Management of Inventory Systems

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Lecture – 39
JIT-based Approaches for Materials Management (Contd.)

During the first 3 lecture sessions of this week, we are discussing the several aspects of the JIT based the Materials Management system. So, you have the come across the several kinds of approaches, you need to apply for implementing the JIT philosophy in a production system and the interesting the point to be observed is that whenever you try to the implement JIT based approach; you not only concentrate on the inventory control systems, but you also concentrate on the production control system. That means, the inventory control system and the production control systems in any say organization, they must be taken care of jointly or simultaneously.

Now, we have already discussed in detail the kanban system and as we have pointed out that the kanban system is essentially used at the shop floor level for the shop floor control. So, the materials flow at the shop floor you can control quickly effectively with the help of a kanban system. So, essential you know the elements in a kanban system is the kanban card and there are 2 types of the kanban cards you may be using one is the conveyance kanban and the second one is the production kanban.

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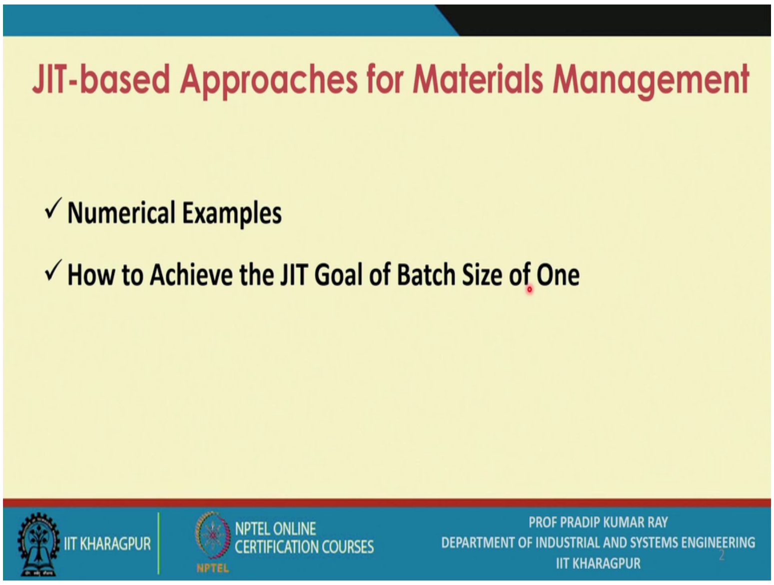

Now, the determination of the kanban or the number of kanbans to be used, it is an important issue and we have already discussed that there could be the 2 types of models you can prescribe or you can suggest for determining the number of kanbans in a production control system. And this, the two approaches are referred to as the deterministic model, as and the next one is that is the probabilistic model.

So, both these models we have discussed, now during this lecture session the first I will be taking of a typical numerical problems related to the determination of the number of kanbans in a particular say the production system. And, then I will refer to the second important aspect in JIT based manufacturing system that is how to achieve the JIT goal of batch size of one ok.

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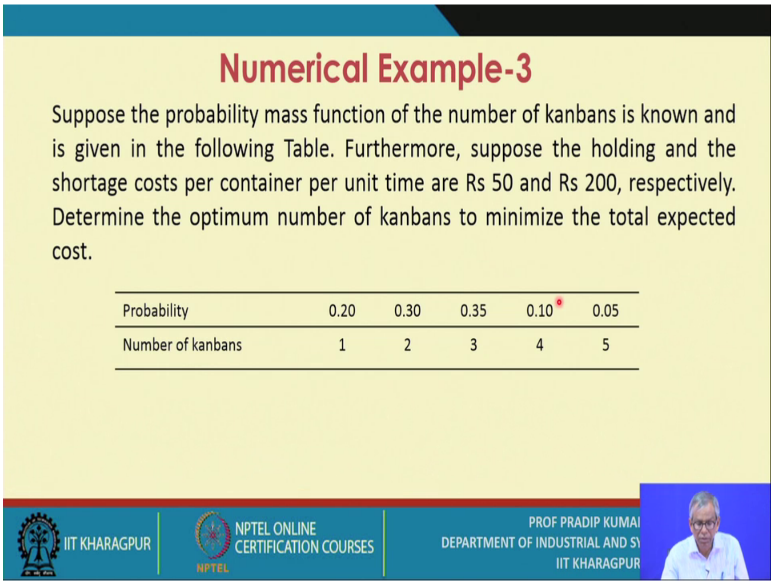

