 1, is related with how it is related to CTQ 2 over here? So, how they are interrelated basically that will be shown over here. Let us say the symbol that they are using over here is cross; that means they have a negative relationship. Negative relationship means, one if you try to improve one the other one will deteriorate. So, in that case they have a correlation within the CTQs.

So, energy needed to close the door and door seal resistant. So, you see if door seal resistance is high and then in that case energy needed to close the door will be small ok. So, there is a negative relationship; that means, one any if one increases the other will decrease basically ok. So, that is CTQ relationship between them that will be shown in the roof of the this matrix what you seeing the or roof of the house you can think of.

So, all this will be defined by the quality personnel or production personnel or the experts opinions that will say based on evidence what we have literature or other references. We can also relate CTQ how they are interrelated. So, we can just have a picture of the, means idea about that one ok.

So, voice of the customer any voice of the customer will be related with any of the CTQs over here ok. If the voice of the customer is not addressed by any of the CTQ; that means, we are missing something in the design basically ok. And or maybe this voice of the customer is not relevant, so much relevant because we are not interested in this voice of the customer while we are designing this one.

So, every CTQ is important and it is addressing a voice. If CTQ fails then customers will be dissatisfied because it will impact their voice of the customer and it will impact the customers opinion or feedback about the quality of the products basically ok. So, this voice of the customer will be related way and this matrix what you see technical evaluation over here where we stand, where B and A stands as compared to our product which is X maybe.

So, we are X company. Similarly, competitor's evaluation which will be done by customers. So, in this case what will happen is that customer will evaluate this one and maybe we are standing. So, this will be in a rating of 1 to 5 that you are seeing over here and maybe we are standing at 1 near to 1 and A and B is standing near to 4 and 5. So, they are getting highest rating as compared to our products in this case for specific voice number 1 over here.

So, where we stand is also important as compared to our competitor and that will basically dictate that what changes are required. So, if I have to address this one then I have to go back which is the CTQ is addressing this voice. And then compare the CTQs with the competitors CTQs and what is the target value which is known as reverse engineering so that we can also do something on this. So, that our technical feedback is also saying that we are lying at the lower level over here.

So, we need to improve to A and B. So, maybe our specification should be closely following the specification what is given by A and B and let us try out that one and experiments and find out what is going wrong basically ok. Any company does this reverse engineering. You go to any companies they will do reverse engineering and they have ideas of the competitor products also. So, that is also reflected over here. So, in this matrix over here.

So, this matrix, how it helps basically? So, I want to voice this prioritize over here. So, then you will see an importance matrix importance to customer over here. So, there will be some rating that is given over here 7, 5, 3, 3, 2; like this. This is a rating that is given over here. So, this importance relating may be based on customer feedback.

They will get some customer feedback over here an average customer feedback will be noted down over here. It may not be integer over here. It can be any numbers. So, in a scale of let us say 1 to 10 which is most. So, some numbers can be given over here importance number for every VOC's.

So, this input will be taken from the customer and also we have a Kano model which will also which also says which voice falling in what category, maybe this is attractive features or this must be category. So, we can also differentiate one dimensional category. So, this can be hypothetically this is a hypothetical one, I am just arbitrarily mentioning this one.

But, you can think about this and which will fall in what categories and it will be shown by Kano model. When they are doing surveys they will figure out which is following a which strata; that means, which category basically. So, in that case that is also possible.

So, Kano model will also say, so, if it is a attractive features maybe we can give a also a score to this and we can also give a score to this and we can give a score to this and must be components can be given a score of 1. So, 4, 2, 1 scale we can use for this attractive must be.

And this is also one weightage we can think of over here and also we can ask the customer to give the rating. So, this is given by the customer rating and Kano stratification also says which is important which is less important ok. So, this numbers will be used too. So, I want to prioritize because voice is already prioritized by Kano model, I want to prioritize the CTQs also.

