Manufacturing Systems Management
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Lecture 34
Statistical Fluctuation, Random events, Principles of SM

We continue the discussion on Statistical Fluctuation.

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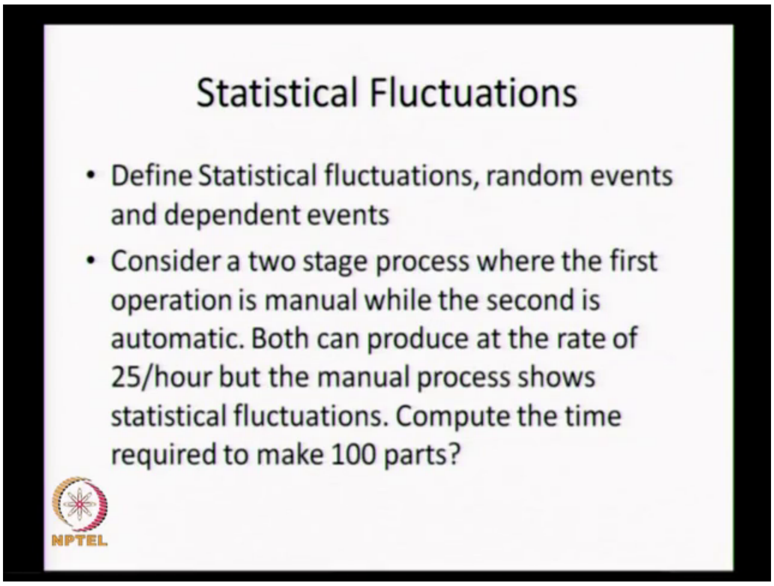

In the previous lecture, we define statistical fluctuations, random events and dependent events.

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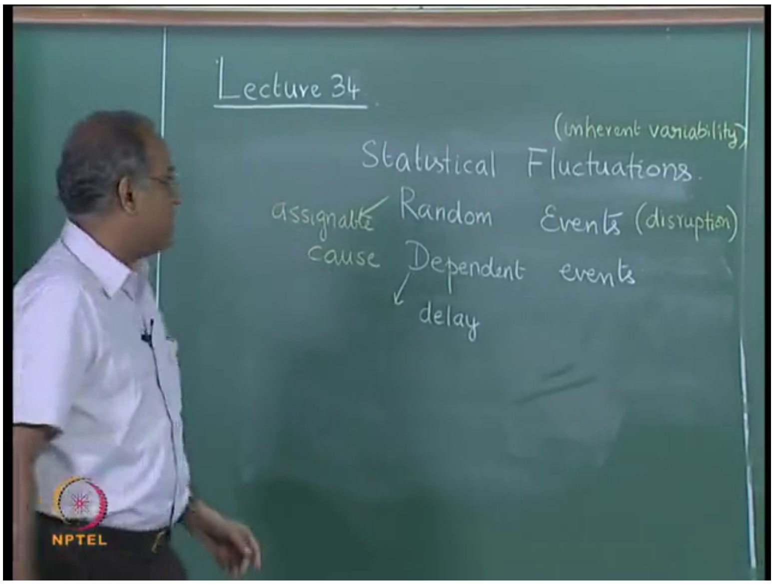

So, statistical fluctuations are result of inherent variability in the system and they essentially cancel out each other with passage of type. The variation is also very less and many times they cannot be explained or assigned to a specific cause. When the variation or when the effect is assigned to a specific cause it is called a random event. So, random events always have assigned or assignable causes and random events create disruption to the process that is actually happening.

Now, we have the third one which is called dependent events, so dependent events in the particularly in the context of dependent events the ability of the statistical fluctuations to cancel out each other does not happen when we have dependent events. So, let us look at a simple example to understand the effect of statistical fluctuations and dependent events and also try to understand what happens if a random event comes in. So, consider a 2 stage process where the first stage is manual and the second stage is automatic both can produce at the rate of 25 per hour, but the manual process shows statistical fluctuation, compute the time required to make 100 parts.

So, let us look at something like this let us call these processes as A and B. So, A is the manual process and B is automated.

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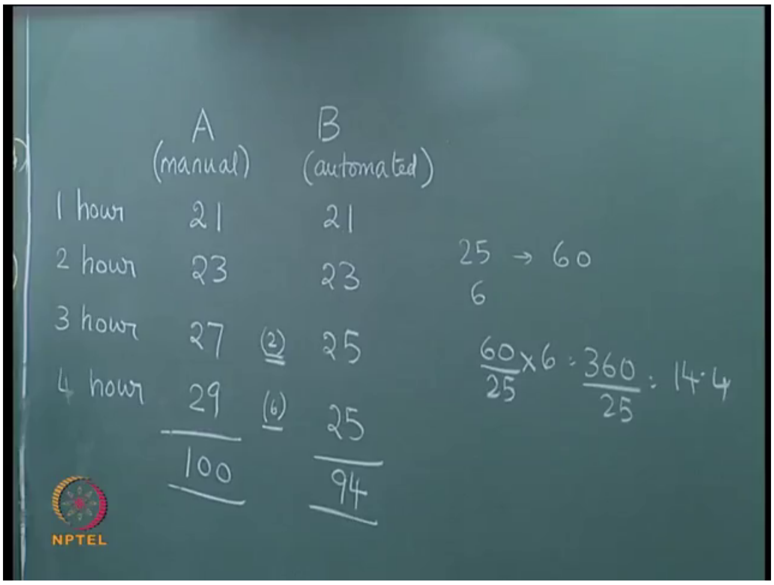

Now we have to produce 100 parts. So, it is customary to say that A which can produce at the rate of 25 units per hour will require 4 hours while B which can produce at 25 per hour would also require 4 hours. So, let us say that how much time it can take to make this 4 hours and let us assume for a moment that A and B are very physically located close to each other and one piece can move from A to B.

