Design Practice
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Lecture – 10
Concurrent Engineering part-2

Hello and welcome to this design practice module 10, we would talking about concurrent engineering and we in context of that. So, how you know you could have a series of machines and plan for a certain specification on a certain machine. So, we started using normal distribution, and tried to estimate the perceptive, n a system of specifications which is earlier defined.

And then, the idea was that could we do everything in terms of a cost term, and try to find out that if there is a under capable machine that, how the costing of an a component gets influenced, or if there is an over capable machine then are we making a mistake in, you know or the cost overall cost by putting up more processing cost then, what is really needed for the specifications to be obeyed or followed?

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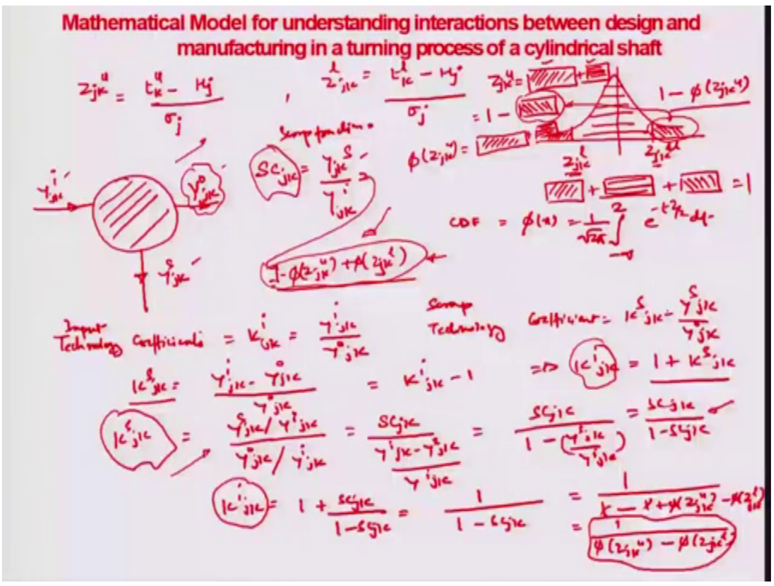

So, in in context of that we had already in one module, talked about the Z variates and the normal distribution and there for the jth process , over which we would make a specification of machine, a specification which is of the kth kind for the upper side. We would have a Z variate corresponding to the tolerance limit, given on the upper side minus the process mean, divided by the process standard deviation and similarly the Z variate for the lower side, would turn up to be the lower tolerance of the case specification, minus the process mean for the machine divided by the standard deviation for the jth machine.

So, having said that we had already looked into the aspect of, if these Z values are plotted, in this particular normal distribution, anything to the left or anything to the right of the Z values are considered to be reject and in context of that, we had already made a statement saying that. All these 3 shaded areas would typically add up to have 1, particularly if it is normal if it is a standard normal variate ok; which is scaled up by sigma which actually these are and so, this would typically sum it or you know total or add up to about one or 100 percent of the components.

So, in context of that also we had recorded that the, total fraction of the scrap of the kth specification to be machined on the jth machine, would then be found out as the ratio of the total number of scrap, going into the transfer or coming out of the transformation process given a certain input level ok. So, let us say if there are exactly why I components coming into the transformation process, which would actually obey the kth specification, which would be developed on the jth machine.

And Y s j k coming out as crap and similarly, Y o j k coming out as the output so; obviously, this scrap ratio then or you can say scrap fraction S c j k then, can be ratio between the input and the output input in the scrap, and that is Y s j k by Y I j k and this was represented through what are the process rejects. So, basically, we would typically look at you know the area under the curve up to the Z variate here which happened to be the cumulative distribution function CDF, which is actually 1 by root over 2 pi integral from minus infinity 2 the values and Z could be either this value or this value ok, E to the power of minus T square by 2 DT.

