Manufacturing Systems Technology

Prof. Shantanu Bhattacharya

Department of Mechanical Engineering and

Department of Industrial and Production Engineering

Indian Institute of Technology, Kanpur

Module – 08

Lecture – 47

Hello and welcome back to this module 47 of the Manufacturing Systems Technology.

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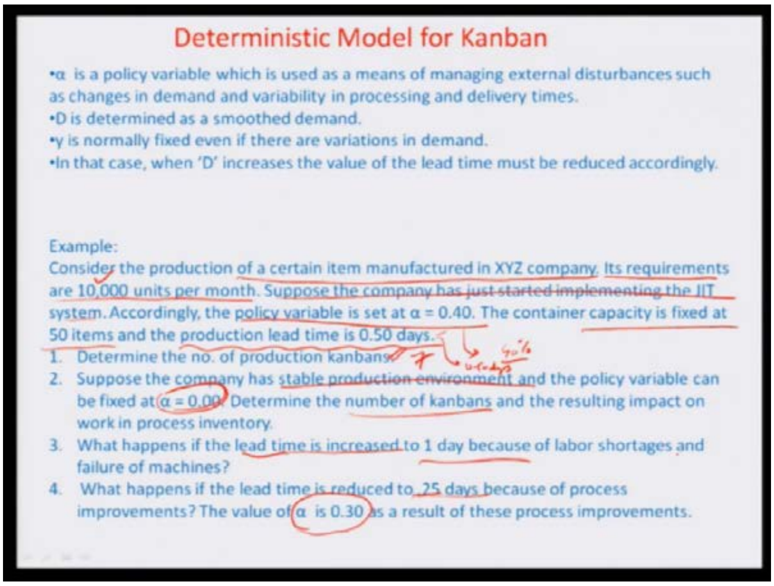

We were at this problem and we were trying to evaluate the number of Kanbans in the situation given in this particular problems statement, where there was a production of a certain item and the demand was given per month. 20 working days month was assumed and we wanted to calculate, what is the number of Kanban and given the policy variable, given the number of items in one bin and also the production lead time, which is the Kanban waiting time and the production time.

So, we calculated the number of Kanbans to be 7 in this particular case and now this next situation is, that suppose the company has stable production environment and the policy variable now is fixed as 0; that means, there is no over stocking.

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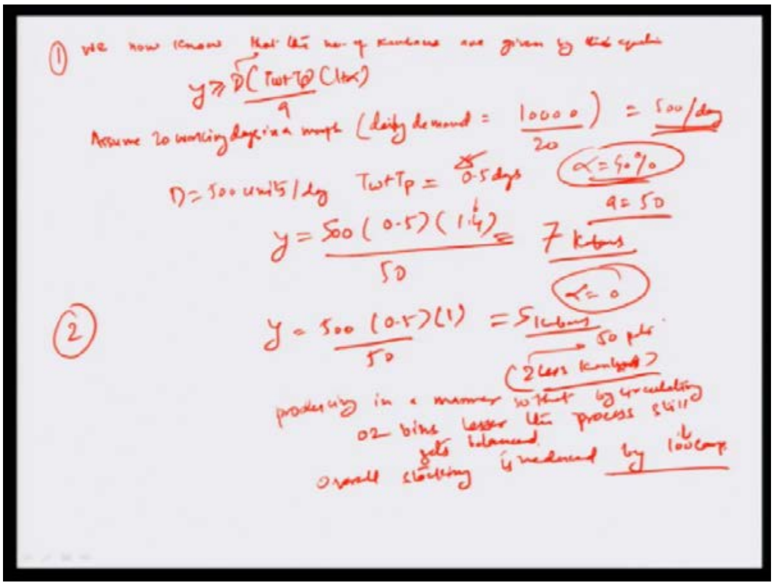

So; obviously, in that event if the alpha here which was about 40 percent is now reduced to 0. So, alpha becomes equal to 0, so the Kanban numbers would also reduce to 0.5 divided by 50. So, it is basically only one multiplied, so this would actually make it about close to 5. So, we are having 2 less Kanbans, because we want to now only operate at the demand level and there is no over stocking what so ever. So, essentially you are producing in a manner, so that by circulating 02 bins lesser the process still gets balanced.

So, the overall stocking is reduced to about 100 components, by about 100 components. So, that is how the, you know you can really estimate what happens in case of change of policy. So; obviously, these 100 components which were there earlier were, because you wanted to keep a 40 percent additional stock at every level. Now, you just remove that and so why I am saying 100 is because as you remember that every bin contains 50 parts, so 2 less bins means about 100 components less at which you can still operate.

