Industrial Engineering

Prof. Inderdeep Singh
Department of Mechanical & Industrial Engineering
Indian Institute of Technology, Roorkee

Module - 4
Lecture - 2
Materials Management – II

Warm welcome to all of you in this second lecture on Materials Management, in the first lecture on materials management we started the discussion with the very simple example of buying the potatoes. If you remember, we have seen that what are the different decisions that we have to take, when we go out to the market to buy any simple commodity such as potatoes. We have seen that material management is one of the most important aspects of industry management or industrial engineering.

We have seen that what is the scope of materials management, what is the responsibility of the materials management department and then we have seen that inventory that is the stock of materials, kept in order to meet the future demand It a very important part of materials management process inside the industry. So, we have seen that inventory is required, it is essential and what are the needs of holding and inventory and what are the advantages that we derive, if we maintain a certain amount of stock in our inventory.

So, we have seen that inventory is an essential part and it has to be operated upon or it has to be kept, or the stock of materials has to be held inside the industry in order to avoid certain breakdowns or in order to avoid a smooth flow breakage, in the smooth flow of the manufacturing processes. So, we have seen, so many advantages can be derived if we keep a stock of materials, but it is not that easy. Whenever, we keep a stock of materials there is always a cost associated with that.

Suppose, let me take an example of a warehouse, which is keeping the inventory of refrigerators as well as the television sets, so if we are managing an inventory of hundred refrigerators and hundred television sets. So, we can see that what will be floor area required to manage this type of a warehouse and if we put a cost on each square feet of the floor area, it will run into thousands of rupees, if we are managing this warehouse in a very busy market.

So, holding an inventory is also very, very important and it is associated with economics, so money is required to hold a inventory, we can call it as a carrying cost or the holding cost. Similarly, when we are ordering, we have to do a complete process, that is why we have covered in the last lecture the procurement process, it has different steps and at each and every step there is money involved or the economy involved in the procurement process placing an order, doing the comparative study, so many things are there that we will cover that what comprises of a ordering cost.

So, there is ordering cost associated with holding an inventory, developing is a carrying cost associated with holding an inventory and all these add up to the total cost of the inventory. So, in today's lecture we will start our discussion with a different types of cost associated with the inventory and then we will try to find out another important point that is what is the optimal quantity that we should order, then there are different models for this. There is a economic order, quantity model, there is a production quantity model.

So, we will see, that what are these models, what are the assumptions of these models and then we will try to solve certain simple problem, so that you get an ideal that what are these tools and how these tools can be used in order to solve problems related to inventory management in specific and materials management in general. So, we will start today's discussion with a brief introduction to the different types of cost associated with the inventory, so in the next slide, I am just going to show you a very simple diagram.

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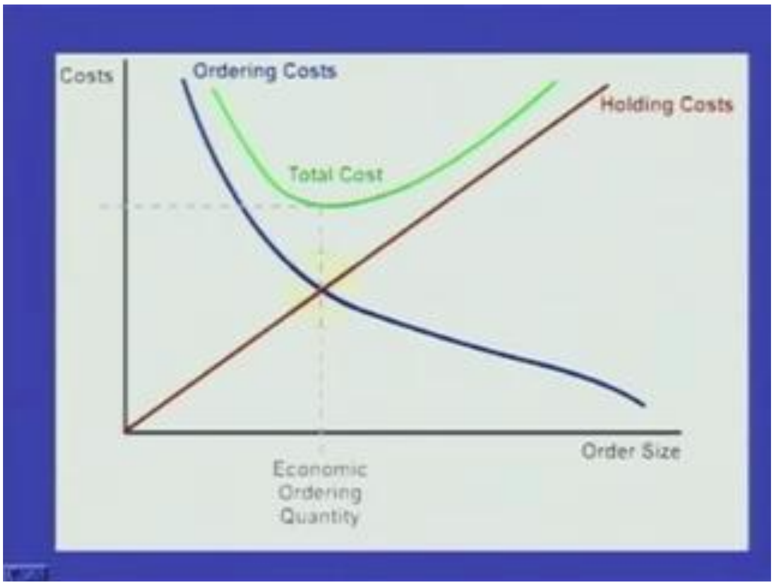