So, that is how the scaled distribution would work, context of that the total amount of rejects of being towards you know unable to meet the upper specification, would be 1 minus phi of Z j k u, simply speaking the Z j k u in this particular case would be, the summation of both the areas like this area as well as this area. So, this would further be 1 minus the area here shaded like this, which is actually at this particular corner which is exactly what I am talking about here 1 minus. So, phi of Z j k u would actually be the summation of these so, 1 plus 2. So, phi of Z j k u can be represented as the area here, plus area here and we are talking about 1 minus that which is actually this much, which is this area. So, exactly that is you know the reject because of not unable to meet the upper specification limit. So, here this comes out to be equal to phi of a 1 minus phi of Z j k u plus phi of Z j k l, that is how you divide or define the scrap coefficient.

So now let us suppose we want to create everything in terms of the output because; obviously, a better mapping of this transformation process would be hinged about the output, because output is not really changeable. It is dictated by the requirement of the next process. And so, if the next process has a certain level of output that it needs as input then you really cannot change that. So, let us actually develop certain ratios or we call them in in a little more, complex terminology as technology coefficients ok, and we call these technology coefficients to be ratios between the various, you know different quantities of materials, or pieces of materials which emanate into or away from the you know the transformation process.

So, let us say if there is an input technology coefficient for the jth machine on processing the kth specification, we would define this as the ratio between the input and the output ok. So, it is mapped now in terms of the output similarly, if I just you know develop. So, this is called the input or this is assumed as the input technology coefficient, similarly I can develop a similar kind of technology coefficient for scrap, mapping everything in terms of output again.

So, this happens to be K s j k which is equal to Y s j k by Y 0 j k so; obviously, there is a interrelationship between these, because if we what to talk about K s j k, this happens to be the input minus the output, that is how the scrap is ok. And in in other words I can call this to be the input technological coefficient minus 1 or in other words the input technological coefficient for the jth machine using or processing the kth specification to be a submission of the scrap technological coefficient, in the similar situation plus 1.

Similarly, in the case of you know let us say K s j k, if we wanted to evaluate this this of course, is as you know the map of Y is j k with respect to the output. So, if I divided it on the numerator and denominator both by, you know the input number of materials which go into the transformation process, I should be as well able to represent this in terms of the scrap fraction, which was calculated earlier from the normal distribution. So, without doing any real experiments again, if I knew just how what what is going to be the process mean and the standard deviation and also what is going to be the tolerance, I should be from a normal table just glance and look at this particular value which is percentage reject.

So, let us calculate this in a little better manner. So, this happens to be the S c j k, which is actually Y s by yi from the last step and this again could be recorded as Y I j k minus Y s j k; obviously, input minus scrap is the output per unit the input material. So, we can record this as 1 minus Y s j k by Y I/ j k, or in other words this can be recorded as S c j k by 1 minus S c j k. So, we can actually calculate the scrap coefficient by looking at normal tables finally, the input coefficient from this crap coefficient by using this relationship that is all what we have to take care of.

So, in this event K I/ j k also is represented as, now the 1 plus K s j k. So, it is 1 plus S c j k by 1 minus S c j k, other words it is 1 divided by 1 minus S c j k which is equal to 1 by 1 minus 1 plus phi of Z j k u minus phi of Z j k l ok, in other words it is 1 divided by phi of Z j k u minus phi of Z j k l. So, that is how you represent everything in terms of what you obtain from the normal distribution, including the K s and the K K I/. So, once this is done, let us actually put together in terms of what would be the material balance equation as finally.

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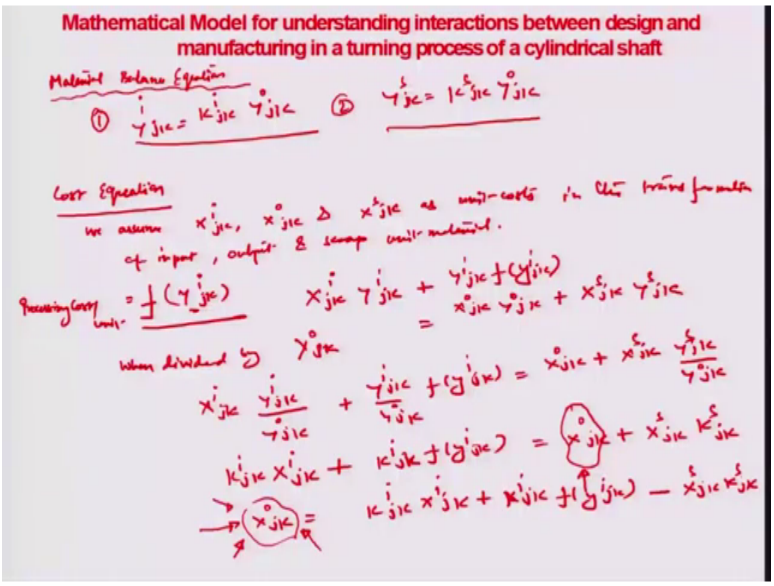