The other problem statement that has been given is that, supposing in the situation what would happen to the if the lead time is increased by one day to one day, because of the labor shortages and failure of machines.

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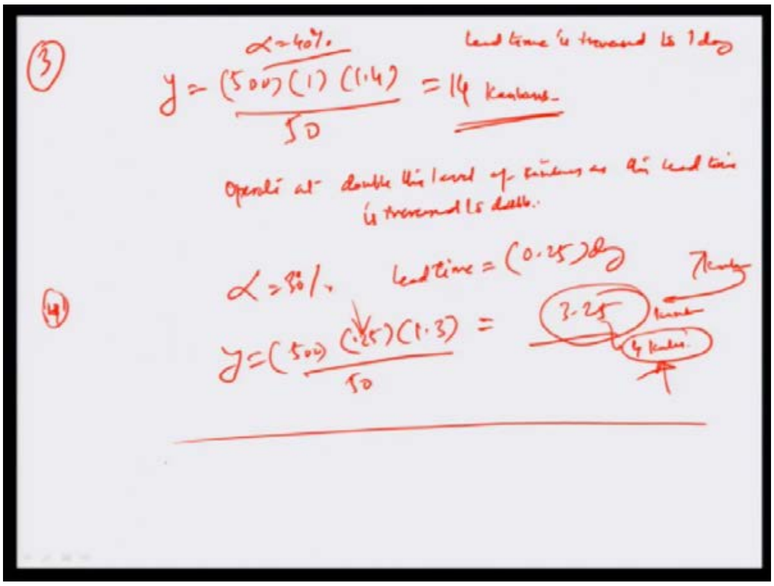

So, in that event; obviously, you had a policy variable 40 percent, let us assume no changes in this condition and you want to supply and balance the number of Kanbans y. So, here it will then come out to be 500 the demand per unit day times of the lead time, now the lead time has been sort of you know increased to about one day. So, lead time is increased to one day, so the T w plus T p becomes equal to 1 and then you have the policy variable which is still operating at 1.4 and you divide it by the number of containers here. So, this comes out to be again about close to 14 Kanbans.

So, you can see that you have to operate at double the level, so operate at double the level of Kanbans as the lead time is increased to double. So, whatever model you are proposing actually works out very well here, that now if the lead time is reduced is increased from 0.5 days or half day to a single day, because of whatever issues, the Kanban should also get doubled, because then you are accommodating for a greater period and you have to buy more stock and keep more stock in question.

So, the stocking area gets increased by 7 bins about closed to 350 components more and that is how. So, the inventory levels goes up because of that and this is something that you should record very well and this is something that you should monitor. You cannot; obviously, star away process by not feeding it material just, because you are implementing lean manufacturing. But, if you can have a record on a monthly basis of how many such components are there, where the overall Kanban level has gone up and you have to create a situation, where you are having a higher policy variable.

So, those are the most problematic areas which are in direct view of the management and you can do something. So, that the processes and the way that you know the supplies etcetera are happening can; obviously, improvise in the lead time for the Kanban can reduce because of that. The moment the lead time again gets reduced, you are back to the normal level and you are operating at the linear level, this has to be done mind you, for all the inventory that is involved in particular manufacture of a certain product.

So, the next situation again is a situation where the policy variable is changed to about 30 percent and the lead time again reduces, because of some process improvements etcetera to about 0.25. Now, it is a quarter of a day that the lead time has been reduced to. So; obviously, in that level the Kanban will go down further, so 500 into 0.25 times of 1.3 at which it operates now divided by 50 makes it about 3.25. So, it is going down from the 7 Kanban level which you are earlier obtained to 3.25.

Actually you know, you should record this as 4 Kanbans because; obviously, you cannot under stock the situation. So, it is a good idea to estimate on the over side, so 3.25 gets converted into about 4 Kanbans. So, you are having at least 3 Kanban reduction, because of this improvement that has happened leading to the reduction in the lead time to about quarter of a day. So; obviously, such improvements are what the management practice should be to get into and the more the improvements can be suggested, the better it is in terms of overall line balance using Kanban techniques.

So, that is how you basically try to understand the whole deterministic estimation of the Kanban. When we are talking about sub assemblies for example, let us say there are two parts of assemblies which has the individual production and you know withdrawal Kanbans and then they are matching together do make one product assembly. There would be a slightly detoured scheme of things, where there are many values which are involved.