So, we will assume that in the first hour A is the manual process and the person who does the manual work does say 21 pieces in a first hour can do 25, but then you do some fluctuations and the person is slow the person is able to 21 per hour. Now in the first hour this one receives 21 from this the automatic process can do 25, but it has received only 21. So, it will do 21 at the end of the first hour.

Now, we look at the second hour now let us assume that this person now knows that he has be he has been little behind now due to any assignable reason, but has just been a little behind and let us say this person does 23 pieces in the second hour. Now the automatic machine will receive 23 pieces, but it can do 25, but since it has received only 23 it will do 23. Now in the third hour this person has been doing it for some time. So, this person now gets used to it and can do slightly faster. So, let us say this person does 27 in the third hour.

Now, this receives 27, but it can do only 25. So, it will do 25 in the third hour and there will be some inventory that will be waiting here. There will be an inventory of 2 here at the end of the third hour. Now the person knows that he has to finish the job. So, this person goes slightly faster and does 29 in the fourth hour; now this can do only 25. So, it does 25 and there is an inventory of 6 that is remaining here between these 2 at the end of the fourth hour. So, now, we go back and check that this process has finished 100 in 4 hours, but this has finished only 94 in 4 hours even though it is capable of doing 100 within 4 hours.

Now, the extra time that is needed is this can do 25 pieces in 1 hour. So, to do 6 pieces it will do 25 pieces in 60 minutes. So, it needs times for extra 6, so that will become 60 by 25 into 6 which is 360 by 25, 110 14 za 100 then 14.4, extra minutes is required. So, in 4 hours and 14.4 or 15 minutes it will be done.

Now, there are some assumptions which we will clarify in this example the first piece will come to the second machine after a few minutes, but luckily it has a capacity of 25 therefore, it can absorb that little delay which would have happened for the first piece to come. So, this will not be affected by it. In a similar manner this will not be effected by it here it is more. So, it will be taken care the only place where it can be effected a little bit is actually here it has this there will be a slide delay for the first piece to come in which we are ignoring right for the purpose of computation. We are not looking at a situation where these two machines are far away and there is a batch transportation every 1 hour in such case it will need 5 hours, it will not need 4 hours because the first batch the first hour the automatic machine is idle it can start doing only from the second hour. So, it will require 5 hours in such a situation we are not looking at that situation in this example.

Now, the lessons from this example is most of the times when we do the scheduling we would have given 4 hours for this and 4 hours for this, we would not have given 4 hours and 15 minutes for this. So, automatically schedules get delayed now this is an example of dependent events and there is a delay for no fault of this, this is capable of doing 25 per hour if properly fed. So, because of the dependency this becomes a bottleneck and in our terminology that we use this becomes a CCR; it becomes a capacity constrained resource because it is unable to meet its demand due to some other reason.

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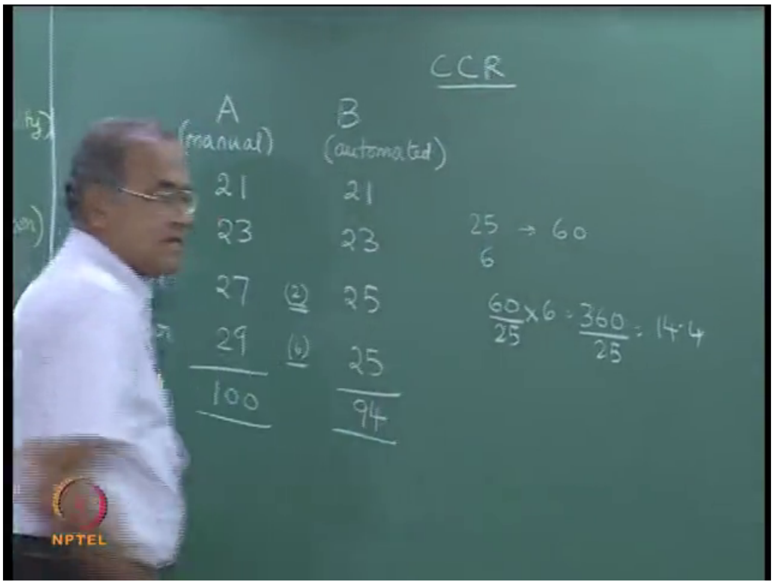

Now, the effect of dependent events can be understood here the effect of statistical fluctuations can be understood. Now this can be seen as a statistical fluctuation 25 plus minus 4, we cannot assign it to any specific cause we cannot even say that at the beginning the operator is expected to be slow afterwards the operator will become will do it faster and so on, but other than that there is no assignable cause. So, statistical fluctuations cancel out each other their variation is small, but dependent event creates disruption and delay and manufacturing is made up completely of dependent events because the products move through multiple machines and so on. So, we may be able to absorb the statistical fluctuations with respect to a single machine, but with respect to the dependency we will not be able absorb the statistical fluctuation.

Now, second we could counter this by saying if the first operation was the automatic operation and the second operation was the manual operation then these calculations will show that both can actually do 25 per hour whereas, if the first one is manual and the other one is automatic then we have this. So, this leads us to a very interesting situation as to where do we automate in a manufacturing process. Many times we automate a process which is time consuming, many times we automate a process which is which is which requires a lot more precision, but many times we do not consider the position in the sequence sometimes position in the sequence also matters when it comes to automation.

Third lesson from this example is that this is a this is typically an example of partial automation while we got this done very nicely through automation with no variation and it can do 25, the real effect is not gained by automating here because of the dependent events and the presence of a manual operation in before the automatic one is still causing disruption in spite of the fact that this has been streamlined. So, this emphasizes the need for total automation and not partial automation.

The last one is we have not seen the effect of a random event now if there is a random event and if for some reason this person in between is not available for 30 minutes or there is the machine break down for 30 minutes, then we will quickly understand that this 23 would have become some 10.