So, material balance equation in this particular case, happens to be the input material is represented again in terms of the technology coefficient, times of the output material. So, this is how our mapping with respect to the output and similarly, the scrap material is represented in terms of the scrap technologic efficient times of the output material ok. So, this is how the scrap material is recorded and with all this material balance happening, if I wanted to put everything together to develop a cost equation, I should finally be able to evaluate everything in terms of what is the impact on the cost of production, of a particular specification to be manufactured on a certain machine.

So now let us assume some unit costs. So, we assume X I j k X o j k and X s j k as unit costs, in the transformation process of the material. So, this is per unit material cost per unit material of the input, output and scrap unit material, further let us assume that somewhere around you know, there is a cost of processing which is also dependent on the input level and I think all of us, are aware that if the input increases to a process and the overheads get distributed among a greater number of inputs, the cost goes down ok. So, there is a function of the input material, which we can assume as the processing cost per unit in this particular case ok.

And therefore, the final cost equation which would roll out, which will just create a cost balance, would be that whatever cost happens on the input side mainly X I j k per unit price, of the input times the input number of materials plus you know the number of input materials times of the processing cost, that would go into making this, this would be equal to the output unit price times, number of units of output plus, scrap unit price times of the number of units of the scrap j k.

And so, when we divide by Y 0 j k in this particular case, we are left with again everything in terms of the technologic coefficients, this is the input technology coefficient, plus we have Y I j k by Y 0 j k again the input technology coefficient times of the processing cost of the input, and that is equal to the unit price of the output times, of the unit price of the scrap times of the scrap technological coefficient.

Thus, we are left with an equation K I j k the technological coefficient of input times of the unit price of the input plus, again K I j k technological coefficient of the input times of the processing cost of the input ok, happens to be equal to the unit cost of the the output, plus the scrap unit cost times technological coefficient of the scrap and this is what is our concern here, that what would be the influence on the output price. So, I should be able to get an output price X 0 j k by looking at the other part of the algorithm here, K I j k times of f Y I j k minus of X s j k times of K s j k.

So, I would now have a comparative of cost between different, you know processors and different specifications, that we to use in order to choose 1 which would be operational at optimum cost ok. There are other factors also which are important for example, in this case if there are variety of capabilities of machines, which are there I should be able to find out which machine produces more or more waste and may induce a quality problem, or you know in you know it can also give you an idea about if supposing, there is a manufacturing lead time associated with each product, which is in place the ratio between the output in the scrap, would kind of be deterministic off what is going to be the extra time, that is needed if you produce on a one machine visible the other.

So, all these decisions then based on the business environment, or on this parametric space when the business environment could be looked at very easily, to take a realistic decision and. In fact, in concurrent engineering what we do is that when the decision is from day 1 a decision taken together, with all departments on board like quality or finance or after sales service or even the production guys you can actually very easily optimize, the cost from the very beginning.

So, that there is a consolidated opinion about, what machine could be used for what particular specification set. So, I think we will now start the problem right away, for this concurrent engineering approach and I would like to again relook at, first the serial engineering example, and then compare it with what would be the benefits if we can do it in the seaway or the contour engineering way.