So, I will do one example, where or one case study where such a situation is available, that you have two or more components going into a sub assembly and that stage how do you do Kanban. And then, we will slowly move on to the next module, which is about the cost analysis into picture and how to make the estimation of the Kanban problestically.

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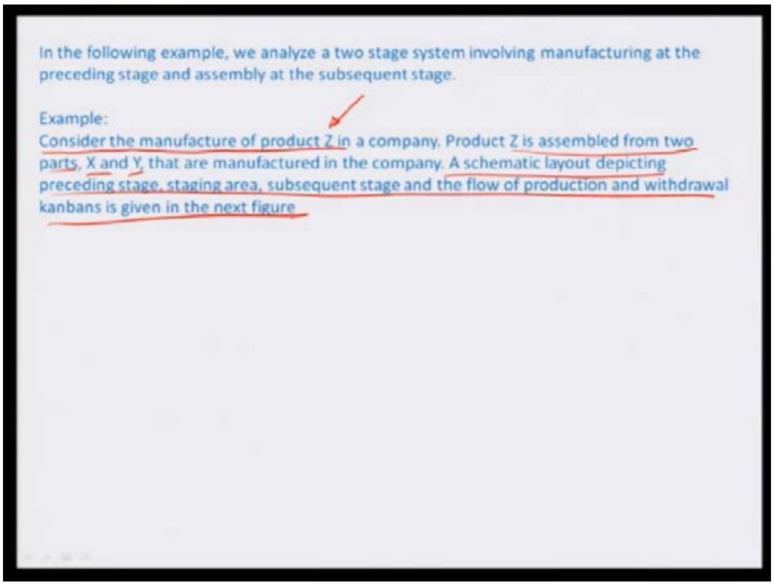

So, let us look at the sub assembly module, here is such a case which involves the sub assembly level Kanban planning. Let us say you consider a manufacturing process, which produces the product z in a company and the z is assembled from two parts by sub assembling these two parts x and y to each other. So, z comprises of two sub parts which are sub assembled into one another to make the z and a schematic layout depicting the preceding stage, the staging area, subsequent stage and the flow of the production and withdrawal Kanbans is given in this particular figure here.

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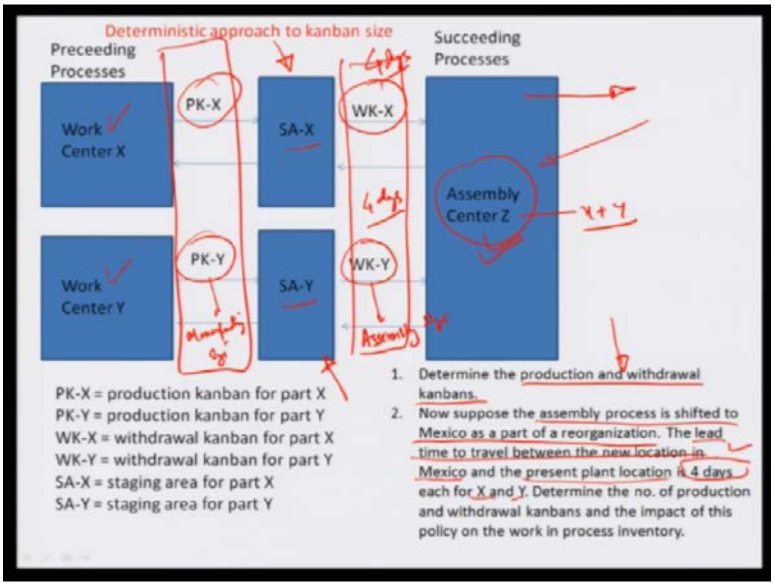

So, you can see that there are three work centers principally involved in this particular process. The work center for the production of the part x, the work center for the production of the part y and they are sub assembled into a sub assembly center z which comprises of the sub assembly of x and y and there is stocking area separately given for the component x and the component y close to the assembly center and there can be a withdrawal cycle for x and y simultaneously to go to the assembly center.

So, that z can be produced and they can be a production cycle as illustrated earlier between the work center x and work center y, which would feed the stockings area for x and stockings area for y. So, that is how the whole line balancing is done in this particular case. So, we need to determine the production and the withdrawal Kanbans I will give you some of the values here related to the lead time or the policy variable or the demand per unit time, so on, so forth.

And so we have to create instead of a balance between one process to the stocking area to the next process we are creating between two processes, two stocking areas and one final process based on that. So, that is the only diversion that we are having in sub assembly level Kanban planning. So, this let us address the first part of the problem statement here how to determine given the values here, let us look at the values.

