Design Practice
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Lecture – 11
Concurrent Engineering Approaches

Hello and welcome to this design practice module 11. So, we were talking about serial engineering earlier and now we would like to slightly take a detour into what would be the concurrent philosophy behind this design.

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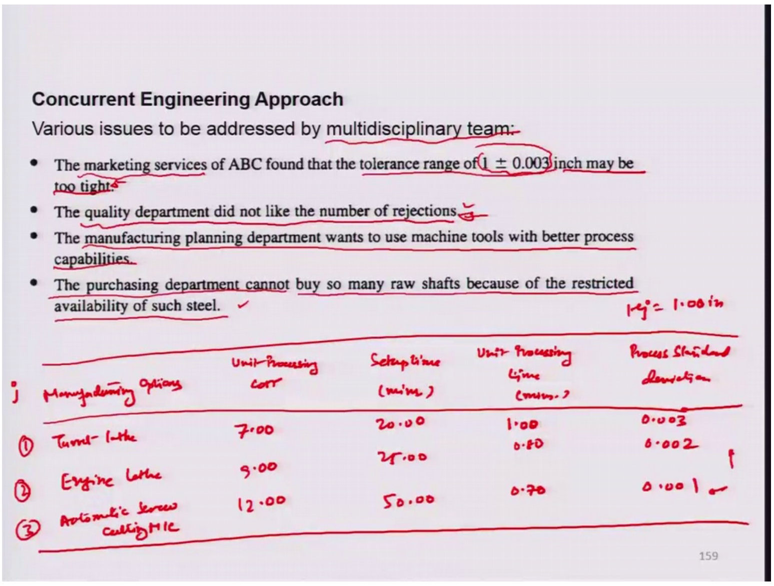

So, let us say in the concurrent engineering approach they there is a multidisciplinary team of people formulated out of all different departments, who are stakeholders in the process and there are several suggestions given for example, the marketing services a provides a suggestion out of their finding that the tolerance range of 1 plus minus 0.003 inches, may be too tight for the customer they really do not need this much tightening on the tolerance.

So, there is a certain slack that is given by the marketing service ; however, the quality department did not like the fact that the number of rejections were very high and the scrap level was very high. So, something needs to be done related to that at the very beginning of because of the change I mean you know because of flexibility of everybody participating, the design can be a mutual decision and. So, these all these inputs can be at the very beginning. The manufacturing planning department again wants to use the machine tool with better process capability.

So, I would like to give you some details about what other machines are available as options, we are manufacturing planning can have a span of control over not just limited to j equal to 1, but maybe j equal to 1 2 3 or 4 how many whatsoever number of machine tools they have? To check which one would be there which one of the machines would be able to give it a lower cost and also reduce subsequently the number of rejections. And then finally, the purchasing department gives a constraint that they cannot buy so, many raw shafts because of the restricted availability of such steel.

So, it is obvious that if this scrap is reduced than the total number of inputs would also be substantially reduced. In the serial engineering for example, you saw that for every 1000 pieces you make you reduce you waste about 465 pieces ok. So, this is actually a very big number and so, we can take a decision in a manner based on the span of you know different machines with different capabilities available as well as all these slightly slacking of the specification which is not the tightness is probably not needed or again aspects like rejection and inputs, to give a consolidated overall decision in this particular case, which will be better than what you did in the serial engineering case.

So, let us look at it. So, let us say we have a very basic data table which is used in this particular case, which is furnished by the manufacturing planning; which says that there are many options which are available to the manufacturing let us say there are the following manufacturing options. So, there is a turret lathe, which you have already tried on while doing the serial engineering approach. But apart from the antique manufacturing also the planning also sees that there are 2 more machines engine lathes and the automatic screw cutting machine, which could be used you know to give you a better illustration or better capability for processing the products.

So, some of the demand set in by the quality department or the purchasing departments could be as well met; although a a closer control on the manufacturing would mean a more stringent a tolerance range, which may not be that desirable as for the estimation done by marketing services based on the customer opinion ok.

So, let us say we have unit processing costs in all these machines which are mentioned here. So, the unit processing costs while turning on turret lathe could be envisioned as 7 dollars a piece or it goes slightly above when it comes to engine lathe, and then quite high when it comes to automatic screw cutting machine ok.

So, there is also an issue of setup. So, the setups setup times span over various ranges in all these different machines for example, in the turret lathe the set up time could be as high as about or as low as about 20 minutes ok. So, this is let say in minutes whereas, in the engine lathe it could go to about 25 minutes and then in the automatic screw machine, cutting machines for 50 minutes close to an hour. We also have data from the manufacturing planning related to the unit processing time of the components on these machines. So, they are not similar.