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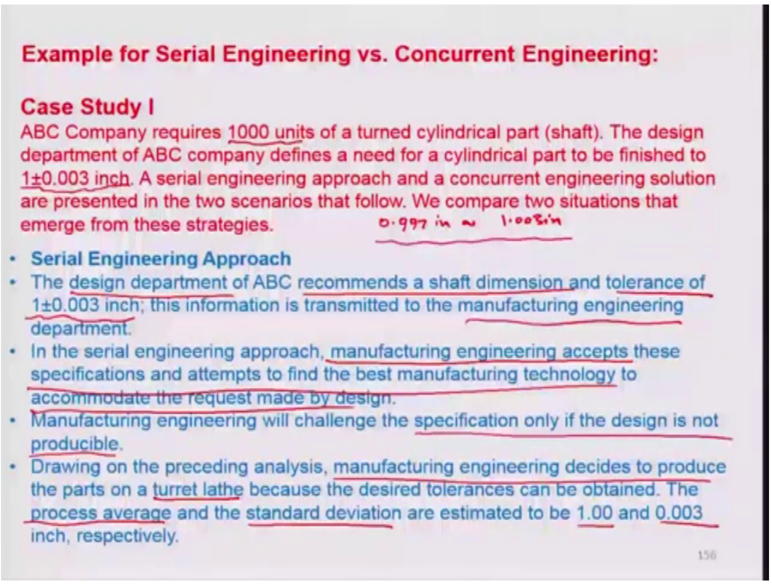

So, let us look at the serial engineering example first, I think I had just mentioned this, in context of which we had started this cylindrical part, turning and fitting 2 different machines, and the transformation model that we discussed in the last few slides. So, there is this company which requires about 1000 units of turned cylindrical part and the design department suggests the need for a cylindrical part to be finished up to an extent of, 1 plus minus 0.003 inches meaning there by that the specifications which would be there start from 0.997 inches to about 1.003 inches ok.

And in the serial engineering approach, is the design department of the company which recommends the shaft dimensions and tolerances at the outset ok, and this information is now transmitted to the manufacturing engineering, in the serial engineering approach the manufacturing engineering accepts first, there is no other choice because they have to accept the design will start evaluating their specific their capabilities.

And so, once they accept the specifications and attempt to find the best manufacturing, technology to accommodate the request made by the design, you know they can only challenge when the specification in the design is not producible at all. You know with the facilities that they would have, and if we in this particular stage, try to find out the right fit of whatever they have, as you know alternatives we could actually get a very good picture of, what is the level of cost or output cost? That would come out.

Because, they may have an option of a certain machine, which is amenable to these specifications which have been sent out whereas, in the see example you will see that at the very beginning, they may influence in changing the specification slightly, where their overall cost component may go down substantially, because they have the right fit or right fitting machine which would produce almost 0 scrap.

So, drawing on the preceding analysis the manufacturing engineering decides to, produce the parts on a turret lathe, the specification of the turret lathe I will just give, and you know these specifications that they find out of the turret lathe from their standard sheets, are a process average of 1.00 and a standard deviation of 0.003 inches respectively.

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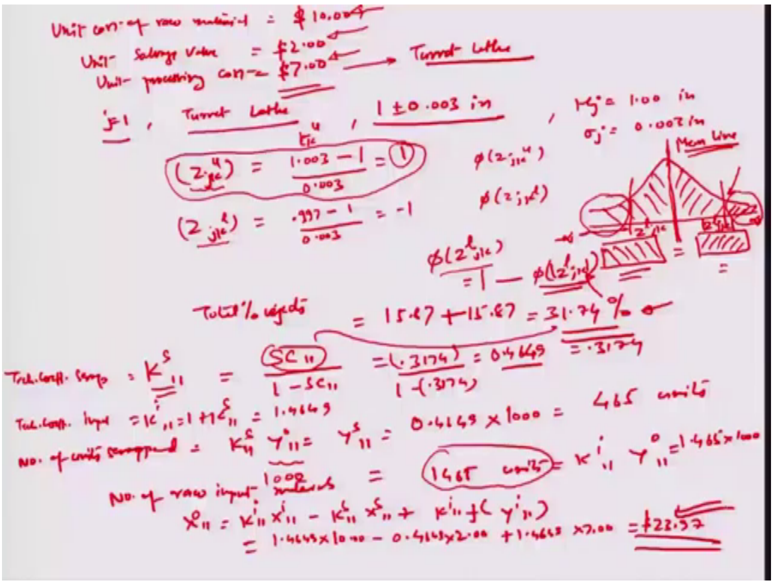

So, let us look at by assuming certain unit costs you know of the raw material, for example in this case let us assume the unit cost of raw material to be, about 10 dollars per piece ok. The unit salvage price the scrap cost to be about 2 dollars per piece and the unit processing cost to be about 7 dollars a piece.