CTQ 1, CTQ 2, up to m CTQs which is important which is not important. So, when you see many of the one voice is addressed by many CTQs or maybe one voice is addressed by only one CTQs that can happen. So, that is also possible. One voice is addressed by many CTQs ok or many voices are addressed by one single CTQs is also possible reverse way.

But, the voice that is noted over here basically what is important to the customer and CTQ is those CTQs which are important and addressing the voice of the customer ok. So, nothing is unimportant over here that is there is no redundancy over here ok. So, not on the CTQ not on the VOC.

So, every voice should have a CTQ. So, that is what is emphasized over here. And then this what you see is that let us say the CTQ number 1. Let us say consider the CTQ number 1 and it is having a strong relationship with a first voice of the customer. So, voice of the customer 1 is having a CTQ with 1 is having a strong relationship that is symbolically shown as delta over here ok, which is given a rating of 9 let us say which is given a score of 9.

If it is strong we will say this is about 9, we can think of a number which is arbitrary we can which is defined by the organization ok. And the rating that is given over here let us

say customer average rating is 7 approximately and this is the attractive feature and we are giving a rating Kano rating of 4 over here.

So, let us try to see how this calculation happens over here to calculate the CTQs over here. Also the engineers will rate the CTQ in a scale. So, engineer has rated 10, he has given a score of like this score is given in a scale of 1 to 10. So, it is given a score of 10 by the engineers for the CTQ over here.

So, then what happens is that for CTQ 1, I have to calculate the total score of this. How do I calculate? For voice number 1, the weightage is approximately 7. So, 7 multiplied by and this is a strong relationship that we are seeing, 7 multiplied by 9 is the rating over here. Then for the CTQ I go column wise over here.

There is no other association between this CTQ 1 with any other voices over here. So, all other will be equals to; so, all other will be equals to 0 over here. So, this will be continuing up to this n number of voices that you see over here. So, this will be continued and nth observation will also be 0 over here. So, in this case and this will be so, summation of all of this will be 7, 63 over here and the importance rating is approximately equals to 10.

So, this will be score will be around 630 over here. For this CTQ the overall score will come out to be 630 over here. Similarly, for the 2nd CTQ for the 2nd CTQ, CTQ number 2, what you can see is that 7 will be multiplied. So, this is 7 rating for this voice of the customer and medium relationship exist between this, 7 multiplied by 6 and then what we can do is that this is easy to open is also related to CTQ 2. So, in this case this will be 3 multiplied by and this relationship medium is shown over here which is given a rating of 3. So, 3 multiplied by 3 like this.

And similarly third one what you see is that does not leak in rain over here. So, this is equals to what you are seeing is that 3 rating is given over here. So, this is 3 multiplied by; 3 multiplied by; so, this will be sorry this will be. So, we will go back to this. So, this will be equals to 3 multiplied by strong relationship like this. So, this will continue and total summation will be multiplied by importance of weightage that is 6.

So, this is this will be equals to 6 multiplied by this. So, this two; overall rating can come out let us say this is some number over here which is number some number is coming

out. So, we can calculate this one and we can say this is N 2 like this. So, this is N 1 over here. So, we will get for every CTQ number over here N 1, N 2 like this N m.

So, this is the total rating we can think of; total rating number what we are getting out of this for CTQ 1 and CTQ 2. Then what we can do is that from highest to lowest we can arrange the CTQs and we will get we which CTQ is getting the maximum ratings and we can prioritize.

Because if the CTQ is more important; that means, more rating it is getting and so, we need to concentrate on those CTQs and those CTQs should not fail because if that CTQ fails in that case voice of the customer will be will also fail. So, in that case that we have to keep in mind, ok. So, this is the overall house of quality or quality function deployment.

It is done at the design stage, it is done at production stage. For any improvements we always do this QFD. So, QFD can be in shop floor also. So, every time what is the CTQ and what is the voices and conversion of this? So, existing products and also for new products we can we need to do this QFD analysis ok. So, that we understand where we stand as compared to our competitors.