I have already mentioned that there are the 7 possible say the goals of JIT and 1 such goal is the batch size of 1 and obviously, when you try to achieve this goal then make sure that the setup time and the corresponding setup cost is held to a minimum and the ideal value is 0. That means, there is a hardly any set of element in the entire say the manufacturing system. So, that is an ideal situation so we will definitely discuss that under what condition you know you may have a situation or the condition of almost negligible the setup time and the setup cost. Now, here is 1 numerical example I want to discuss at this point in time to determine the number of or the kanbans.

Suppose the probability mass function of the number of kanbans is known; that means, we are referring to the probabilistic model we have already referred to numerical problems related to say the deterministic model, now you are referring to the probabilistic model. So, that is why the probability mass function of the number of kanbans must be known and this is a standard procedure you refer to any the probability and statistic textbooks how to determine the probability mass function of a the given you know say the discrete random variable or so that that is already it is known and you refer to those approaches.

So, here the discrete random the variable is the number of kanbans now what we are assuming that the probability mass function is predetermined that is known and is given in the following table. So, what is this table? That means, against the possible the number of kanbans what is the corresponding probability. So, what we believe in that is that the system is having the corresponding say the frequency counts and these are the objective probabilities; that means, there is you know that the database is already there related to the frequency counts of that events.

So, against the number 1 that means, what is the probability that the number of kanban what is that probability that number of kanban is 1 that is point 2. Similarly, against number 2 the probability is 0.30 30 percent of the cases 35 percent of the cases the number of kanbans maybe 3 and similarly for other 2 possible the number of kanbans 4 and 5 the corresponding probabilities are known. So, this is the probability mass function the table is given furthermore, suppose the holding and the shortage cost per container per unit time are rupees 50 and rupees 200 respectively. Now, these are the estimates and in many a time or any exercise on say the production control or an exercise and inventory control or for both you need to have the estimates of us of the relevant of the cost.

So, here the relevant costs are holding cost or inventory carrying cost and the shortage cost or out of stock cost. So, we have determine these estimates are there and obviously, we are assuming that these estimates are highly reliable; that means, even if there is an error. But the error is acceptable or tolerable level of error you have determine the optimal number of kanbans to minimize the total expected cost, so this is your problem a simple problem.

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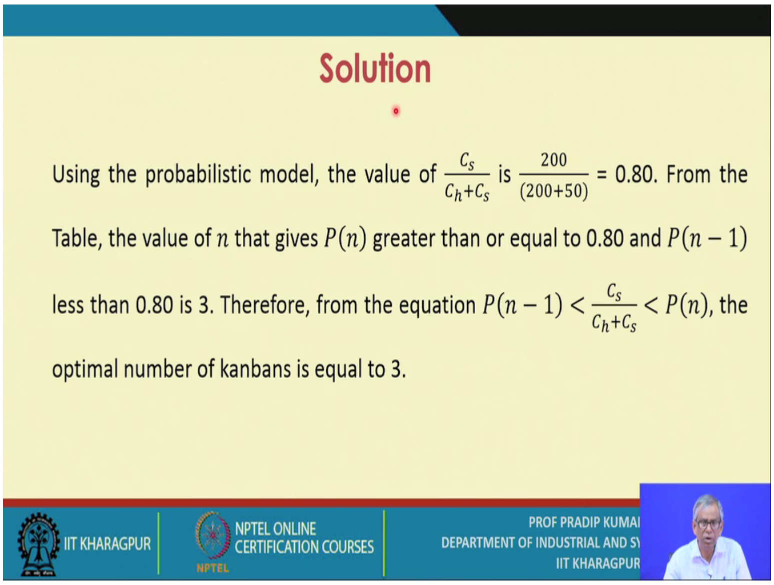

So, how do you get the solution using the probabilistic model the value of this ratio; that means, the Cs divided by Ch plus Cs. So, what is Cs? Cs is basically the shortage cost per unit per unit time definitely, so this value is given 200 the Ch is 50 and the Cs is 200. So, this ratio is 0.80 now from the table the value of n that gives you know this is the cumulative distribution function. So, the Pn greater than or equals to point is 0.8 that is the value of n you can get and similarly the value of say the n is such that Pn minus 1 is less than 0.80 ok.