On your screen, you can see that on y axis we have the costs and on x axis we have the quantity or the order size, so we see that as the order size is increasing, now this is the ordering cost this the color of the text also explains, this is the blue color and the blue color line is showing up ordering cost. And similarly this is the red color, if we call it as a red color, this is the holding cost, so we can see that as and when the order size is increasing, increasing in positive x direction.

So, as the order size is increasing, the ordering costs are decreasing, so we can say this we have already covered in the last class that if the quantity will be more the ordering cost will be less. Similarly, the holding cost, already I have told you with a help of an example I have told you that holding cost, basically is associated with holding an inventory inside the work space or inside the industry.

So, it will require certain space, it may also require certain air-conditioning requirements, certain environmental requirements, certain the requirement, so certain requirements are there and those will add to the cost. So, whenever we are holding an inventory it will be having some cost and the holding cost will also be increasing with the order size, so, when the order size is increasing the holding cost will increase and when the order size is increasing the ordering cost will decrease.

So, the ordering cost is decreasing and the holding cost is increasing with the order size, so we the find out the total cost, a total cost of holding the inventory will be a summation of the ordering cost and the holding cost. So, we have already seen just to summarize as the order size increases the ordering cost decreases, as the order size increases the holding cost increases and then the total cost is found out by the addition of these two and the green line is showing the total cost.

Now, total cost is this much, this may be rupees y and corresponding to the total cost there is a minima that is happening at this point and this is called as the economic order quantity. So, this economic order quantity, we need to find out at which the total cost is giving us the minimum value, so in after adding the holding and the carrying cost or ordering and the holding cost sorry I have said holding and the carrying cost that is one, one and the same thing.

So, holding cost plus ordering cost when we add, we get the total cost and wherever the total cost is minimum that is called the economic ordering quantity. Now, may there may be I have been using these words quite often in this lecture itself ordering cost, holding cost, total cost, so we need to understand that what comprises the ordering cost, what comprises the holding cost that we are going to discuss in the subsequent slides. So, that you may be able to better have an idea that what is the ordering cost and what is the holding cost. So, the inventory cost, basically are carrying cost, which can also be called as the holding cost.

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This is the cost of holding an inventory or holding an item in an inventory, so the carrying cost can we say, said to be per unit, so per unit carrying cost is this much, it can be 0.75 dollars per unit, it can be 1.5 dollars per unit. So, the carrying cost is the cost of holding an item in the inventory, ordering cost basically is cost of replenishing the inventory. Now, the inventory has declined or the stock of items that have been kept in the inventory has declined to a particular level.

Now, we want to replenish it, we want to reorder, we want to again have the stock to a particular level, so that basically is the ordering cost or the cost associated with replenishing the inventory is called the ordering cost. We will also see that what are the various components of cost that will add up to make these costs in the subsequent slides, but right now just in order to understand the various terms that are used in finding out the economic order quantity that we are trying to discuss.

In the first diagram, I have shown that the ordering cost decreases with the order size and the holding cost increases with the order size and the total cost minima gives us the economic order quantity. Then, there is a shortage cost that is temporary or permanent loss of sales when demand cannot be met, so always there is a cost associated with the shortage, if the material is not available with us we will not be able to have a smooth flow of products or the smooth manufacturing of the products because of this shortage.

There will be a cost associated with the shortage, now different types of cost we will try to have an idea that what are the various components of the ordering cost, what are the various components of the carrying cost and we will see that how these components add up to make up a total carrying cost and a ordering cost, so let us see that what is first, the unit cost.