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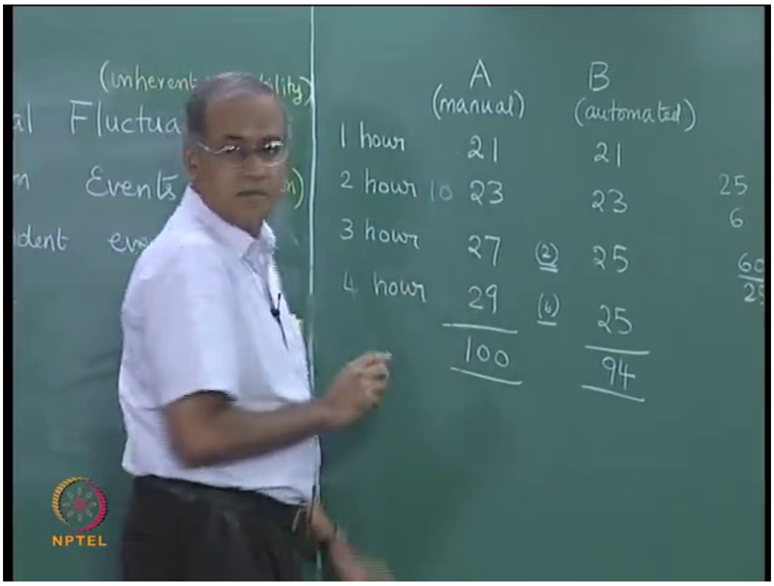

So, let me show that with a different colour. So, this 23 would have become 10. So, this also would have become 10 and this would have become 81 and this would require almost another 19 units have to be produced, so this would require almost another 45 minutes on the whole thing.

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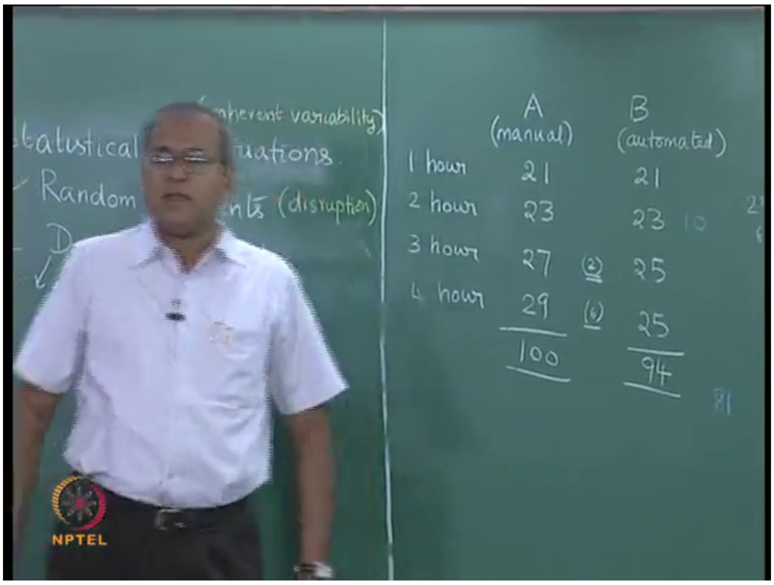

So, typically any random event in addition to this is only going to make this situation worse and not best because it can never be compensated by something which cancels out the effect of the random event. So, or for that matter if this 23 is fine, but here the machine breaks down for 10 minutes or for some time as a result of which the output is only 10 it would still be 81. So, random events always create difficulty in manufacturing systems.

And the combination of all 3 of them is something which can create lot more difficulty and more importantly has to be understood when we actually do scheduling. Now one other way by which we can overcome this is by saying that when we actually schedule this activity we may try and give a little bit of a buffer rather than 4 hours, but 4 hours plus something. It is also not possible to do that for every manual operation because it would eat away whole lot of extra time because at the end of it statistical fluctuations will cancel out each other.

So, what is normally done is in terms of availability a certain factor is given there and it is said that not all the time the person is available. So, some cushion is provided when the scheduling actually takes place. But the most important thing through this example is to understand the effect of combination of statistical fluctuations and dependent events. Now synchronous manufacturing essentially talks about this and makes us understand the combination the effect of combination of statistical fluctuations and dependent events and tells us to look at scheduling in the context of the dependency.

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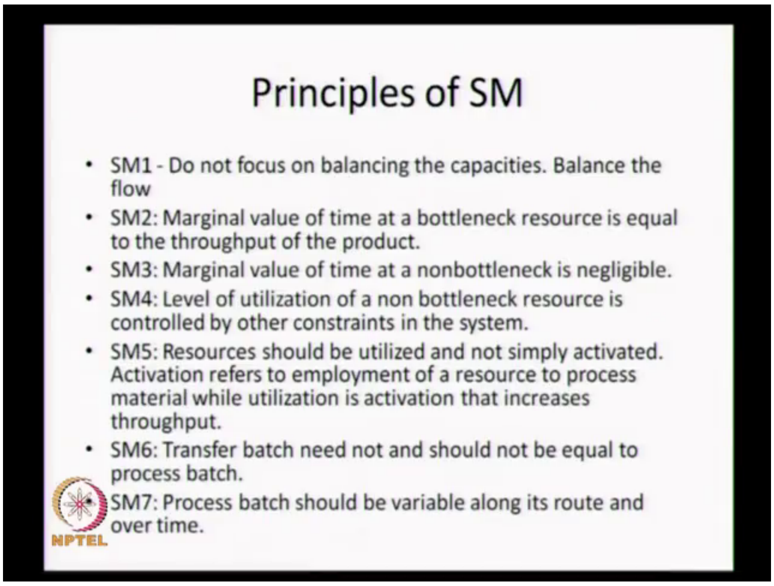

Now, let us move to the important parts which are called the principles of synchronous manufacturing and we will actually explain this principles through a numerical illustration that follows, but let us look at these 7 principles of synchronous manufacturing. Now there are 7 principles of synchronous manufacturing which we call as SM 1 to SM 7.