So, that is 3 that means, you refer to say that the PMF table and what we do this is an exercise you have to carry out; that means, you add the cumulative the say the probability distribution say the you add 1 more column or 1 row in the in the PMF table and from this the cumulative probability values. You can you just find out that for which say the value of n you get the that is the value of say greater than or say equals to 0.8 and simultaneously you know you get a value with for Pn minus 1 less than 0.8 is it ok, so this value we will find that 3.

So, cumulative the probability the values of the table we may must refer to and then we have this defining relationship. So, this relationship holds when the up to n the value of n is 3 and hence the optimal number of kanbans is equal to 3. Now just you play you just refer to the previous the lecture sessions and we have already derived this expression to determine the optimal number of kanbans you know in a probabilistic model. So, this is a a simple approach and you know how to get this relationship and so this is the solution.

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Now, so at this point in time you know that the number of kanbans actually the determines to what extent your inventory control system is smooth under a specific conditions. Like say you know: what is the demand rate then what sort of say the relationships you have between the different stages and what are the conditions you are going to implement for getting the benefits of the kanban systems. So, the 5 or 6 important rules we have already mentioned, so while you design a kanban systems you check you verify at what extents we are able to say or the follow those rules are not. Now whenever you try to develop a JIT based the kanban systems just make a note that it is a highly ordered system highly ordered highly discipline systems.

So, it is a rule based and the specific rules for maintaining the kanban system, so that the benefits of the minimum inventory level order the WIP inventory is to be is to be ensured and you can prove later on that if you can say the manage a system or if you can develop a the JIT based systems or what kanban systems and the shop floor with a given number of say the kanbans. Then obviously, this number of kanbans being circulated at a particular point in time or during a period of time in a production system essentially this number determines the amount of more or less the amount of say the WIP inventory in the system.

So, while you determine the number of kanbans make sure that this is the optimal number and not only say the 1 objective is fulfilled, but a number of objectives of the JIT based systems you are going to fulfilled by implementing a kanban system. Now, the next important issue as I have already pointed out that is how to get a condition of batch size of 1; you are already aware of the what is a EPQ economic order quantity and economic order quantity is the finite number. And it is and always you will find it is substantially greater than 1 and there are certain assumptions and particularly in the classical EPQ the formula when you use there are 10 specific assumptions.

Now obviously, you will find that if the EPQ becomes 1 you if you and if you consider the relevant cost which we have considered while the deriving the original EPQ the formula, you may notice that with a batch size of 1 you are getting a higher the total relevant cost. So, obviously, the question may arise that why do you then the prefer a condition of batch size of 1, but then again you know if you remember that we have just considered essentially 2 types of costs while you derive the expressions for the EPQ. The first 1 is obviously, the inventory carrying cost and the second one is the ordering cost.

Now, what happens what you may observe later on that in various kinds of resources for different types of situation EPQ is in it is original form may not be applicable. Now, one important say you know the problem you might face that is what we say that your inefficiency in the inventory control systems may go up and corresponding to this inefficiency there is a cost associated with it. So, can you not the consider for different order quantity the inefficiency cost.

Now in the original EPQ formulation this the inefficiency cost is missing or you are enable to consider, now here when you move towards to the JIT based systems your first objective is to how to reduce the inefficiency cost. That means, the efficiency is to be guaranteed that means, it must be a very you know of highly responsive systems there is a hardly inning say the ideal time and the waiting time.

So, this is to be ensured so if you say they reduce the ideal time, if you read reduce the waiting time; obviously, the efficiency of the system goes up and so the cost of inefficiency will be very very less. So, you have to have this logic to you know the justified or to justify that why a batch size of 1 is well acceptable. Now in order to achieve this condition in a JIT based manufacturing systems while the batch size of an inventory item is determined we need to consider economic production quantity model.