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It is usually the purchase price of the item under consideration, if unit cost is related with the purchase quantity it is called as a discount price, so unit cost is basically the money that we spend in order to a require that item or in order to purchase that item, but if certain discounts are available then we call it as the discount price. So, we can see that unit cost is something that is related to the cost of the product or the price of the product or the purchase price of the item under consideration.

So, here in our discussion, we will take the unit price as the purchase price of the item under consideration then the ordering cost, this includes the cost of the order preparation, tender placement, cost of postages, telephone costs, receiving cost, set up cost. So, all these costs will add up to finally, form the ordering cost, so you can see that there are so many components of the ordering cost, so if the quantity of the order size will increase this order, ordering cost will decrease which has been shown in the very first diagram with which we started the lecture.

So, once again to give you an idea that what are the various components of the ordering cost, I will read it for you this is the tender placement cost, cost of postages, telephone cost, receiving cost and setup cost. So, all these cost will add up to form the ordering cost, now next is the carrying cost, the cost of maintaining the inventories in the plant. Now, we have ordered, we have received and we are now keeping a stock of those items within the plot or in the industry or on the shop floor or in the store house.

So, the cost associated with maintaining that inventories in the plant is called the carrying cost, so it includes the cost of insurance, security, warehouse rent, taxes, interest on capital engaged, spoilage, breakage etcetera. So, we can see, there are so many components that add up to the total carrying cost, so we can see that if we depute two security man outside the store that is going to add to the carrying cost.

If we are, if we want that whatever material we have put in the inventory that requires are refrigerated atmosphere or certain temperature has to be maintained then the cost of running that kind of equipment will be added up to the carrying cost. One example already I have given that if we have to manage an inventory of refrigerator as well as the television sets, again the floor space requirement will also add up to the carrying cost or the rent that we have to pay in order to manage that warehouse will add up to the carrying cost.

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So, just to revise that what are the different types of carrying cost that is it includes the cost of insurance, for sure security, warehouse rent, taxes, interest on capital engage, now this is an important point that we want that minimum amount of capital should be tied up to the inventory and that is why we want to find out the economic order quantity. So, that less amount of capital that is the total cost involved in the inventory should be minimum.

So, interest on capital engage because all the industries will have certain capital and they might be paying certain interest as they might have arrange the capital on loan, so that interest will also get added to the carrying cost and the spoilage breakage, this is very simple that even if certain amount of items are spoiled or broke are broken down while transferring them within the store room or in the warehouse that will also be added to the carrying cost.

So, we have till now seen that what is a unit price, what is the ordering cost, what are the different components of the ordering cost, what is the carrying cost, what are the different components of the carrying cost, now last is the stock out cost that we have already seen as the shortage cost. The cost of loss of demand due to shortage in supplies, now for example, there is a demand in the market, but because of shortage of the raw materials available in our inventory we are not able to supply the final product for which the demand is there or we are not able to service the demand, which has been raised by the customer, so this is going to result in a loss.

So, this includes cost of loss of profit, if we would have been able to meet that demand we would have got certain profit, but we as we are not able to beat that demand then the loss of profit is going to take place. Loss of customer then the customer will automatically go to some other competitor, as I have told you that if a customer comes to a show room and he wants to buy a motor cycle of our company, but we are not able to meet that demand because of the lack of materials or lack of inventory in our manufacturing plan then the customer will automatically switch to some other competitor.

That is why we are losing the customer, we are losing the profit, we are losing the goodwill as well as sometimes we may even have to pay the penalty. For example we are manufacturing a particular product for a particular company and we have agreed in our contract that we will be able to supply this product after three months and after three months every alternate week will invite a penalty, now because of the lack of materials that are available in our inventory, we are not able to meet that stipulated time of three months.

So, every week, now we are paying the penalty because of the lack of materials or the stock out cost, so this cost will be added to the stock out cost. So, if we are not able to manufacture the material on time or there is a stock out situation, what is the stock out one line definition I will give in the subsequent slide. So, if there is a stock out then there are, so many cost associated with it. So, what are those costs, loss of profit, loss of customer, loss of goodwill as well as certain penalty cost that are there in the contract agreement between the supplier as well as the buyer.