So, the first one talks about it says do not balance capacity, but balance flow now what is capacity and what is flow. So, if there are 2 machines that are required to make a product if we say that the process goes like this if this machine can make 10 per hour if this machine can make 8 per hour; if we balance capacity then every hour this will make 10 this will make 8. Now, how much can we sell, what we can sell is the minimum of this 10 per hour and 8 per hour which is actually 8 per hour.

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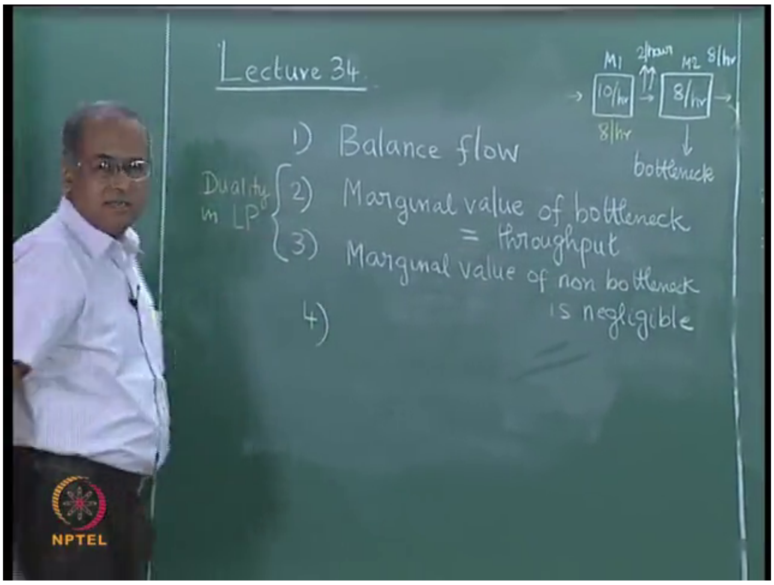

Now, if this works continuously then there is going to be an inventory build up here at the rate of 2 per hour and this inventory is never going to be converted to throughput. So, we should not try and balance the capacity by making both of them work it is necessary to balance the flow which is 2 to produce the minimum of the capacity of both of them. So, it is enough that this produces at the rate of 8 per hour. So, that the flow is optimized. Now the second principles of synchronous manufacturing talks about marginal value of time at a bottleneck resource is equal to the throughput of the product. So, marginal value of bottleneck is equal to throughput of the product. Now in this simple example this machine is the bottleneck if we call these machines as M 1 and M 2, now M 2 is the bottleneck because it takes more time to produce its output is 8 per hour. So, it takes more time to produce than the one which has 10 per hour.

So, marginal value of the bottleneck is equal to the throughput because this is the bottleneck now the throughput is 8 per hour, but throughput should be represented not in terms of time, but it should be represented in terms of money. So, if the profit for this particular item is 10 per unit then we will be able to produce at 60 by 8, 8 per hour, so per hour we will be able to produce 8 units. So, the throughput is and if the profit is 10 the throughput is 80, 80 per hour or 80. But then if we want to increase the throughput we have to increase capacity on this machine and make it produce let say instead of 8 per hour we need to make it produce say 9 per hour.

So, if we are to spend money to increase the capacity of either this machine or this machine we will realize that increasing the capacity on the bottleneck machine will always increase the throughput. So, if we increase the capacity to 9 per hour from 8 per hour then the throughput increases from 80 to 90. So, marginal value of bottleneck is equal to throughput. So, throughput in this case if we say the unit profit is 10 if you are able to increase the capacity by 1 as 9 per hour then the increase is 10 therefore, the amount of extra money that I can spend to increase the capacity from 8 per hour to 9 per hour is a maximum of 10 which is the profit per piece.

So, the throughput is 10 per piece 10 per unit and if you want to increase the capacity or the worth, the worth of this item or this machine which is the bottleneck or the worth of additional capacity on this machine is 10 if the throughput is 10 or the profit is 10 then if I have to increase the capacity of the bottleneck from 8 to 9 I can spend 10 or less. So, the worth of additional time very important additional time and that is the reason why we use the word marginal value it is its right now doing 8 per hour I want to increase the capacity by creating something and getting additional output. Then if I do something to increase the output from 8 to 9 the additional the marginal increase is one and that is equal to the throughput which is 10.

So, if I can do something to increase the capacity from 8 a per hour to 9 per hour and I spend less than 10 then I make extra money, but if that increase in capacity can be done at more than 10 then I want do it because I spend more than 10, but I get only 10. So, the marginal value is the value of an additional unit of resource is equal to the throughput which is the second principle of synchronous manufacturing. The third principle of synchronous manufacturing is marginal value of a non bottleneck is negligible is negligible.

Now, let us go back and see that I can do something to increase this is at 8 per hour this is at 10 per hour now I want to do something spend money to increase the capacity of the first machine. So, if I spend some money to increase the capacity of the first machine from 10 per hour to 11 per hour say now what happens to the throughput the throughput still remains at 8 per hour. So, I will not be able to sell more I would still be able to sell the minimum of 11 and 8 which is 8. So, even if I spend money to improve or increase the capacity of this machine I will not be able to get more revenue therefore, I should not be spending any money to try and increase the capacity of the non bottleneck. So, the worth or value of increasing the capacity of a non bottleneck is 0 or negligible because effectively the throughput is not going to increase if I increase the capacity of this.

Now, principles 2 and 3 are extremely important and they actually have a lot of relationship with the duality theory in linear programming. Now when we study linear programing we also understand that there is a dual problem associated with every primal problem in linear programming. Now the decision variables of the duel are called shadow prices or marginal value of the primal resource at the optimum. So, essentially when we talk about marginal values of resources here we are talking about the shadow price of the resource or the duel variable which represents the marginal value of the resource. In linear programming there is something called the complementary slackness theorem which would tell us that if there is the primal constrained which has the slack variable u and then there is a corresponding duel variable which is y then complementary slackness would tell us that y into u equal to 0 at the optimum.