So, you are already aware of EPQ model this is just you know it is essentially when you go for EPQ model essentially it is an outside supply case; whereas, if you opt for the EPQ model economic production quantity model essentially it is a self supply the case. That means, you have placed an work order to your own systems another subsystems of your plant and they are producing your item in the required quantity and it will it will reach you once you start when these are all the produced.

As has already been stated in the previous lecture sessions, I have already mentioned that the EPQ depends on production rate this is one important parameter you specify the production rate, you also specify the demand or the consumption rate and for the given item. That means, it is the inside supply case and one important conditions you try to fulfill that is you say that that the production rate must be greater than the consumption rate and then only it becomes an inventory related problems.

Other factors determining EPQ are the setup cost and the holding cost, so you just referred to that the total relevant cost equation you will find that this equation is formed in terms of the setup cost and the holding cost. That in JIT system it is essential that the batch size or the EPQ, EPQ is nothing but the batch size is reduced to 1 now this condition can be achieved only when the setup cost becomes negligible ideally 0; that means when you look at the EPQ formulation you look at the EPQ formulation, what do you find that there is a direct relationship between say the setup cost per setup and the order quantity.

So obviously, in order to reduce the order economic the production quantity, so what do you need to do you need to reduce the setup cost per order ok. So, ultimately what you find that when you reach a condition of say EPQ of 1; that means, Q star is 1. So, optimal say the production quantity suppose the notation is Q star. So, the Q star becomes 1 and so under Q star becoming 1 what is the value of the setup cost for order.

So, what you will find of logically you can also establish that this value of setup cost per setup cost per setup is almost negligible and then so we say it is tending to 0 and is tending to 0 cannot be at exactly at 0 you cannot determine, but it is tending to 0 maybe say the a 0.4 naughts 5 or 0.4 naughts 2. Whatever so that also you can it also determine ok, so let us first formulate the problem how to achieve the JIT goal of batch size of 1.

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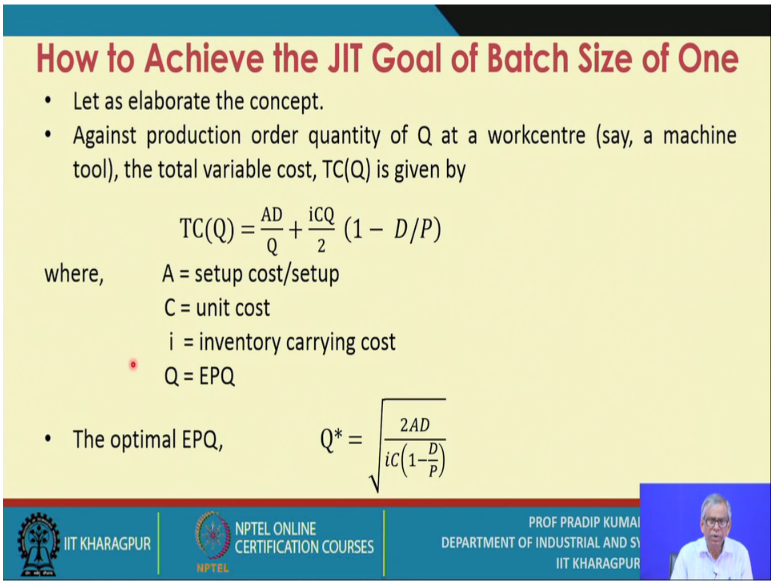

So, let us elaborate the concept and elaborate the concept against the production order quantity of Q at a work center; that means, for which this the production run or the time or run length is known and at a particular work center say a particular machinery of the machine tool, the total variable cost this expression is given by this is essentially your the total setup cost and this is this expression we derived for the total inventory carrying cost.

So, here what is capital A, capital A is the setup cost per setup so this estimates you must have capital C is the unit cost i is equals to inventory carrying cost ok, this is already known to you and the Q is economic production quantity. So, we have used this notation capital Q, so this is the capital D is the demand rate or the consumption rate and the P is the production rate. Obviously, the demand rate must be less than the production rate then only it is considered an inventory problem.