So, in turret lathe would be able to produce a component in for example, 1.00 minutes whereas, the engine lathe would be much faster it would produce in about 0.8 of a minute about 48 seconds and then again the automatic screw cutting machine would again be able to produce this is about 42 seconds about 0.7 of a minute. The process standard deviation for all these machines are also given. So, the process standard deviation while working on a mean size of about one, so you know that the mean you know the desirable mean for all these machines are about 1 inches as given earlier.

So, but the standard deviation of the processes are different. So, in the third cathe for third lathe case for example, you already know that the sigma j happens to be about 0.003. So, this is the j th manufacturing option let us say. In case of the engine lathe it happens to be 0.002 and in case of the ASN it is even more tighter control 0.001. So, this is the most precise machine the automatic screw casing machine which is available and this is the order of precision the order of precision sort of goes down as one goes from the j equal to 3 to j equal to 1 option.

So, therefore, the first concurrent engineering team meeting begins with all this information on board let us call it concurrent engineering team meeting number 1 ok.

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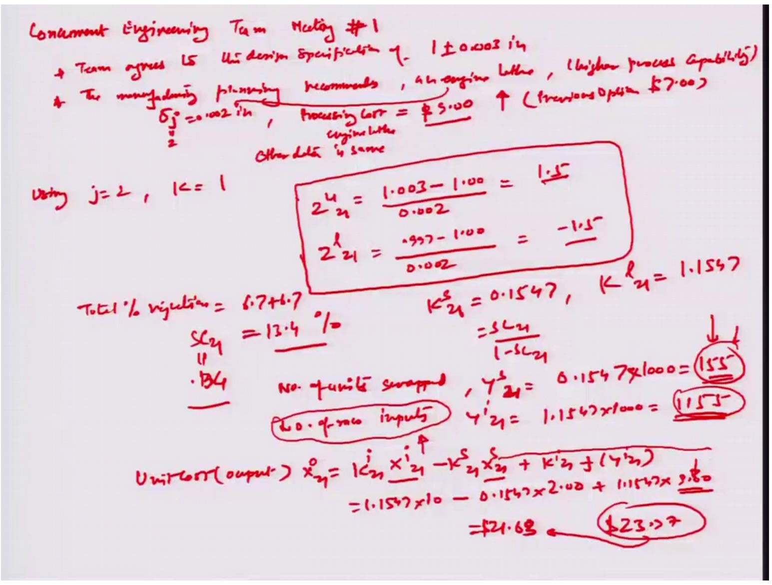

So, the team begins by agreeing to hold the shaft dimensions at the design specifications. So, the first decision taken by the team is. So, the team agrees to the design specification of 1 plus minus 0.003 inches and you know because everybody is working with the design in the team, if the manufacturing department recommends an engine lathe.

So, the manufacturing planning recommends an engine lathe which has a higher process capability as you have already seen in the table in the last slide, resulting in a processor standard deviation sigma j for the engine lathe to be 0.002 inches ok

So, that is how j equal to 2 option is poised; however, as you know that the processing cost is on an increase. So, the processing cost goes up to 9 dollars a piece from the previous 7 dollars. For engine lathe is 9dollars it goes up from the previous option which was 7 dollars a piece. So, this is what the differences other data is same.

So, all the unit costs etcetera can be assumed to be the same, and let us now calculate in this case what is the result of all this. So, let us say if we use j equal to 2 for the specification k equal to 1 the Z u 2 1 happens to be 1.003 minus the process mean 1.00 divided by 00.002. So, this happens to be about close to 1.5 and then the Z l 2 1 using the engine lathe over the specification 1 set 1 is exactly 0.997 minus 1.00 by 0.002 that is actually equal to minus 1.5ok. So, that is how you have the upper in the lower specification limits set in. So, if I looked at again the 1.5 number in the normal distribution table.