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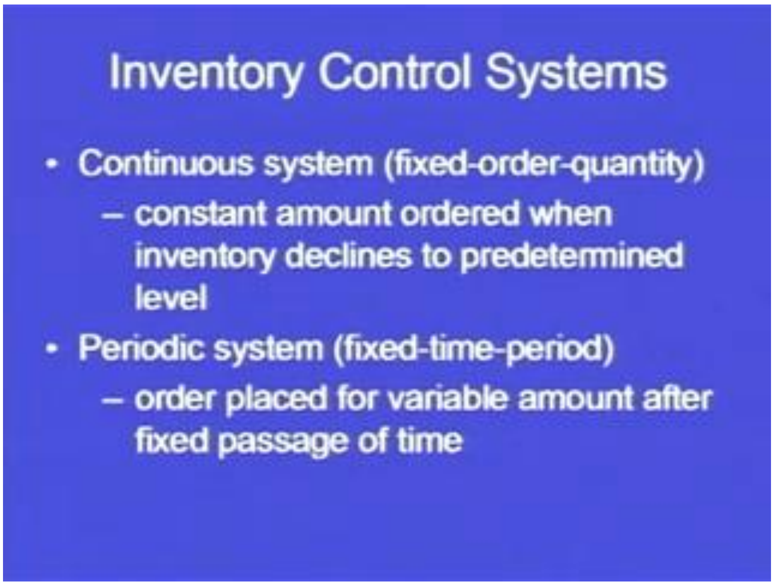

Now, inventory control systems, there are two types of inventory control systems that the namely continuous system. In continuous system we are having fixed order quantity, what does this mean, this mean that constant amount ordered when inventory declines to a predetermined level. Suppose we have hundred parts in our store, every day we are using ten parts, so after eight days, ten multiplied by eight because ten parts we are using per day, eighty parts will be used only twenty will be left.

Now, we will order again hundred parts that is fixed order quantity, constant amount order when inventory declines to a predetermined level, now what is this predetermined level, predetermined level is twenty in our case we already have hundred every day we are using ten after eight days, eighty have been used twenty are left. So, we this predetermined level is twenty as soon as twenty are left we are again going to place a order, so that order will be fixed order quantity order that may be hundred, that may be five hundred, that may be five thousand, but the amount or the predetermined level is fixed.

So, this is called as a continuous system as and when we are using the inventory as soon as we achieve that level or we reach to that level, where we have to again place an order for the fixed order. Constant amount is ordered, when the inventory declines to a predetermined level, now contrary to this there is another control system, which is called as the periodic system, in periodic system there is a fixed time approach. In first case there was fixed order quantity means the quantity is fixed, in this case time is fixed.

So, order placed for variable amount after fixed passage of time, so the amount is variable here, but the time is fixed, now we can say this periodic system they can be very easily understood. If we take an example of a shopkeeper, a shopkeeper is running his business suppose he is selling the cosmetic items, a particular salesman of a particular brand comes to this particular shopkeeper after every one month, so the time is fixed, one month is fixed.

Every one month, the salesman will come and this particular shopkeeper has to order whatever quantity he decides, suppose he has face creams he has ordered last time hundred face creams over one month he has been able to sale forty. So, sixty are all already lying in on his shop, so he can take a decision how much he should place an order after one month, but the time is fixed every one month he has to place an order.

In first case, the quantity is fixed as soon as the quantity comes to that level no matter what is the time, the order has to be placed for the fixed quantity, but in this case the quantity is not fixed, quantity is variable. We have, on your screen you can see order placed for variable amount or variable quantity after fixed passage of time, so that time is fixed that after every one month or after every fifteen days or after every seven days you have to place an order of the variable amount.