So, this is already we have elaborated the no point in you know elaborating it further. So, what do you do in order to minimize this the total variable cost, you take the while assuming that this is a continuous function and the differentiable. So, we take the first derivative with respect to Q and set it equals to 0 to satisfy the necessary condition and once you do this you get these expression that means, Q star is given by root over twice ad divided by i into C into 1 minus D by P is it and obviously, if you take the second derivative with respect to 0. So, the for minimization it will be positive, so that also you can prove; that means, making the sufficient condition.

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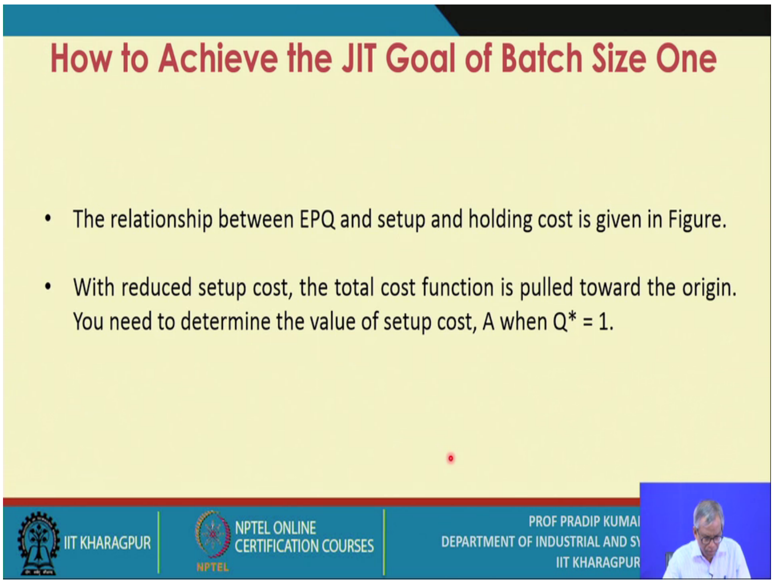

So, the relationship between EPQ and the setup and the holding cost is given in figure. So, I will show you the figure so how do you establish the relationship. So, if you have with respect to the different possible values of Q, so you get you know the different say the total relevant cost values and if you plug those values you get the relationship or the characteristics you will get.

That means, defining the relationship between EPQ and the costs the relevant cost here in this case the setup cost per setup and the holding cost these 2 are the relevant cost elements with reduced setup cost the total cost function is pulled towards the origin. So, this is very very important in fact that means, as what happens that as you try to reduce the production quantity the total cost also as getting substantially reduced. So, we need to determine the value of setup cost a when Q star is equals to 1, so that is your goal and one of the goals of JIT based manufacturing system than the batch size of 1.

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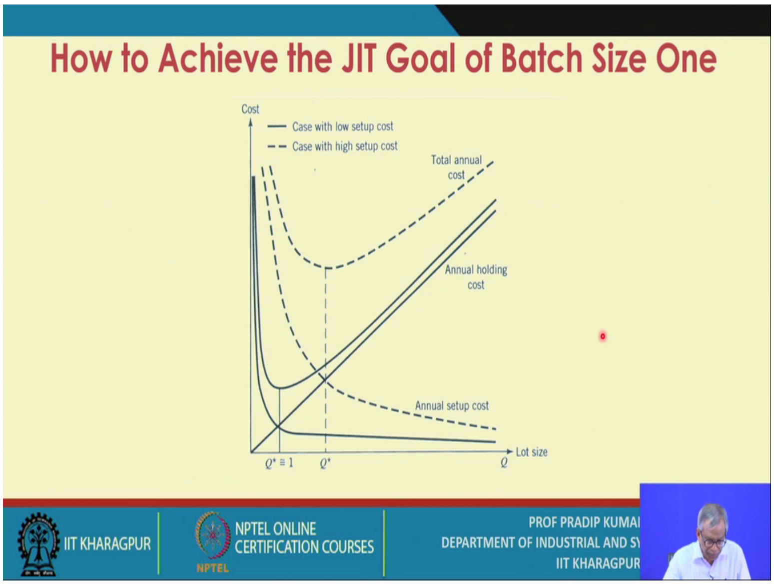

So, this is the total cost curve, so this is the total cost curve when these is the EPQ ok; that means, your say the order quantity or say you know the production quantity economic production quantity is substantially greater than 1 that is the usual case. Now what you are trying to do you are trying to reduce the value of Q star and ultimately reaches the value of 1. So, that is the batch size of 1 condition.