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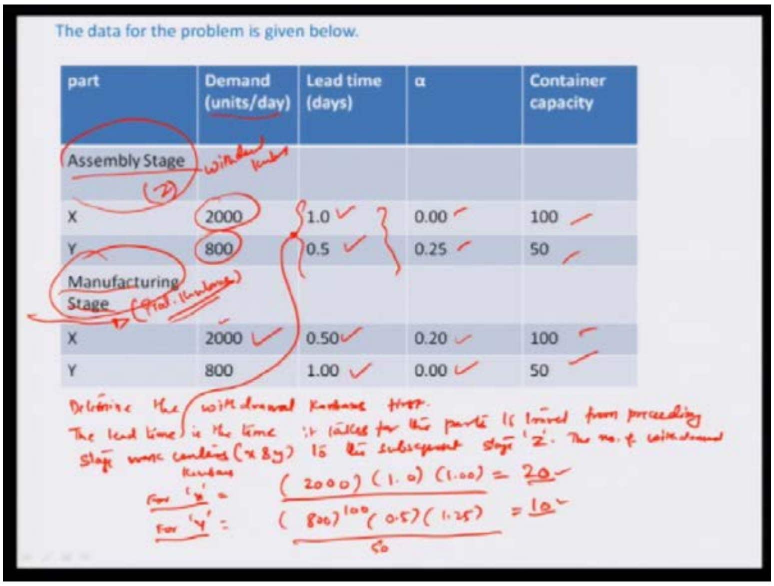

So, at the assembly stage the demand per unit time which is you know mentioned in per unit days is 2000 for X and 800 for the part Y and the lead times which are available for the part X and Z for planning the assembly stage is one day and half a day respectively, there are two policy variables 0 percent and 25 percent level which is operated for X and Y respectively. And further the container capacity is defined as 100 parts per container of

X and 50 parts per container of Y.

Similarly at the manufacturing stage we which we also know as center which would be needing really the production Kanbans. So, it is a back end process manufacturing stage. So, let us now define it here, so this side is really the assembly stage that we are talking about which I have just described before this and this side here is the manufacturing stage and the values are given in commensurate manner based on different stages.

So, you can see that the withdrawal stage is the assembly stage in the production stage is really the manufacturing stage. So, that is how you plan the production and the withdrawal Kanbans. So, this assembly stage Z would mean the withdrawal Kanbans and the manufacturing stage would typically involve the production Kanbans. So, given this value we want to find out the different levels of the withdrawal Kanbans and the production Kanbans in cycle. So, that there can be a proper process balance.

So, let us determine the withdrawal Kanbans first, the lead time used for determining withdrawal Kanbans is the time it takes the part to travel from the preceding stage work center to the subsequent stage which is Z. So, therefore, just write the statement here that the lead time which is given in this particular portion of the table here is really is the time it takes for the parts to travel from preceding stage work centers which are actually the manufacturing stage I can call these centers x and y to the subsequent stage, which is the z.

So, the number of withdrawal Kanbans for x for example, would be the demand per in a day which is 2000 times of the lead time which is 1.0 times of the policy variable. So, 1.00 again you are operating in a very lean 0 percent inventory level divided by the container capacity. So, that comes out to be 20 for x and for y it comes out again the demand units per day divided by or times of the lead time which is half a day, times of again 1.25 you are operating an alpha value of 25 percent divided by the container capacity in this case which is 50. So, that brings a value of 10 respectively, so for x the number of withdrawal Kanbans is 20 for y the number of withdrawal Kanbans is 10 respectively.

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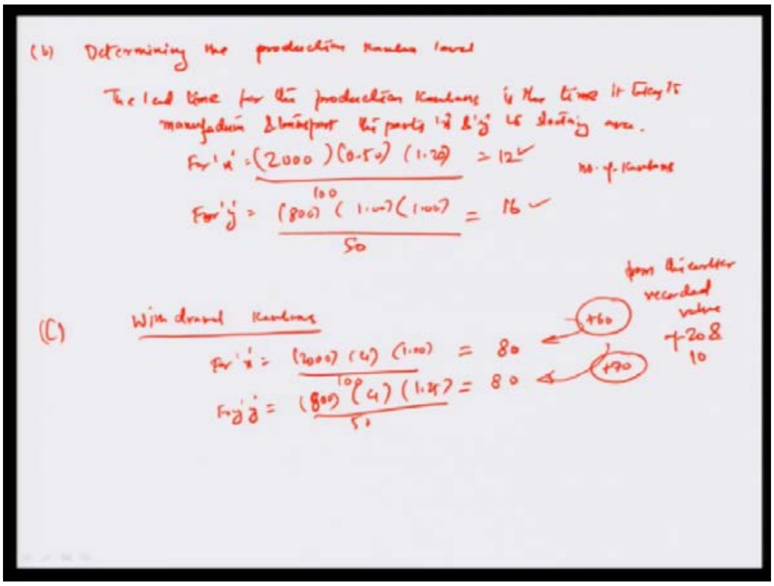