So, we have to take a decision as a manufacturer or as a materials management personal that what type of system we have to follow, whether it has to be a continuous system or it has to be a periodic system because this is also going to have a bearing on the total cost of holding an inventory. Now, we come on to a very important tool, which is used in inventory management which is called as the ABC classification.

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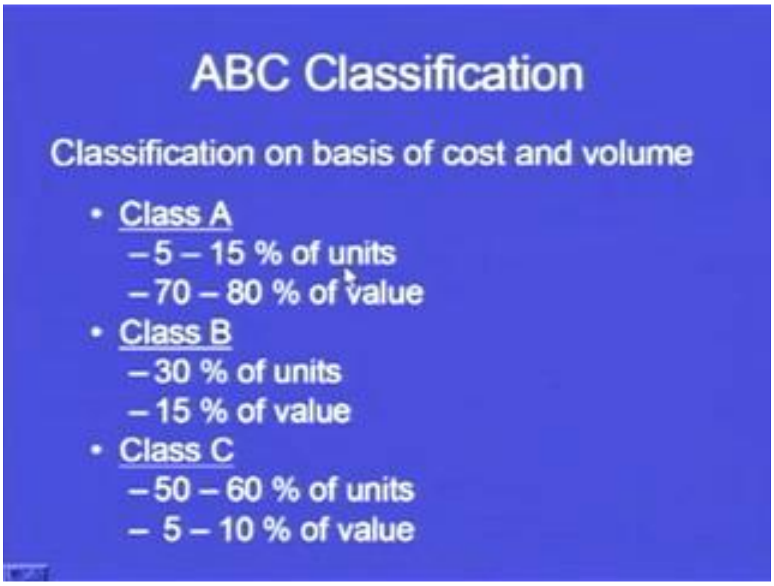

Now, having taken a decision that we are going to hold an inventory there will always be a cost associated with holding an inventory that we have already seen there will be a total cost, wherever the total cost will be minimum that will be the economic order quantity. And then in the last slide we have seen that there are two types of systems one is the periodic quantities periodic system and another one is the continuous system, all that we have already covered.

So, we have to now see that how the materials will be classified, so ABC classification is one of the most important classification schemes used in order to classify the materials into three categories, so here we see that this is a classification that is based on either the cost and the volume. So, either we can on the basis of cost only we can say this is the classification of materials that are used in our industry or on the basis of volume or on the basis of both.

So, the criteria on the basis of which we are going to classify these items is given on your screen, so we can say that class A items will be the items which will be 5 to 50 percent of the units. So, on the basis of volume, on the basis of volume these will be 5 to 15 percent of the units only, but from the point of view of the value this will be 70 to 80 percent of the value. So, we can see class A items are those items which are less in quantity, but the dollar value associated with them or the rupee value associated with them will be 70 to 80 percent.

So, these are costly items, so the costly items which have more value are having less number of quantity or they should be sold in less in of quantity. Similarly, class B items are items which will be 30 percent of the units, so 30 percent of the total volume, but 15 percent of the total value. Similarly, class C items will be 50 to 60 percent of the units, so this is bulk, suppose we take an example of any manufacturing company, so the stationary items pen, pencil, copies all these things can fall in the class C items, so we can hold a large inventory are the amount of these items can be more.

So, 50 to 60 percent of the units by volume will fall under class C and 5 to 10 percent of the value, so the money associated or the dollar value associated or the rupee value associated with class C items is less. It is 5 to 10 percent only, but 50 to 60 percent of the items, so volume wise it is more, but money wise it is less. So, this we will try to understand with the help of a very simple diagram.