We already know that, there is only j equal to 1 option, which is available because they have made up their mind on the turret lathe, they do not have any flexibility on the change of specification, it has already been designed by the design department and given as the only option ok. So, j is 1 in this particular case and we assume a tolerance that has to be produced in this particular shaft as an engineering requirement from the design to be 1 plus minus 0.003.

So, in this particular example, as you have already seen the mu j value which is being found out by the manufacturing engineering, in the turret lathe happens to be about 1.00 inches, and the sigma j value of the turret lathe happens to be 0.003 inches. So, we find out what is the Z variate. So, again the Z variate for the jth machine and you know this is the first machine and maybe the first specification, the upper tolerance limit here is 1.003. So, that is how the T T K U is in this particular case, minus the mu j divided by 0.003. So, this happens to be about 1, similarly the Z j k I value happens to be again 1 minus or or 0.997 minus of 1 divided by 0.003. So, this supposed to be minus 1 in this particular example or in particular case.

So, we then go to the normal tables, to have a look of look out as to what corresponding cumulative distribution function would be, corresponding to this value as well as you know the other value here 1 is negative so; obviously, we would try to make an assumption here, that because as we know that the normal distribution is a sort of a symmetric distribution, the area on the left and right sides of this curve is exactly equal to each other ok. So, this area is equal to this area right here.

So, if I wanted to let us say find out, what is the cumulative distribution function? Here from minus infinity all the way to let us say, Z l j k in this case Z l j k be negative, it could be same as the cumulative distribution function from Z l j k or Z l j k being plotted here, with the modulus to infinity. So, this area right here and this area are all the same because, you can fold the area, to superpose to exactly each other among the mean line the mu j line here, or let us say we call it a mu mean line here ok. So, you can exactly superpose both the areas as as as have been shown.

So, essentially if I am trying to find out what the phi Z l j k is, it would be amounting to finding this out in terms of 1 minus the phi of Z l j k modulus, which is being plotted on the right, just in the case or just in a way we had earlier done about those which would not the components, which would not meet the upper specification in the same manner. So, you can always refer to the positive you know Z l j k value and go back to the normal tables and read and I am going to now go ahead and tell you how to read this, from the table. So, we want a Z l Z u j k value of 1 to be read and then, we do 1 minus that value because, the modulus of Z l j k in this case is modulus of minus 1 is 1.

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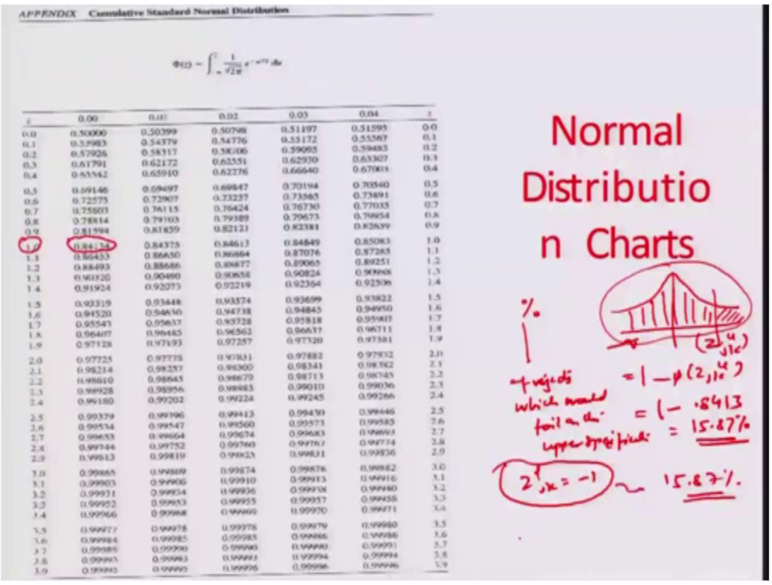