So, there is no voice that will be noted over here that does not relate to any CTQs. So, there will be no CTQs which does not address any other voice. So, redundancy will be not be there. Now, this ratings that we are getting over here, so this is 7 rating over here. So, again this can be multiplied with 4. So, overall importance matrix may be 7 multiplied by 4 which is coming from the Kano model.

So, that importancy can also be multiplied over here and then summation of this will be multiplied with 7, 7 into 4. So, that score can be taken into consideration. So, many of the research articles also consider that Kano rating along with customer rating can be multiplied together and that number will also can be noted down and that overall rating can be given based on the inclusion of this Kano rating also.

So, that is also possible and the, but all these things are somewhat some numbers are arbitrary because 9, 3 I can change this number over here. So, I can make it 6, 3, 1. So, it depends on company what marks they are giving and that can influence that can totally dictate the scores, but more or less the analysis will be it will reflect the same thing.

Because if there is strong relationship it only the numbers will somewhat change and it will change for every locations. So, strong medium small we can change the numbers, but overall which CTQ is important which is not important will be always reflected because importancy is given by the customer and Kano importancy we know. So, that will be multiplied with the correlation matrix that we are getting over here and based on that overall score will come.

So, which CTQ is important that will not change basically, top priority CTQs will not change over here even if some number changes you are here and there you are making. So, that will not impact the overall importancy of CTQs where every CTQ stands. So, that will not change much ok.

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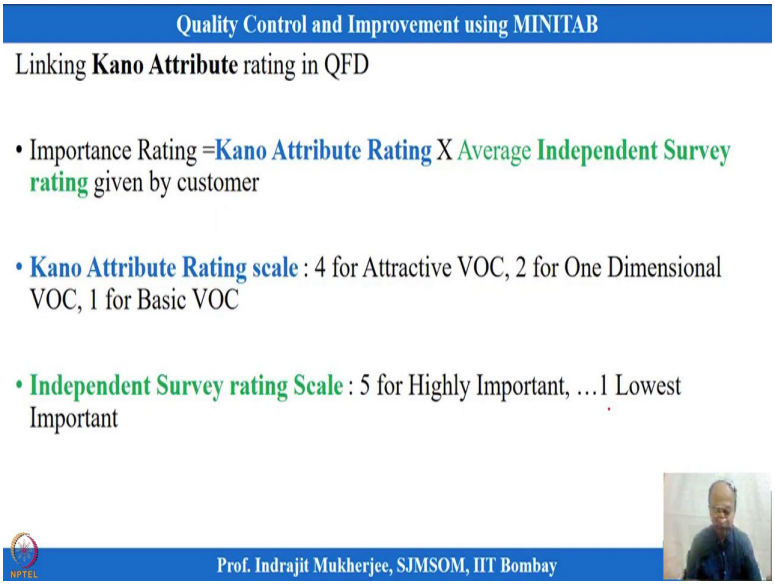

So, this is what I was mentioning over here. So, Kano ratings can be multiplied with the independent survey ratings and Kano can be taken as 4, some of the authors as mentioned. So, if it is a basic requirements, it can be given a rating of 1 because we are interested in attractive one dimension and basic. So, here we should not fail anywhere we should not fail, so, ok.

So, reversible we reverse we are not interested and we are indifferent also we are not interested because in the QFD we only put attractive one dimensional basic because that is the; that is the core ok. So, that is the core and that will define the CTQs basically ok.

So, if it is indifferent; that means, that dimension is not so important. We can also drop that from the design ok.

So, that was we should not address we are not concerned about addressing that one and reversal anyway they will not include in the design. So, most of the time. So, in that case we are only interested in attractive one dimensional basic. So, ratings can be 4 to 1 and that can be multiplied with the survey ratings in a scale of 1 to 10. So, that I have shown earlier in the QFD matrix what we have drawn over here.