So, now it determines the production Kanban level. So, let us say part b determining the production Kanban level meaning there by we need to use the values towards the lower part the manufacturing stage part of the table and here for the lead time there exist a similar definition. So, we call that the lead time for the production Kanban is the time it takes to manufacture and transport the parts x and y to stocking area, just as in the withdrawal case we had seen it was really related to the mode of time taken by the parts x and y to go from the previous stage, there is a stocking area to the assembly center z.

This case in the case of production Kanban it is just how much time it needs to manufacture and transport this part x and y to this stacking area. So, here again for x if you look at individually the demand per day about 2000 and lead time is about half a day alpha is 0.20. So, 20 percent level, so the x becomes equal to 2000 times of the lead time for x and the production side times of 1.20 operating at 20 percent level of the policy variable divided by 1000 and in this comes out be equal to be about 12 units or 12 containers as the Kanban level.

Similarly, for y we will have a similar calculation starting with 800 demand per unit day times of one day lead time times of policy variables are at 0 percent divided by 50 which makes this about 16 respectively. So, for x and y you have 12 containers in one case and 16 containers in another case. And so that is how you can plan the number of Kanbans into picture.

So, since the lead time is basically defined by this proximity of the assembly stage with respect to the manufacturing stage. The second part of the problem involves a little bit tricky situation that there is a you know reorganization of the company because of which the assembly stage has been shifted now to another place and the new lead time to travel between the new location and the existing place and the present plant location is about four days. So, the lead time is really increased for both x and y components from the earlier level of you know the one day and half a day respectively to know about 4 days.

So, naturally the withdrawal Kanban would increase because now your whole idea is that this stage is going for away. So, this is 4 days away and the withdrawal side are now having increased leads because of you know the proximity issue because of the assembly stage moving distance I mean to a greater distance from the work center. And so therefore,; obviously, the stocking area size has to go up, because it can accommodate that way the manufacturing plus the lead time constraints which have been imposed on the system and it should be able to still create a flow or a balance between the manufacturing stage and the succeeding assembly stage.

So, therefore, in this particular case the Kanban level will simply bloat up because of this. So, the withdrawal Kanban level will definitely be different in this case. So, withdrawal Kanbans now would be calculated for x to be equal to the demand per unit day, which is about 2000 times of the lead time now which is 4 times the policy variable which was 0 percent earlier at this particular stage for x divided by the container capacity. So, this becomes 80 and similarly for y again you know it is 800 units per day demand and then you have a 4 day lead time and then the policy variable of 1.25 divided by 50 which is also again 80.

So, therefore, if you see the increase in the withdrawal Kanbans from earlier 20 and 10 levels. So, there is about a plus 60 increase in the x withdrawal Kanban level and about plus 70 increase in the y withdrawal Kanban level from the earlier recorded value of 20 and 10. So, let me just write this here 20 and 10. So, it; obviously, means that you creating a overstocking situation to sort of mitigate the constraint additional constraint put on the system by increasing the lead time.

So, that is how you do the Kanban level planning at this sub assembly stage and it is very important for me to mention that whether it is a just a once stage process like appreciating stages a stocking area and as a succeeding stage or many such stages process, like you saw like in this particular case two stages converging into one stage and there may be case where five such sub assembly units are getting assembled together or there may be a chain of such sub assembly events, all you need to do is to sort of meticulously balance the production side and the withdrawal side for individual components keeping the individual stocking areas in question to maintain the balance or harmony of the flow of the product.

So, that is what the whole concern is for designing a system which would have a perfectly harmonious Kanban balance. We will now look at a little bit different a side of the story which is about the just in time manufacturing and an understanding of what really this Kanban planning would have to do with just in time manufacturing.