So, what happens that this is the relationship; that means, as you reduce the value of Q towards 0, so this total cost curve is the changes and this total cost curve moves towards say you know the 0 point is it ok. That means, towards the origin that means as you reduce. So, the first at Q star equals to at this level you find that the cost curve is this 1.

The total annual cost or the yearly cost as you try to decrease the value of Q star, so this cost curve changes it is pattern is it ok. So that means, it came it might come at this level and when it reaches Q star equals to 1 proximately 1 the cost curve look like this is it this is a typical shape you will observe. So, what we are trying to say conclude that the total cost curve moves towards the origin is it ok, so this is the interpretation of these characteristics.

So, please you know the look at this first curves and you can definitely get an idea that what are the factors actually impacting the value of say the lot size or economic production quantity in this case. So, this is a very important the figure, so you please read it and if you have any Q the later on definitely we can interact with say with respect to your possible Q ok.

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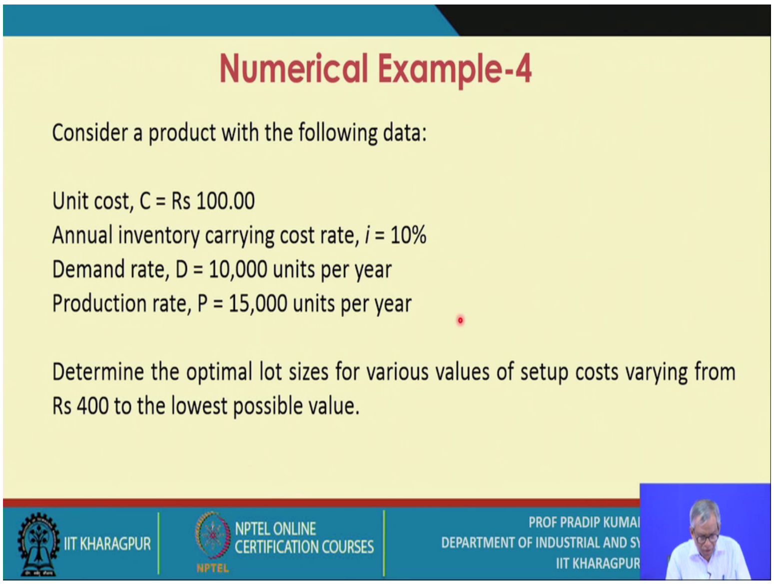

Now, here is one numerical examples related to say achieving a goal of say the lot size of 1. Now, consider the product with the following data that means, the unit cost that is 100 rupees annual inventory carrying cost rate, i equals to 10 percent is considered to be well accepted it is not that at all high in many cases inventory carrying cost could be as high as 20 percent 18 percent and all is it ok.

So, this the reflects are definitely an acceptable the condition that is i equals to 10 percent demand rate 10000 units per year and obviously the production rate should be greater than the demand rate, significantly greater than the demand rate that is in this case we are assuming that the production rate is 15000 units per year. Determine the optimal lot sizes for various values of setup costs varying from rupees 400 to the lowest possible value.

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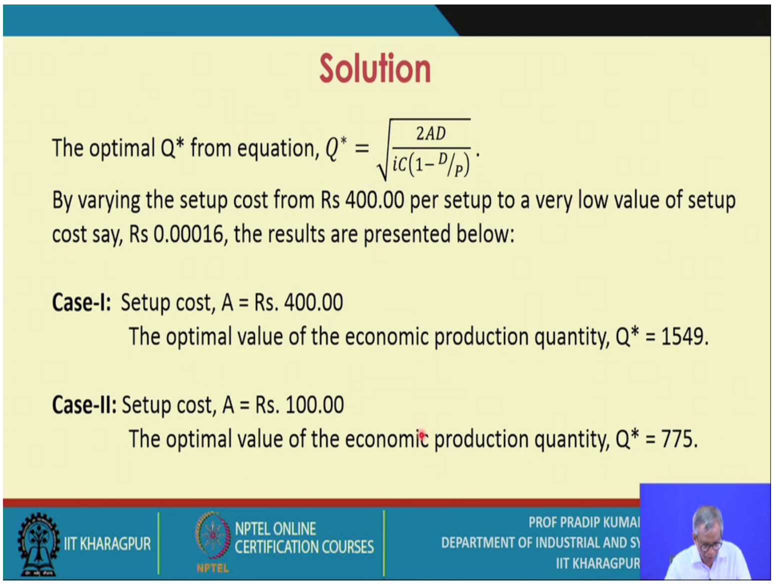