So, complementary slackness from linear programming u is a slack of the primal constraint y is a corresponding decision variable.

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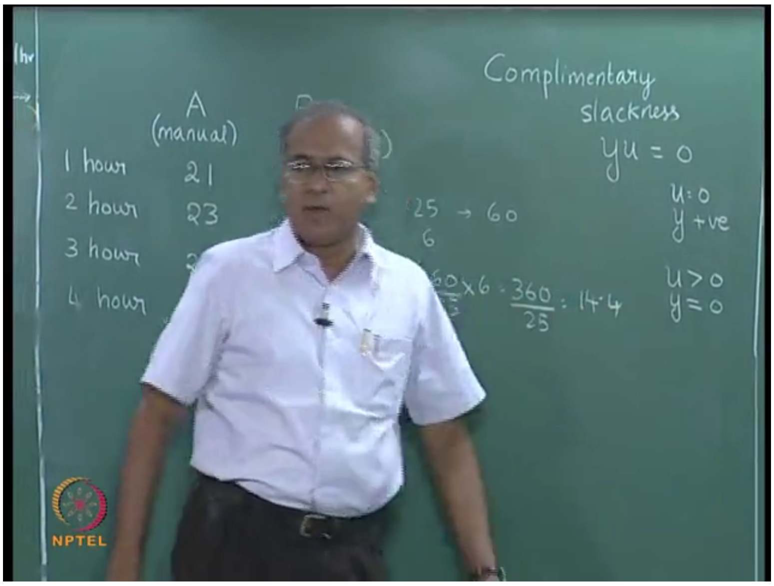

So, when a machine becomes a bottleneck the time constraint on the machine is used fully. So, when the time constraint on the machine is used fully then u is equal to 0. Now that would allow y to take a positive value in the duel and that y value will be the marginal value of the resource which is the profit that can be gained by increasing the resource by a small quantity delta which is the objective function increase which is the throughput.

Now, if this for this machine, if we apply that condition this is the non bottleneck machine. So, if we produced 8 hour instead of its full capacity of 10 hours, we are not fully utilizing this machine. So, the constraint will be satisfied as an inequality. So, when the constraint is satisfied as an inequality the slack variable u will be greater than 0, but when we satisfy the complementary slackness theorem then since u is greater than 0 this will force y to be equal to 0. So, this simple rule is given in linear programing when the primal constraint is satisfied as an equation then the duel decision variable will be a basic variable having a value that is the case for case number 2 where we look at bottlenecks. So, the duel variable is positive showing a marginal value.

Now, when the primal is satisfied as an inequality then the corresponding duel variable is not a basic variable and will take value equal to 0 and that is our SM 3 it says marginal value of non bottleneck resource is negligible or 0 in the sense that that will give us a u greater than 0 which will force y equal to 0, u greater than 0 implies the resource is not fully utilized which would give us y equal to 0. So, principles 2 and 3 essentially talk about the duality theory in linear programing, but 2 and 3 have been very nicely defined in the context of manufacturing to understand the role of utilization versus marginal value.

Now, SM 4 level of utilization of a non bottleneck is controlled by other constraints in the system. So, 4 talks about utilization of non bottleneck.

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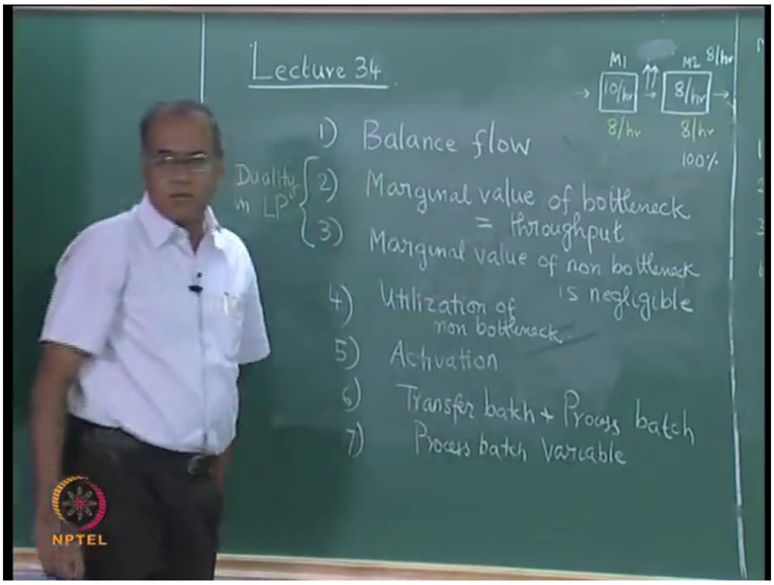

Now let us go back to the simple example that this is capable of doing 10 per hour this is capable of doing 8 per hour and at present we are not going to put in extra effort to increase this 8 to 9 or 10. So, the throughput will be based on 8 per hour and if the unit revenue is 10 the throughput will be 10 into 8. So, throughput is 10 10 into 8 80.

Now, from the first principle we do not balance capacity, but we balance flow. So, from the first principle this will produce 8 per hour which is what I had written earlier this would also produce 8 per hour, so that maximum throughput can be obtained under the condition that this is the constraint.