So, this number 7; this number 7 which is given by the customer is can be multiplied with 4 over here and then it will be multiplied with or overall I can multiply increase the number over here. So, this will be 7 multiplied by 9; 63 and this will be multiplied by 10, 630; 630 can be multiplied with 4 because this is attractive VOC. So, we can multiply again with 4. So, numbers will increase. So, change in numbers will happen ok. So, I am giving some weightage to the Kano analysis also over here.

So, that is considered over here and that is what we can think of as Kano model that we can think of as Kano model in brief idea that we are placing over here ok. So, and more can be studied in books you can see books and there can be many other views like this ok, but overall idea is. I want to relate the voice of the customer with CTQs ok. So, then CTQ has to be translated into products. So, how this is done in manufacturing?

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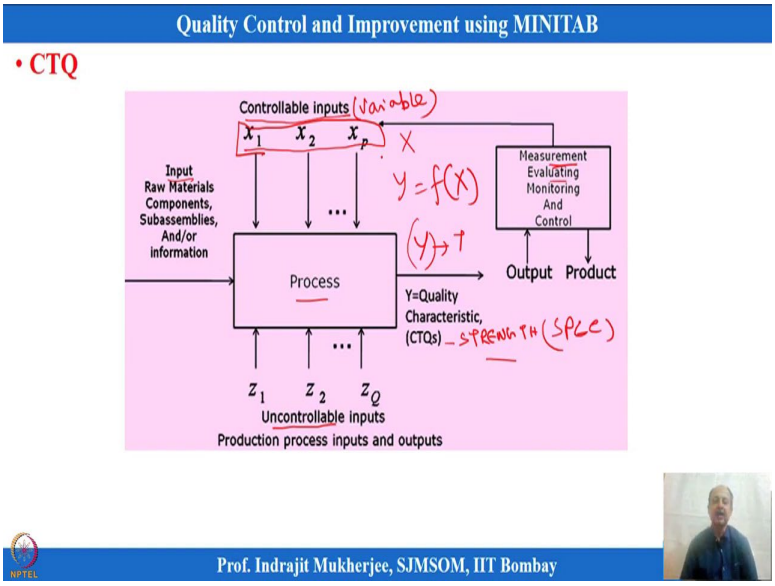

So, we will have this is the diagram what we can use as a basis. So, there will be some inputs over here. There will be some inputs that will come in the process. It can be sub assemblies, this can be raw materials, it can be any other inputs. So, then what will happen? This is the process. When it goes inside the process you can think of machines.

So, whenever the raw material is entering into the process or maybe a continuous manufacturing a steel industry there will be inputs over here. So, in that case raw materials will be provided and the process will run or value addition will happen. And then we will have products as an output and products will have some characteristics maybe strength or something other which is a CTQ basically. So, CTQ can be strength over here strength ok.

So, CTQ can be any other dimensions over here strength elongation or any other parameters which is important to the customer basically. So, these are the CTQs which is coming out of the process. So, product will come out then we will measure in that product this dimensions over here is the strength ok. As per specification is it produce as per specification, is the elongation ok as per dimensions what is given by the customer.

So, then we will do measurement and evaluation over here. And accordingly what is coming out of the process? The CTQ dimensions what we are getting. What we can do is that we can change the process settings. So, this is a controllable inputs conditions or inputs or variables we can think of and these variables can be changed like knobs over here. So, like in machine speed, feed, depth of cut, this can be changed ok.

So, similarly there will be inputs in a process. There will be output will be basically quality characteristic what we are measuring what we are interested in that is the CTQ what we will measure. We will not measure everything. You go to inspection and you find that they are not measuring everything. They are measuring only CTQs which is important to the customer.

If deviation from there happens then it will affect the customer. It will not affect much if some radius is gone wrong or something in a product dimensions ok, but if the diameter has gone wrong it will create problems. If surface finish has gone wrong it will create problems ok because it will impact the customer basically. Dissatisfaction will improve if it fails in the dimensions what is provided by the customer ok.