So, what we are trying to do we apply this formula for Q star this is already known to you and what do you try to do you try to vary the setup cost from 400 and per set up to a very low value of setup cost say 0.00016 as already I have pointed out that you will be this. You know the setup cost to achieve a condition of say unit the lot size that is very very the less as almost approaching 0.

So, this could be the possible value so the results are presented below that means, case 1 thus when the setup cost is 400. So, it simply you apply this equation or this formula, so you get a value of Q star 1549 when the setup cost is reduced to 100.

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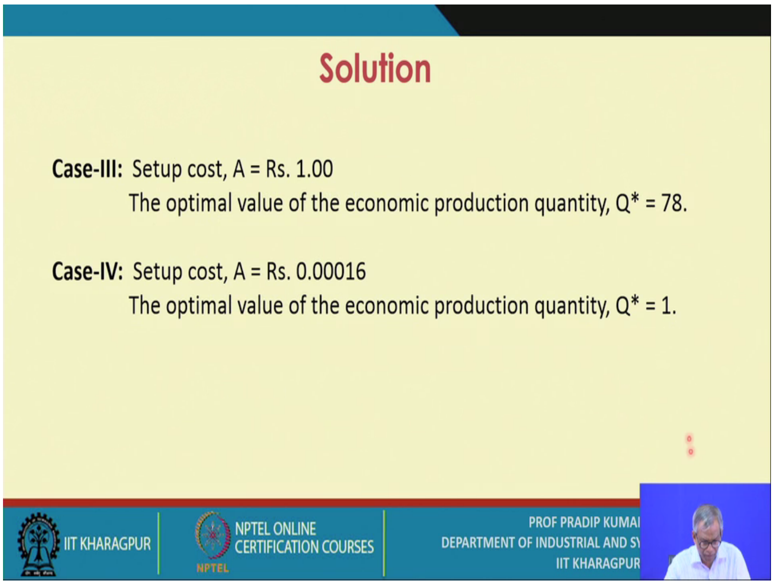

You get a value of 775 and similarly when the setup cost is as low as 1, so the production quantity Q star becomes 78 and when the setup cost is very very negligible say 0.00016.

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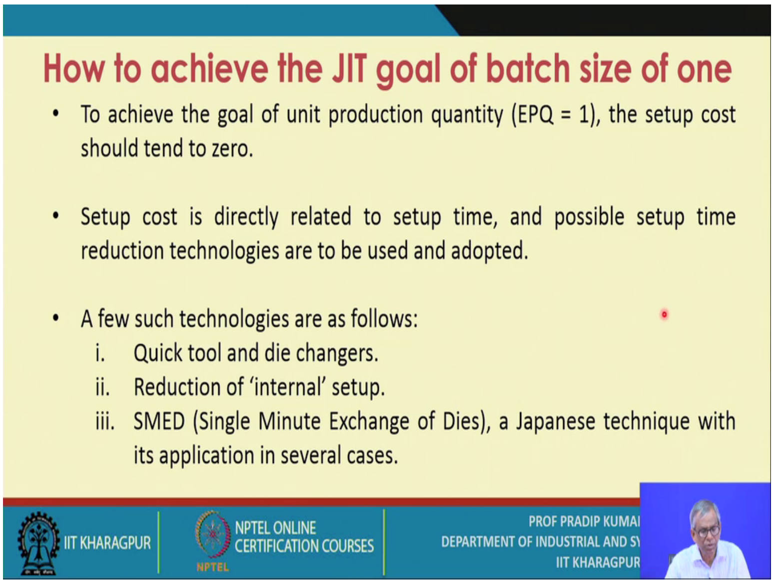

The optimal value of the economic production quantity Q star becomes 1, now the question is to achieve the goal of a unique production quantity the setup cost how to reduce the setup cost to almost 0. So, the setup cost is directly related to setup time and possible setup time reduction technologies are to be used and adopted. So, just I will mention later on and course of time we will elaborate on this, but at this point in time you must know. So, what are the possible technologies available for reducing the setup time.