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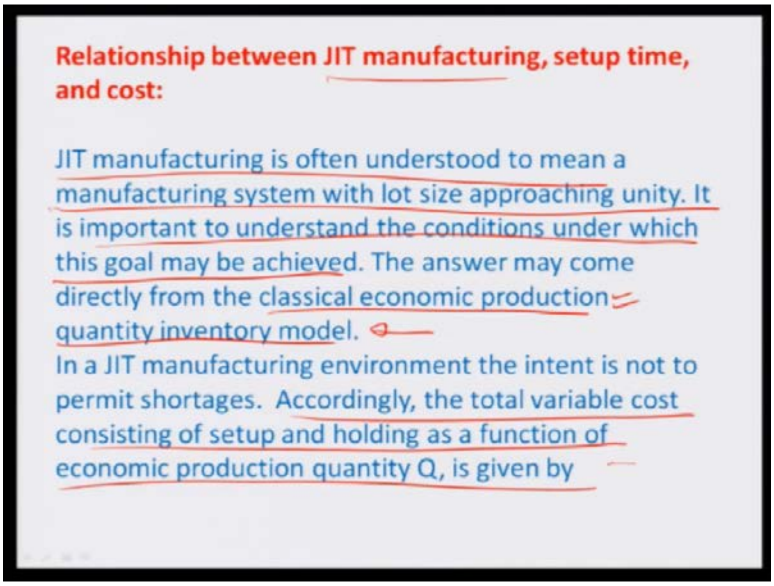

So; obviously, the JIT manufacturing is often understood to mean a manufacturing system with the lot size approaching unity, meaning there by that only one part is needed at a point of time you have to supply that only one part to the system. Obviously, it is too far away from the realistic situation you really have to do a lot of home work in order to create that situation, where the container size of the Kanban is operating at a level of n equal to 1. So, it is important to understand the conditions under which this goal may be achieved and the answer may come directly from the classical economic production quantity inventory model.

Now, this is something which is really emerged from the MRP or the Materials Requirement Planning I am not going to the details of how you arrive at this you know economic order quantity or the economic production quantity for the inventory model and accordingly the total variable cost consisting of a setup and holding as a function of economic production quantity Q is also provided.

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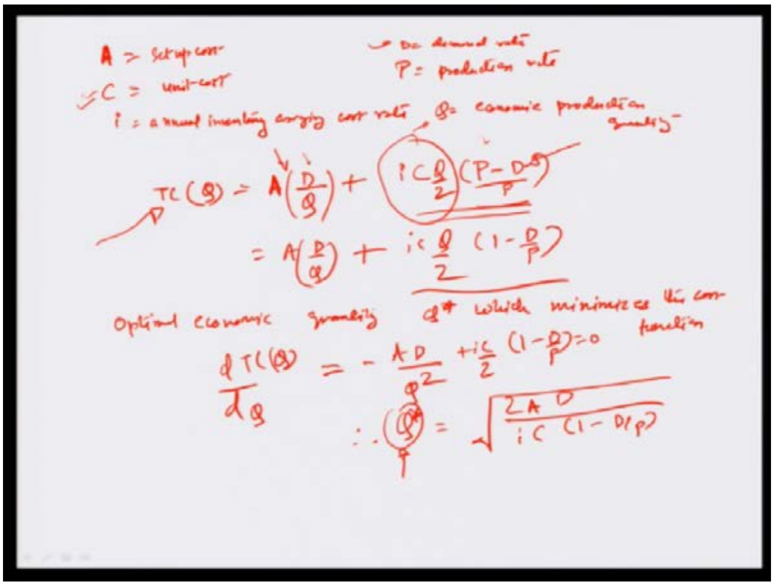

So, let us say I just want to sort of go ahead and see what is the kind total cost which is involved, we have a situation here where A is supposing the setup cost of the equipment of the plant machinery and C is the unit cost. So, is the sort of you know the price of the item or the inventory in stock and i is the annual inventory carrying cost rate, D is the demand rate, P is the production rate. So, all of this is per unit time please take a note of all these and then Q is the economic production quantity that we are talking about.

So, if you look at the total cost of the inventory carrying which comes into the system it is; obviously, related to the setup cost. So, if D is let us say the demand rate and Q is the you know one production lot size or one production quality. So, the number of times that the equipment needs to be setup is really D by Q assuming that there is a complete variance between one economic lot and another economic lot. So, that is how number of times you can associate, where you can reset the equipment before starting a production process and; obviously, the setup cost comes as A.