So, customer wants this, this dimension which is coming from the voice of the customer. So, those are the CTQs which we are trying to emphasize over here and those are the CTQs we will try to improve ok. So, there will be some variables which are known as controllable variables over here and this can be changed.

This is in our hand basically. This is in the hand of the operator who is operating the machines, but there can be also uncontrollable variables over here, uncontrollable variables what we are seeing over here or uneconomical to control or maybe unknown variables which we are not able to locate which also influences.

Raw material, we can understand. Maybe supply to supply variation also we can understand, but there may be hundreds of variables which we have no ideas about in the process. So, there may be very minor effect of that maybe from previous process or any other any other thing. We are not able to look at that one.

So, those things which has little impact or if it impacts in that case we should be able to locate that one, but in case it is we cannot do anything about that those are known as uncontrollable variables or it can also be somebody can say noise variables. So, their impact is very less. So, in that case we are not so much concerned, but later on we will see that this also needs to be considered in making a product robust.

So, in that case that is also considered like. So, these variables are uneconomical to control and may be unknown, no information is there about these variables and even if information is there we cannot do anything. So, these variables we are not, but if you can control these things at least our output will be within the specification or whatever is required.

So, in presence of these variables, which cannot be controlled, which is known as uncontrollable variables, I need to set this machine over here with these parameters. So, that I get the Y, which is required which is close to the target over here which is close to the target that is our overall objective.

So, CTQ idea of CTQ in a process we can think of like this. There will be inputs there will be output, a product is coming out, but we do not measure everything out of the product. We only measure the CTQs which is important because CTQ will address the

voice. And then, how to improve the CTQs? In presence of some variable which we have no we have no ideas there can be sample to sample variation over here.

So, everything is there and in that case we have some control on some variables which is known as controllable variables and those things we will change in case there is deviation from the target values. What is defined by the customer we will measure and we will change the. So, at the start of the shift you will find that the this operators are changing the knobs.

If you go to the process at the start they will see one product what is the outcome and then they will see they will make some changes and then they will do some twist and turn the knobs or change the settings. So, this x 1 to x P what you are seeing is the controllable variables. These are the critical X, which you are which we are concerned about and this is the critical Y which we are concerned about.

So, basically if we know the functional relationship between X and Y then there is a favourable situation. So, I can I know the relationship. So, in that case where to change the X so, that I get the best buy so, but mentally sometimes shop floor operators you will find that they are doing it mentally basically ok.

They have something in mind. So, in that case how this parameter influence, how this x 1 variable influences the process and how it influences, why they have some ideas, so, which one to change, which one not to change. So, they have a strong idea about that. So, some does not have qualifications to understand optimization mathematical part of that, but mentally they are doing calculation and with experience they have some idea about if I change this variable what will happen to the Y.

So, that is inbuilt knowledge you can think of which they have, but overall this is the process scenario what you see. So, I want the CTQs to be to the target and for that what should be the setting that is our overall goal in a process. And for that input conditions will change input will have variation and there will be some variables which we have no ideas, but which have little impact ok, but that can be exploited also to understand the behavior of Y.

So that we will try to figure out in subsequent lectures, ok. So, this is all about this is the CTQ diagrams we can think of process diagram. You can think of this is one process this

manufacturing process. You can think of service process also. There will be some control variables there will be some uncontrollable or noise variables there will be certain inputs and there will be certain CTQs which is required by the customer.

It can be 8 dimensions in quality; it can be 5 dimensions of quality service quality. So, you can think of but we need to measure this one. CTQ whenever I have a CTQ I have a dimensions to measure, I have a specification spec to that is given for this and then I measure this one. And then what I can do is that I can check whether this within specification or whatever is the requirement of the customer and accordingly I will change the settings of this variables and. So that I get the best output ok.