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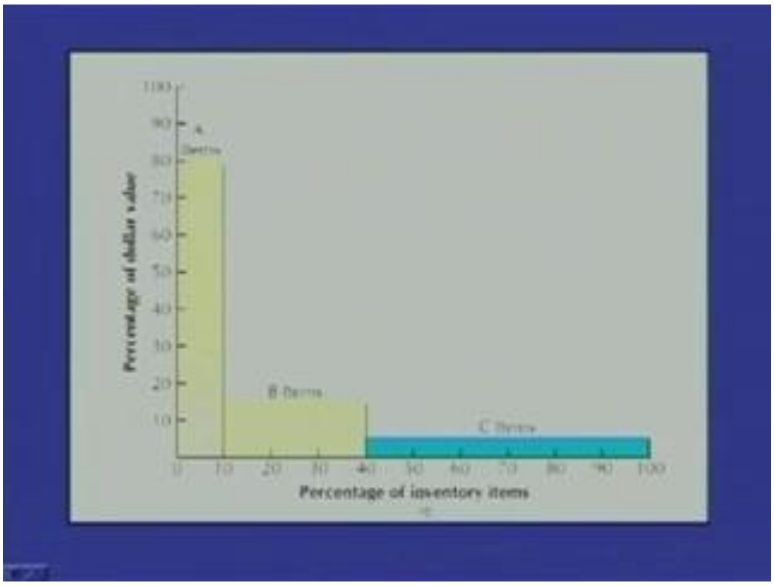

Now, on your screen you can see a diagram, which clearly illustrates that on y axis this is the percentage of dollar value and on x axis this is the percent of inventory items, so once again just to repeat, percent of dollar value is on the y axis and percentage of inventory items is on the x axis. So, we can see that A class items or A items these are having 80 percent of the dollar value, this is the percentage of dollar value, 80 percent of the dollar value and only 10 percent of the inventory item.

So, only 10 percent of the inventory items, which are having 80 percent of the dollar value or the total value, these will be classified as A class items. Similarly, if we come to B items, B class items are having 10 20 30 may be 30 percent of the total volume of items or total volume of inventory items and the cost associated or the dollar value associated with this is, may be 15 percent. So, the dollar value is less and the percentage of inventory items is more.

Similarly, the C items, we can see that the percentage of inventory items falling in C i category items is much more, but on the other hand, we can see that the percentage of dollar value associated with these items is decreasing. So, this can be set as 5 percent only, so the percentage of dollar value is only 5 percent, associated with C class items, but the amount of items or the volume of items we can say is much more, we can say this is from 40 to 60 may be 60 percent of the item sorry 40 to 100, we can say 60 percent of the items are falling under the C class items.

So, how this classification is going to be helpful, now in an industry, so many type of materials are being used some are very costly, some are relatively cheaper, some are very, very cheaper, so we have to classify, so that in order to optimize the total cost that is tied up with holding an inventory. If, we keep equal number of items of each and every class of items then the total cost involved, in holding that kind of an inventory will be relatively higher.

But, if we segregate the total number of items into different categories as here we have done we have classified into three different categories. Class A items, class B items and class C items, so overall we are able to optimize the total cost that we are spending or we are able to optimize the capital that is tied up in holding the inventory. So, there are other classification schemes also available, but in our lectures on materials management, this is one that we are going to cover, there may be others that can be referred to in the related text books and the other reference materials available in the libraries.

But, here we are going to focus our attention on ABC classification of items in inventory management, so by now I think all of you might have been able to understand that what is the need of classification and how ABC classification is done. Now, this percentage that we have identified here, this is variable, when you go and refer back to different books this percentage may be slightly variable, but the broad spectrum or the broad classification will be seen.

A class will have high value items, but the volume contribution of these items will be less, whereas the C class items the large amount of volume of items will fall in C category and the cost associated or the dollar value associated with these type of items will be relatively less as on your screen, it you can be seen that is only 5 percent of the total value. So, now we will try to understand that how to carry out this type of a classification scheme with the help of an example. Now, ABC classification we are going to see an example of ABC classification. Let us see, now there are 10 different parts.