So, the total cost which gets complied compounded is A times of D by Q and; obviously, the if you look at the annual inventory carrying cost rate, the total amount of inventory carrying cost would really depend on the difference between the production and the demand percentage and that is sort of multiplied by the unit costs of which percentage, you know is the annual inventory carrying cost. So, i C is that particular unit cost times the you know the average economic quantity which is Q by 2 in this case times of P minus D by P which is the percentage sort of excess material as a percentage of the overall production rate.

So, if P is the production rate D is the demand rate; obviously, the production is more than the demand and so the question of hold age comes into picture or inventory carrying comes into picture. So, I am not really not getting into how to get into the mathematical derivation of this particular cost equation, it comes from directly from the economic order quantity estimation model of a MRR. But, here the idea is that the total cost can now be related to the setup side, where A D by Q is the setup cost and the inventory calling carrying cost rates side which is defined as i C Q by 2 times of one minus D by P.

So, having set that the economic quantity of the optimal let us say economic quantity which will be formulated here we call it Q star which minimizes the cost function can be obtained by just differentiating the total cost with respect Q. So, this can be calculated minus A D by Q square plus i C by 2 times of 1 minus D by P requiring that to 0. And so the economic order quantity Q star comes out to be equal to twice A D divided by i C 1 1 minus D by P. So, that is how you can define the total economic production quantity.

So, if I would do really plot this cost function as a contribution of the total setup cost as well as the annual inventory carrying cost the or the total amount you know the way that we can plot it.

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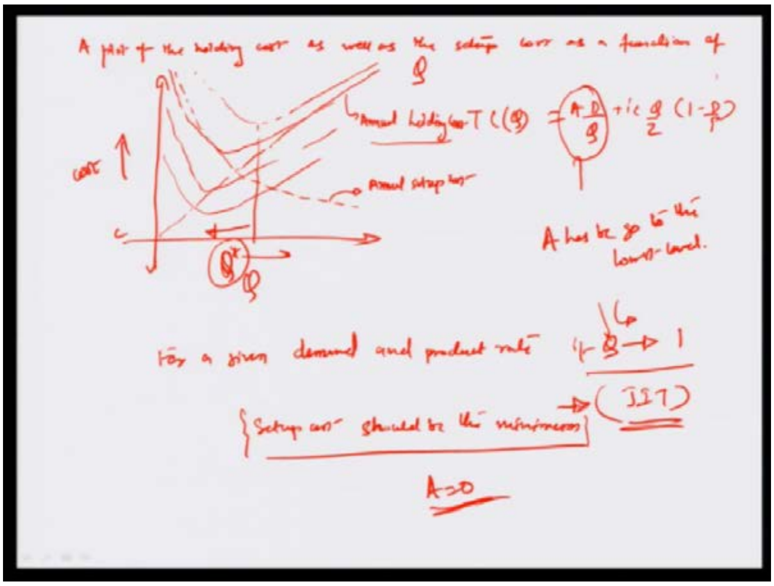

So, let us say we make a plot of the holding cost as well as the setup cost as a function of

Q. So, you have cost on the y axis and Q on the x axis, so; obviously, we are talking about a condition of a minima of this particular cost corresponding to the value Q star. So, this total cost is minimized here and if I really were to plot the cost function which is defined again as A D by Q plus i C Q by 2 times of 1 minus D by P.

So, the inventory carrying cost if you look at is the annual holding cost of the inventory carrying cost is really the linear component and the total cost coming, because of the annual setup cost is sort of 1 over Q relationship which you know sort of comes like this and I can just split this up into the annual holding cost, the linear function and the annual setup cost. So; obviously, while the holding cost increases the cost or function as a linear function of Q or with increasing production lot sizes the holding cost goes up, the setup cost comes down because of increasing lot sizes.

So, there is a sort of a you know harmony between both of them and they would have the maximum effect on each other to minimize the cost function at a certain point Q star. So; obviously, if I were to pull this back or let us say create a situation where these total costs come down more and more the Q would shift to the left which would reduce. So, it would probably try to sort of you know reduce the overall cost and the whole idea is that for a given demand and production rate.

If Q can really go to the JIT level which is actually operating at a single stock or may be corresponding to one item as a only inventory which is involved in this whole process. the overall set up cost in that event should be the minimum. So, for this economic lot size to approach unity and if you want to really minimize the cost function the value of A has to go to the lowest level.

So, in fact, a ideal situation is that if A is equal to 0; that means, there is no setup cost then there won't be any contribution, because of the lower value of Q and you can operate at the almost Q equal to 1 which means that you know the number of times the setup is needed almost is going to be same or commensurate with the rate at which the demand is happening. So, for every product you have a setup, but that setup time is 0 meaning there by there is really no setup which is needed.