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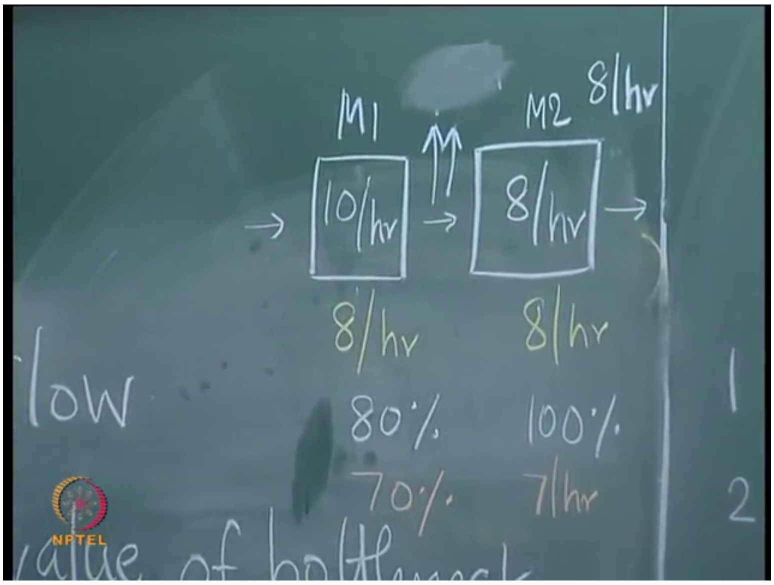

Now the utilization of the bottleneck will be 100 percent whereas, the utilization of this now this can produce at the rate of 10 per hour. So, it is producing only at the rate of 8 per hour. So, 80 percent of the times it is used, 10 per hour would mean it can it produces at the rate of 6 minutes per piece. So, it produces 8 pieces per hour it produces 4 minutes out of 60 minutes. So, 48 minutes out of 60 minutes is 80 percent.

Now, the reason this became 8y percent is because of the first principle. If we had allowed this to produce 10 per hour then this would also show a utilization of 100 percent. Now in such cases the SM 5 will talk about that principle it will talk about activation. So, we will not introduce activation at this stage since we are in SM 4 now because of the first principle this will produce 8 per hour. So, its utilization will come down because it is a non bottleneck. So, non bottlenecks will have less than 100 percent utilization and this number will depend on some other constraints in the system we read SM 4 carefully the level of utilization of a non bottleneck is controlled by other constraints in the system. So, which is the one that is controlling this utilization it is this if for some reason this is not 8 per hour whereas, this output is 7 per hour then this utilization will become 70 percent, so this would become 70 percent is this were 7 per hour.

So, the utilization of the non bottleneck is controlled by the bottleneck or by other constraints in the system, which is what SM 4 talks about and non bottlenecks will not have 100 percent utilization. Now SM 5 talks about resources should be utilized and not simply activated activation refers to the employment have a resource to process material while utilization is activation that increases throughput. Now 1 and 5 are essentially related except that we use the idea of activation in SM 5, if we go back to the same example if this were utilized 100 percent, then this will produce 10 per hour and as I mentioned there will be an inventory build up of 2 per hour which can never be utilized. If for some reason this is the first machine and this is the second machine there will be a forced underutilization on the second machine because material will arrive only at the rate of 8 per hour.

So, depending on the position of the bottleneck if the bottleneck is positioned later the earlier ones we have to force them to work for less time otherwise they will buildup inventory which will never be consumed. If the bottleneck comes early the later will automatically be forced to be unutilized now this extra 2 producing this extra 2 is called activation this extra 2 per hour can never be converted to throughput. So, activation refers if it produces to full capacity which is 10 per hour we may show that its utilization is 100 percent because it is busy, but actual utilization is only 80 percent activation is 20 percent.

So, we should bring activation to 0 percent and therefore, let this produce only 8 per hour and not 10 per hour. So, SM 5 and SM 1 are essentially related, but it introduces the idea of activation which is to the eliminated and left out. Activation essentially shows some kind of a dummy utilization which is not throughput. One other reason why this was brought in here is because traditionally incentives were paid based on utilization. So, there was always the strong tendency to show a lot of utilization particularly utilization of resources towards the end of the month to show attainment of monthly targets.

Now, when that happened just to increase the production and show utilization production schedules were not properly adhered to and whatever was available was produced resulting in a lot all activation and inventory build up. Now because measurement was on utilization this person would constantly ask while I can make 10 per hour why am I being asked to make only 8 per hour and for some reason if I am going to get 80 percent of the incentive that this person is going to get then this person is not going to accept it because this person could have got 100 percent of the incentive that this person would have got if this person had spent are produced at the rate of 10 per hour.

So, if incentives are based on utilization of the machine then activation comes into the picture and we end up producing more things that cannot be sold. So, for that reason activation has been defined explicitly as SM 5. SM 6 is transfer batch need not and should not be equal to the process batch. So, SM 6 talks about transfer batch plus process batch. Now in order to explain this let us go back to this example that we used to show statistical fluctuations and dependent events.

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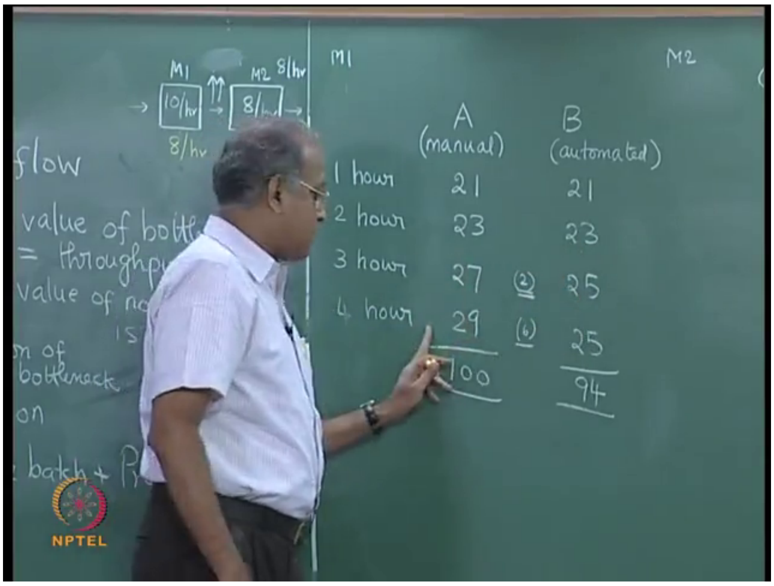

If these machines where located far away say M 1 is here and M 2 is far away in a distance of few kilometres then we may not be able to send items one piece at a time. So, if we start at time 0 this 21 is produced at the end of the first hour, this is produced at the end of the second hour this is produced at the end of the second hour, third hour, third hour, forth hour, forth hour, fifth hour. So, one extra hour is taken simply because of transfer batch considerations whereas, if these 2 machines are located close to each other.