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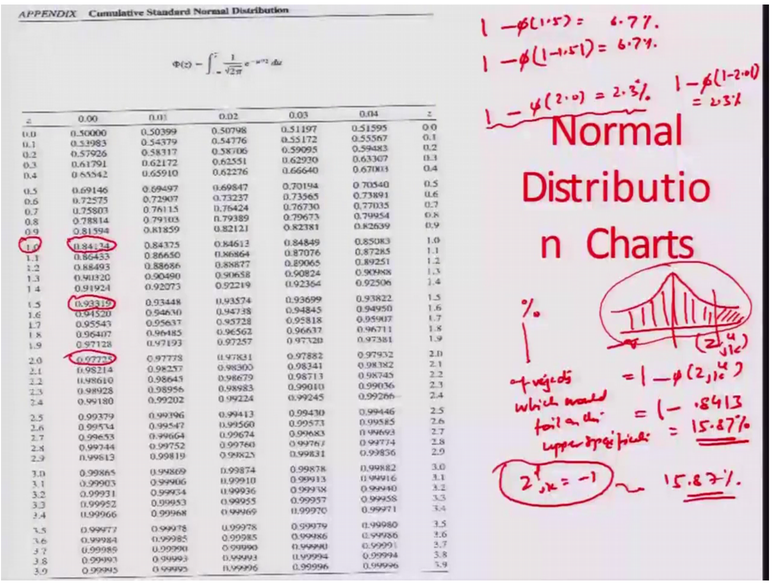

1.5 number corresponds to plus 2 about you know 0.9311 which means that 1 minus phi 1.5 should be typically about 6.7 percent and similarly 5 minus 1 minus phi modulus of minus 1.5 is again 6.7 percent in total we have a rejection of 13.4 percent

So, let us look at the total percentage rejection to be 6.7 plus 6.7 on either side of the mean so the upper and the lower specification side. So, about 13.4 percent so; obviously, the K s to 1 in this particular case would be 0.1547 and similarly the K l 2 1 should be equal to 1.1547 you already know this is equal to the s c j k by 1 minus s c j k in this case we are talking about the second machine on the first specification. So, s c 2 1 which is actually this number right here 0.134 13.4 percentage

So, having obtained this we accordingly find out what are the number of units scrapped in this particular case on the suggestion of the manufacturing planning, which is involved at the very beginning. So, the number of the units scrapped here in this particular case are about close to zero point or or 0.5 1547 times of the output level 1000, so about 155 ok. So, this is much lower number than the 465 earlier as you see. So, the number of raw inputs which are needed here Y i 2 1 are again 1.1547 times 1000. So, it is about 15 you know approximately 1 1 55 which is up you know which is quite lower than the 1465 number earlier. So, we are making the number of inputs lower. So, that the purchase department is happy because the purchase says that input should go down and similarly because the retakes are lower quality is slightly happier that this particular machine may be proving out to be a better options, because it has only a reject of 155 a supposed to 465 in the earlier serial engineering case.

So, already with the first step of concurrent engineering, we have been able to check to some extent the quality and let us look at the cost here. So, the unit cost if I were to calculate for this particular output is going to be given by x 0 2 1 which is K i 2 1 times of X i 2 1 minus K s 2 1 times of X s 2 1 plus K i times K i 2 1 times a function of Y i to 1 which is going to be equal to 1.1547 times 10 minus 0.1547 times of 2 these are the unit cost of the scrap and the unit cost of the input units plus 1.1547 times of 9 dollars this is what the additional increases in the price and in this case the price goes up to 21.63 dollars.

So, in comparison to what was earlier which was actually 23.97 dollars in the serial engineering you still see that there is a decrease in the price of the output you know even though the number of you know the quality biometrics has improved and even though the processing cost is higher in this particular case, because you know the number of scrap coming out of the process is drastically improved because of which all the additional cost which was being packed up in the turret lathe is now gone and it is being estimated as a better process control even though a little expensive processing cost wise, but much much better on the scrap cost side. So, we are going to now do another iteration for another set of meeting for taking a decision related to the quality and the purchase requirements.

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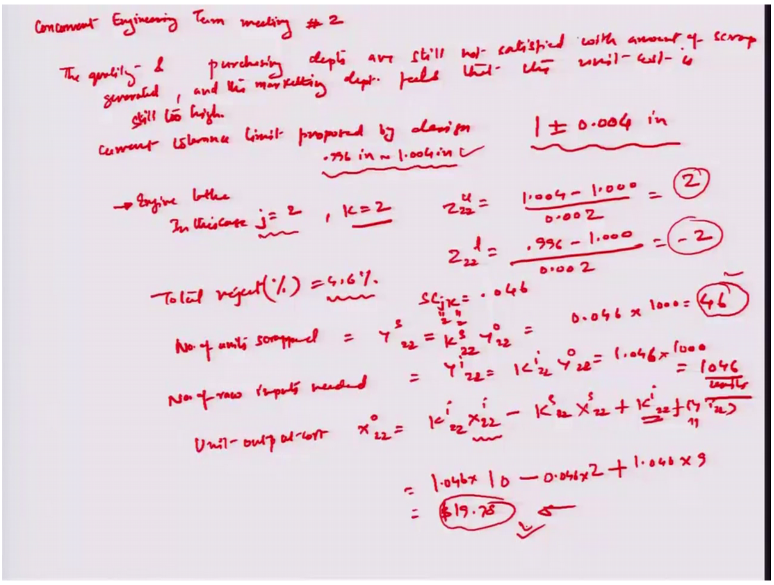

So, let us call this the concurrent engineering team meeting 2. So, as indicated earlier the quality and purchasing departments are still not satisfied with the amount of scrap generator, and the marketing department feels that the unit cost is still too high. So, some other alternative solution needs to be arrived at which will probably get in this meeting.