So, in that kind of a situation which is a one in one out flow of system, you can really maintain the JIT level. But; however, the truth is that the there is a finite amount of setup cost which is involved. And so therefore, it is really a dream to shift to Q equal to 1 level or the economic order quantity level. So, having set that I think we are more or less towards the end of how you can envision JIT with the total Kanban overall Kanban level.

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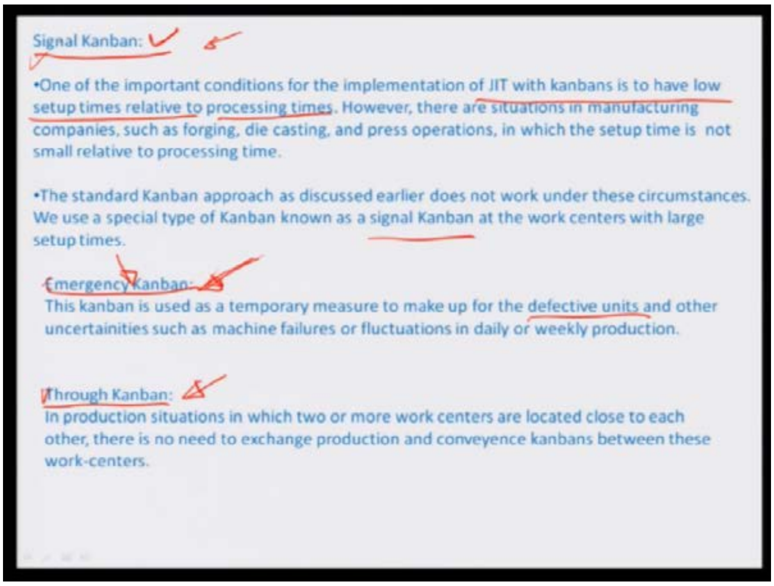

I will just quickly discuss a few more important points, which I felt is you know sort of to be discussed in this part of the course before going into the probabilistic estimation of the number of Kanbans, which would be probably in the next module. So, here I would say that apart from the regular production withdrawal Kanbans there are many other type of Kanbans which are available in the system.

So, one of them is called signal Kanban and this is probably it comes into a existence when we are talking about a large setup time, let us say in a press sort for example, you need to setup the dice etcetera and it takes among this amount of time to do one setup and they are the condition of that economic order quantity Q of sometimes size comes into picture for which we have just done the analysis or completed the analysis.

So, one of the important conditions for implementation of JIT with Kanbans is to have low setup times relative to processing times. But, this is not always the case and so therefore, you have to use a technique where instead of a one by one withdrawal of the item there is a lot by lot withdrawal of the item and so that actually is known as a signal Kanban.

So, signal Kanban is really something where there would be you know the placement of the withdrawal card in a manner. So, that rather than moving one bin at a time, it is moving a lot of certain number of bins at one time. So, that way you can actually increase the Q and reduce the setup cost as you had seen in the earlier analysis and so even if there is a finite amount of setup time, associated set up cost it should be able to operate at a certain basic minimum of Q, where the total cost again is going to minimum because of that.

So, that signal Kanban, so instead of a one by one you have a lot by lot movement there are some other exigencies which are used for example, supposing there is a defective unit which is produced at a work center. So, you have to really produce an emergency Kanban there which is actually not a process in balance, but in order to maintain the flow and this has to be the decision has come from the highest level of the company when you are trying to induce this emergency Kanban into picture.

So, there are many other uncertainties like machine failures etcetera which would result in issuance of an emergency Kanban, where may be an over production in a particular shift or may be a planning in a manner. So, that there is an extra number of hours which are involved because of the machine breakdown. So, that the system flow is harmonized and it gets balanced. So, that is emergency Kanban and then; obviously, the other one is through Kanban which is really the situation when the stations are very close to each other, there is no need of any stocking area. So, it is almost a one and one out kind of a system.

So, that is another kind of Kanban which is in vision and these are the different other Kanbans apart from the production and withdrawal Kanban that you learnt towards the beginning of this lean manufacturing topic. So, with this I would like to close in this particular module and we will sort of you know go to into another very critical area of how to problestically determine the Kanban level in a situation, where there is an associated hold up and a shortage cost based on in the Kanbans are at a level which is higher than the total demand or lower than the total demand respectively. So, we will do that in the next module.

Thank you.