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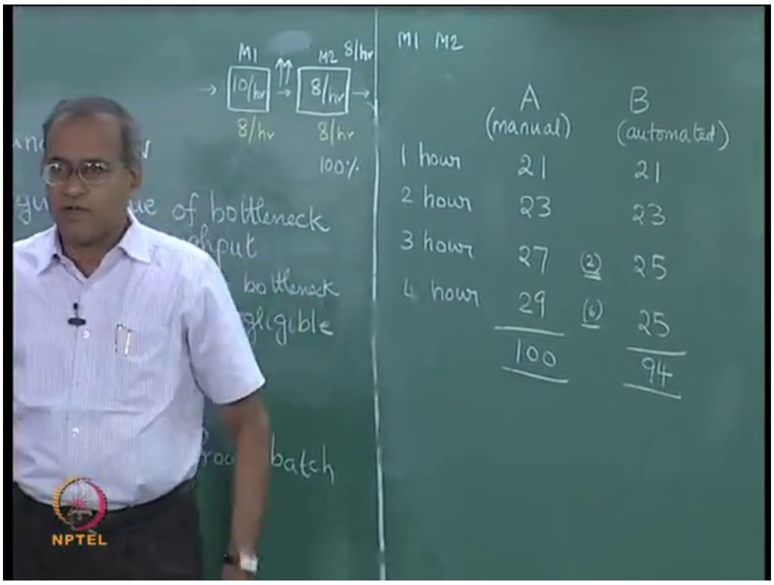

And if we allow a single piece transportation then roughly this is done at the end of the first hour this is done at the end of the first hour. So, first hour second hour third hour forth hour in 4 hour plus something it is over.

Now, keeping transfer batch equal to the production batch one delays the time particularly if machines are located away from each other. Now we have already seen examples that in cellular manufacturing the great advantages that of single piece transportation. So, cellular manufacturing gives us the flexibility or the advantage to do this because in manufacturing cells machines are located physically close to each other. Synchronous manufacturing does not necessarily ask for relocation of machines, synchronous manufacturing principles are used when the layouts are not changed to bring them to cellular mode it may be possible to use these ideas in the cell as well, but this can be used in situations where machines are actually located far away.

So, if transportation batch or transfer batch is equal to the production batch then in this case we will need one extra hour. But if we cannot bring these 2 machines close to each other then what can be do? Now we can have a transfer a production batch of say 25 per hour even here we have assumed that every 25 pieces are being transported, but if 100 pieces are being transported this will take 4 hours this will take 4 hours, so it will require 8 hours to be complete. If we take 25 pieces that are transported it will take 5 hours to be completed, if we take 5 pieces transported every time we would require about 4 hours and 15 minutes or 4 hours and 12 minutes to finish. So, as the transportation batch reduces the time taken to produce also reduces.

So, transfer batch need not and should not be equal to the process batch in the context of synchronous manufacturing where even if the machines are away from each other. So, let me repeat if we had used a transfer batch of 100 then this would have taken 4 hours this would have taken another 4 hours, so it would have taken 8 hours to complete this. If we had used 25 as transportation then it would of taken 4 plus 1, 5 hours. So, smaller the transportation batch faster we can finish. Ideal situation is single piece transportation. So, this would have been done in 4 this would also have been done in 4 plus a small amount of time when the first piece arrives on M 2. So, SM 6 talks about transfer batch being much smaller than the process batch.

Then SM 7 talks about process batch should be variable along its route and over time this is an important principle in SM, its talks about process batch being variable, being variable. Now, let me explain this through a simple example which is slightly different from this.

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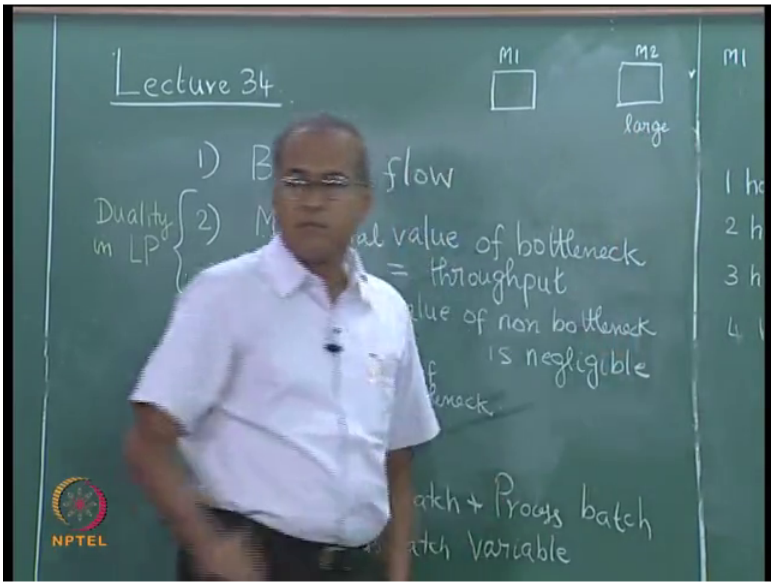

Now, let us again go back to 2 machine M 1 and M 2, now so for we have not explicitly brought set up time in to our computations now if we assume that the set up time is large on the bottleneck machine or if I have to produce 100 of something I have to produce

100 of A and 100 of B that are 2 products on machines M 1 and M 2 we have to produce 100 of A and 100 of B

Now, for this if I do 100 of A and 100 of B let say A takes 1 minute, B takes 2 minutes to produce this the time required is 300 plus 1 setup let say 50 and then I bring it back, so 2 setups plus 100. Now to produce 100 of A and 100 of B let say this is the bottleneck machine this requires 3 and this requires 4. So, I am talking of 700 plus 2, 2 setups 900 plus 2 setups 2 into 100 let say setup is equal to 100 here 900.