So, this technology possible technologies are quick tool and die changers reduction of internal setup is very very important this point already I have elaborated. The technique called SMED a single minute exchange of dies a Japanese technique with it is application in several cases.

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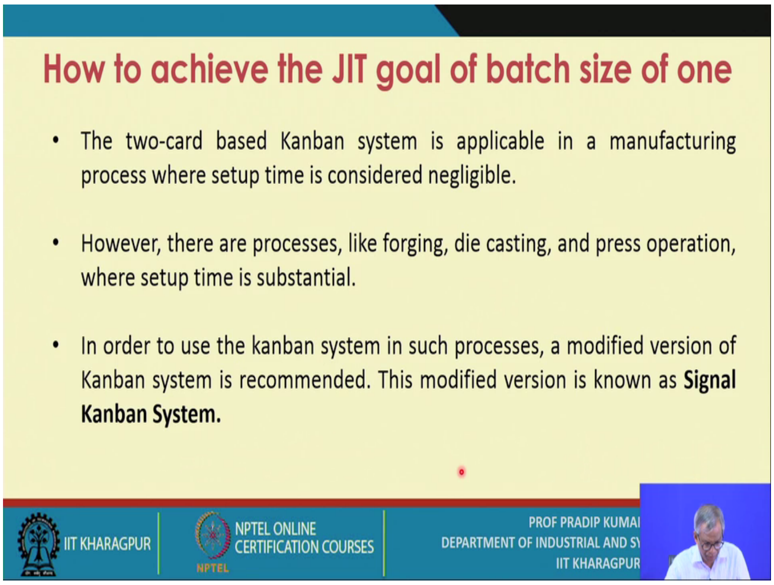

The two-card based Kanban system is applicable in a manufacturing process, where the setup time is considered negligible these I have already pointed out. However, there are processes like forging die casting and press operations where setup time is substantial you cannot avoid. In order to use the kanban system in such processes a modified version of kanban system is recommended and this modified version is known as the Signal Kanban System.

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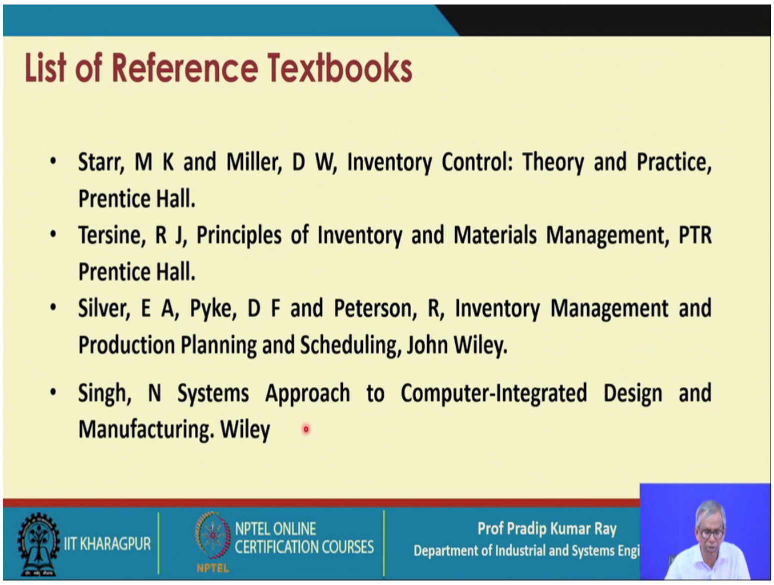

So, we are going to discuss the signal kanban systems with other important issues they related to the JIT based production systems production and inventory control systems in our next lecture session.

Thank you.