So, as a consequence of this feedback from marketing, the design engineers are able to come to a conclusion that the customer requirements in this particular case can be met with a little bit slack tolerance limit. So, the current tolerance limit proposed by the design is keeping the customers viewpoint of not so, finicky about the tolerance limits as shown earlier. So, they assume the new tolerance limits to be 1 plus minus 0.004 inches meaning thereby that the acceptable range now goes between 0.996 all the way to 1.004 inches this is the acceptable range of tolerances.

So, the team now explores this scenario, they consider the component tolerances to be in this current range and again you know the manufacturing wants to produce the same using the engine lathe, because the engine lathe has the right kind of specifications for again handling the very same you know in a very same manner as before as was calculated in the team 1 meeting as an as an output.

So, let us talk about in this case j of the second kind second machine that is engine lathe and even the k of the second kind which is because you know now the tolerance has changed from 1 plus minus 03 0.003 to 1 plus minus 0.004 on the insistence of marketing because they understand that the customer is really not so, finicky about the tight tolerance, which has been proposed by the design in iteration 1.

Other aspects of the data pretty much remain same we would like to find out again what are the costs here in this case for example, the Z variates for the new you know 2 2 let us call it 2 2. So, Z 2 2 upper happens to be 1.004 minus 1 divided by 0.003 sorry this is 2 you know because that is what the standard deviation is in case of the engine lathe, and similarly Z 2 2 l happens to be 0.996 minus 1.000 divided by 0.002

So, this comes out to be about 2 and this comes out to be minus 2 and with all this in mind with 2 in minus 2 in mind, when we talk about the percentage rejects again if we can go back and have a look at what would be the rejects in this particular case with 2 on board we have about almost 0.977 2 5, which means that you know 1 minus phi 2.0 board in this case be about close to 2.3 percent, and for the left hand specification it says again you know 1 minus phi of modulus of minus 2.0 which happens to be again another 2.3 percent; so in about 4.6 percent of the total rejects or total items are being rejected.

So, the total reject as in this case happens to be about 4.6 percent and with this on board we can again calculate the scrap fraction to be 0.046 and find and similarly the number of units scraped to be y s we call this 2 2 because j is 2 and k is 2 in this particular case which is equal to the technological coefficient for the scrap times of the real output which is 0.046 times 1000 approximately 46 components. Ok. Similarly the number of raw units or raw inputs needed in this case would actually be equal to Y i 2 2 which is equal to K i 2 times of Y 022 1.046 times of 1000 which is 1046 units.

So, in this case as you see compared to the previous case, where we were generating something like 150 hundred and 155 additional units here we are only generating about 46 units. So, the scrapper substantially come down making the quality department quite happy in this particular iteration.

So, if I wanted to again calculate the unit output cost in this particular case which is X 0 2 2 it could be represented as K i 2 2 times of the unit input cost minus the technological coefficient of the scrap for the situation 2 2 times of y x is x 0 or x scrap 2 two that is a unit salvage value times K i 2 2 times the processing cost. So, you know that in the engine lathe processing cost.

So, we have the technological coefficient of the input here which is 1.046 times 9 dollars plus minus of the technological coefficient of the scrap 0.046 times of the salvage value per unit which is about 2 dollars piece of scrap cells are 2 dollars apiece is given plus that of the input again 1.046 times of the input price per unit which is about 10 dollars. So, this happens to be around 19.78 dollars.

So, the price of the production per unit or the output price of such a system is going to be much lesser in comparison to that, which was reported earlier in case of meeting 1 or even the serial engineering where in one case it was about 23 dollars and it reduced about 21 dollars. So, you are going to reduce this way in step by step.

We will also look at a few more aspects as we go along where we should be feedbacks from again the market as well as the quality and the purchase department, but we will try to in the interest of time close this particular module. And the next one you will we will again see what when we meet again as a concurrent engineering team for maybe 2 or more times, there is going to be a substantial improvement. And then finally, we do a comparative of what serial engineering versus cognitive engineering would have in respect of each other.

So, with this I would like to end this particular module.

Thank you very much.