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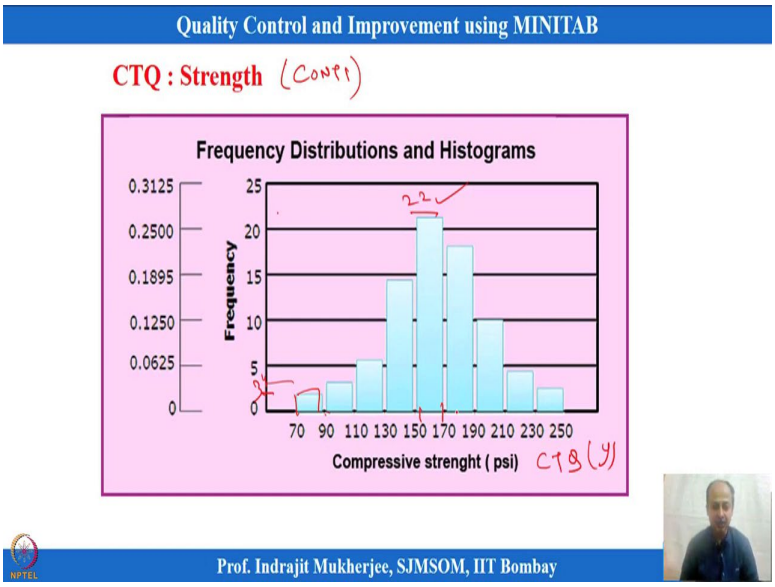

So, that is the idea what we are trying to emphasize over here. Now, CTQ can be strength what I have mentioned earlier ok and you may have done some basic course on statistics. So, the process outputs that is coming out of the process can be let us say 100 dimensions I have. 100 products I have measured and I measure the strength then I can plot that into diagrammatically I can represent that one. So, that is generally done. So, CTQ is one of the this is a continuous variable. So, this is a continuous variable.

So, this variable can be plotted in a chart which is known as histogram and in basic statistics you will you have already done that one and plotting of that is frequency is plotted as compared to the dimensions. So, this will be the CTQs. So, which is the Y measurement that we are getting over here and this is the number of times series comings

that observation. So, 70 to 90 if you can see the observations is around 3 observations are within this zone.

Similarly, 90 to 110 maybe this is 4 observations are within this. Like this is the highest what we are seeing. So, maybe 22 observations are over here which lies in the range of 150 to 170. So, this is the maximum frequency what you see. So, most of the observations are around 150 to 170. So, this plotting of the data that is coming out of the process or CTQs can be done using histogram if it is a continuous data type.

So, this is the this is one of the thing that we can plot this one. So, now, we are just trying to see, understand and visualize the things what is coming out of the process, can we measure that one and if we can measure that one can we see that one or visualize that one that is also important.

Because it is 100 times better one picture is 100 times better other than only seeing the data information because if I give you 1000 data points and you cannot visualize that one it is difficult to visualize in excel sheet if I give 100 data points. So, I need some visualizations tool. So, we are entering into that phase where we will use this visualization tool.

So, in our session 4, what we will do is that we will start with visualization. So, we visualization of the data basically. So, quality talks about visualization of the data. So, more data you will have. So, data and interpretation; it is not all about engineering, it is now about how do we interpret the data how we based on the data what action we take. So, that is important in quality nowadays ok. So, data will give you provide you information for decision making basically ok.

So, from engineering standpoint yes is required because you need to understand what specification is important, what is the CTQ which CTQ is important that addresses the voice. That conversion is happening at the design phase. If the design phase goes wrong everything goes wrong, but whenever I have a strong design I know the CTQs and then I have to improve that one.

So, in that case what is required to be done that we have to do in the process and then what we see that quality of conformance that is the second phase of our discussion. So, quality of design and quality of conformance, are we adhering to the specification that is

given by the designer for a specific CTQ ok? So, that will be our agenda for our next session, session 4. So, we will continue from here ok. So, in session 4, we will start with visualization of the data.

Thank you for listening, meet you in the session 4.