So, let us go to the normal tables, you see in this particular case for a Z value of 1.0, there is a area under the curve which is being reported as 1.0, Z is with the CDF of 0.84131 ok. So, the percentage now let just let us go by what we are looking at in the normal distribution curve. So, we are essentially trying to find out, what is this area? And we do that by subtracting the area which is actually the cumulative distribution function between infinity and Z u j k ok. So, 1 minus that so, because the total area here is 1 as we had earlier explained. So, 1 minus phi of Z j u k is or Z j k u is what we are actually interested in. So, this is the percentage of rejects, which would fail on the upper specification.

So, in this particular case it is 1 minus of 0.8413. So, close to about 15.87 percent, is what would typically fail the upper specification limits in our; you know example problem, because this Z l j k is minus 1. So, in that event the Z l g k would again have the same 15.87 percent value, for obvious reasons which I have elaborated earlier. So, therefore, the total number of rejects, in this particular case I am sorry. So, in this particular case, the total percentage rejects which would happen should be equal to 15.87 on the rejects, because of failing to meet the upper specification plus, 15.87 on the rejects to meet the lower specification. So, around 31.7 of the component; so 31.7 percent of the components are completely rejected ok.

So, if we looked at this number and try to calculate the cost, given all these unit prices I should be able to get a ballpark estimate of what is going to be? The scrap value and what is the unit price. So, for in this particular category let us say if we wanted to calculate the technology coefficient, for scrap for the first process in the first pacification, that we are considering it would be in terms of S c 1 1 by 1 minus S c 1 1, you already know this S c 1 1 number is 0.3174 from this total percentage rejects. So, the case 1 1 happens to be 0.3174 by 1 minus 0.3174, which is actually equal to about 0.4649 that is how the technologic efficient of scrap is ok.

So, let me just call it tech coefficient scrap, similarly the tech coefficient input in this particular case is going to be just 1 plus that number the scrap number. So, K I/ 1 1 is 1 plus K s 1 1, you already seen the earlier specifications. So, this happens to be about 1.6499 and similarly, the number of units which are scrapped in this particular case happens to be the K s 1 1 times of the Y o 1 1 similar, to what you would have is the number of units crafts Y s 1 1. So, this happens to be 0.4649 times of the output which is at a constant level of 1000, remember at the very beginning we have requirements of 1000 units to be produced in terms of turning a cylindrical shaft.

So, you are wasting around close to 465 units for producing about 1000 units ok so, the number of raw inputs, which are needed in this case. So, number of raw input materials happens to be, about 465 units you can also do it as K I/ 1 1 times of the output ok. So, 1.465 times of 1000 and therefore, the total cost which comes out in this case of the output that is X o 1 1 could be recorded as K I/ 1 1 X I/ 1 1 minus of K s 1 1 X s 1 1 plus K I/ 1 1 times of the processing cost, which in this case has recorded by the manufacturing unit, is about 7 dollars in the turret lathe. So, this is the cost for the turret layer, now these values have to be studied and determined by on the various different machines which are available.

So, in this particular case then the x o or the total output cost comes out to be, 1.4649 times 10 minus of 0.4649 times of 2.00 plus 1.4649 times of 7 which happens to be 23.97 dollars. So, this is the unit output price which comes out because, the manufacturing does not have any option, but to use the turret lathe with a certain process capability. So, handy manufacturing caught on the flexibility to extend the design to slightly, you know better or lesser specification limits and then the quality would not have mind that or the finance would not have mind that. So, the decision could have been at the very initial phases just as a concurrent approach normally goes.

In this particular case also, you could do a reasonable amount of cost saving and improvement of quality. So, that is what the defect is behind the serial engineering process of having to work on a design given or forced to, work on a design given without having a say in the design itself.

So, I am going to now sort of change gears and in this particular lecture, I would like to end it here because of the time, but in the next lecture we would look at a concurrent engineering approach and then we will try to see, how the cost as you could see, here could be overall lowered because everybody put their brains together from the design phase itself. So, with this I will end this particular lecture.

Thank you very much.