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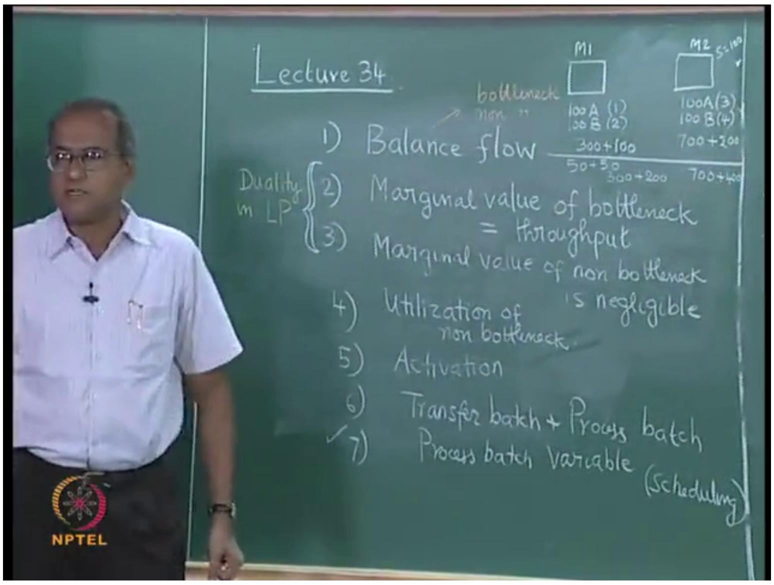

Now, let say for some reason I have only 900 units of time available here, here also I have 900 units of time available now if I do 50 of A 50 of B, again 50 of A and 50 of B the production time required is still 300 plus the setup time required is 200 we have doubled twice I have to do that. Whereas, here production time will be 700 plus setup time will be 400 now I do not have so much time, number one is I do not have so much time because the machine is the bottleneck machine.

And secondly, I also understand through this principle that if by increasing the capacity on the bottleneck machine I can increase the throughput I also know that the time I spend on setting up even though it is absolutely essential to produce is not going to increase my production quantity that time I cannot produce. So, I have to minimize the number of times I change over on the bottleneck machine and if I do that then I have to end up producing larger size batches on the bottleneck machine and smaller sized batches I can do on the non bottleneck because time is available on the non bottleneck.

So, in this situation I would like to do 100 of A and 100 of B here whereas, I can do 50 of A 50 of B followed again by 50 of A and 50 of B. So, process batch on this will be 50 process batch on this will be 100. So, process batch should be variable along in its route the bottleneck will require a larger process batch and over time because demands can change with time and the bottlenecks can shift depending on what product we are producing. We took an example where for both A and B this was the bottleneck now you could have a situation where this is 3 and this is 2 still this to be a bottleneck and so on. So, process batch should vary along the route and over time.

Now, this important principle all the 7 principles are important, but this important principle is the essence of a lot of scheduling in the context of synchronous manufacturing or in the context of theory of constraints. Now these 7 principles are now seen as principles of synchronous manufacturing. One thing that we need to keep in mind is that even though in almost all the examples we write like this and we assume that there are these machines, in practice when this is not applied in the context of cellular manufacturing we should always keep in mind that the machines are sufficiently far away and single piece transportation is not easy.

So, we will have large production batches smaller transfer or transportation batch, but the transportation batch themselves would be slightly bigger than transporting one. It does take a considerable amount of time to transport from one machine to another if they are with they occupy large distances. We need to keep that mind that in mind when we study synchronous manufacturing that we do not have the flexibility there that we have in cellular manufacturing where the machines are located close to each other here the machines are not located close to each other.

So, let me very quickly recap all the 7 principles of synchronous manufacturing which we call as SM 1 to SM 7. So, the first ones talks about not balancing the capacity, but balancing the flow, so do not balance capacity balance the flow. So, the first one immediately introduces the idea of bottleneck and non bottleneck because that machine which is going to determine the flow is the bottleneck machine. Then we get into a little more understanding of the bottleneck and the role of the bottleneck in the sense that bottleneck decides the throughput therefore, marginal value of increasing its capacity is equal to throughput, non bottleneck does not dictate the throughput therefore, its marginal value is 0 or negligible.

And as I mentioned principles 2 and 3 essentially tie up these synchronous manufacturing principles to linear programming. We have already seen in the other illustration on how much to produce and what product to produce we saw that that problem can be formulated as a linear programming problem or linear integer programming problem. So, there is a strong relationship the TOC rule also essentially comes from linear programming.

So, a linear programming and TOC synchronous manufacturing have lot of things in common and 2 out of the 7 principles directly come from duality theory and linear program. Now, 4 essentially talks about utilization and brings in the realization that it is necessary to have some resources to be utilized less than 100 percent for no fault of theirs. There is always a drive to keep people busy to keep things busy, but then one has to understand the context of such a thing on the overall performance of the organization.

Now, 5 talks about the effect of not doing 4 well, if we do not do 4 well and try to increase the utilization of a non bottleneck by making it work more we essentially end up doing activation and not utilization activation is not going to improve the throughput. 6 and 7 essentially it talks about the production system first the understanding of a production batch and a transfer batch, first is the realization that we should not have transfer batch equal to production batch then we will unnecessarily create delays and subsequent resources will become capacity constraint resource.

So, we need to avoid that and have transfer batch less than the process batch, then comes the idea that the time on the bottleneck machine most of the time should be used for production and only minimum time required to set it up should be used which also means that the bottleneck machine cannot afford small production batch sizes. So, it will have large production batch sizes while non bottlenecks will have smaller production batch sizes and process batch will vary with respect to route as well as with respect to time.

Now, in the next lecture we will take a numerical illustration to further understand the principles of synchronous manufacturing that we have seen now.