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PART	UNIT COST	ANNUAL USAGE
1	$ 60	90
2	350	40
3	30	130
4	80	60
5	30	100
6	20	180
7	10	170
8	320	50
9	510	60
10	20	120

So, the part numbers are given, kindly pay attention to the screen that part number 1 2 3 4 5 and similarly to 10, so there are 10 different parts, each part is having a unit cost like we can say part number 1 the cost is dollar 60. Part number 2 the cost is 350, part number 3 30, so in dollars we have may be dollar could have been written here, but the all these costs are the unit costs are in dollars. So, for part 1 the cost is 60 dollars and similarly for part 7 the cost is per unit cost is dollar 10.

Similarly, if we require another information that what is the annual usage, now annual usage we can see that for part number 1 we are using 90 parts or 90 components. For part number 2 we are using 40 components annually. Similarly, for part number 6 we are using 180 components annually, so what is the type of information required when we want to do a classification on the basis of ABC.

We need to know that what is the unit cost of the part or the component and what is the annual usage of that component in the industry and then subsequently we go forward in order to do the calculations and in order to classify these 10 items in A B and C category. Now, we can see, we have arranged them in the total value, in the descending order of the total value.

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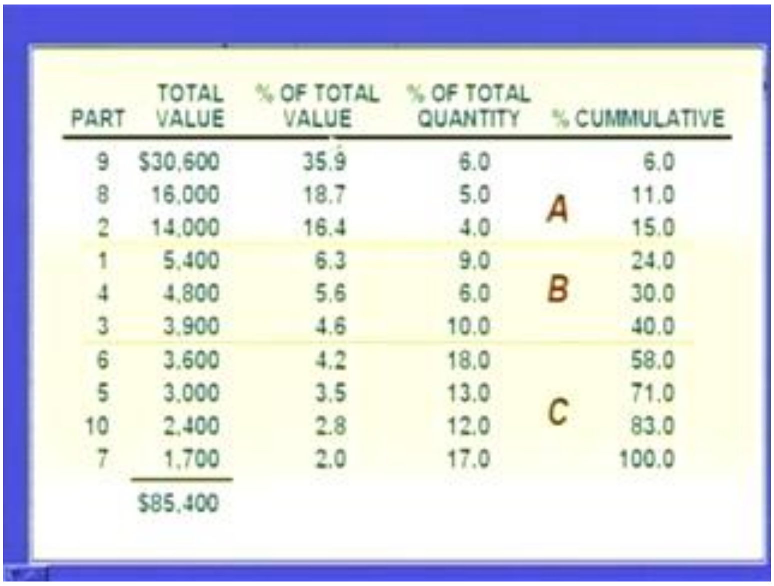

PART	TOTAL VALUE	% OF TOTAL VALUE	% OF TOTAL QUANTITY		% CUMMULATIVE
9	$30,600	35.9	6.0		6.0
8	16,000	18.7	5.0	A	11.0
2	14,000	16.4	4.0		15.0
1	5,400	6.3	9.0		24.0
4	4,800	5.6	6.0	B	30.0
3	3,900	4.6	10.0		40.0
6	3,600	4.2	18.0		58.0
5	3,000	3.5	13.0	C	71.0
10	2,400	2.8	12.0		83.0
7	1,700	2.0	17.0		100.0
	$85,400				

On your screen, you can see the part number 9, if I refer back to the previous slide you can see part number 9, the unit cost was 510 dollars and the annual usage for this was 60. So, just by multiplying it, we get dollar 30600, similarly for all the parts we get what is the total value, so we have arranged it in the descending order, so the part number 9 is having a maximum of the total value that is 30600 dollar.

And part number 7 has the minimum of total value, so you can see part number 7, 10 is the unit cost and 170 is the annual usage, so this the multiplying, if multiplying 170 by 710 we get it is 1700. So, we can see that in ABC classification part number 7 the total value is 1700 and the overall total value, if we sum up all these comes out to be dollar 85400. Now, we will see that how much percentage contribution is done by part number 9 to the total value, the total value is dollar 85400.

So, part number 9 is contributing some values, so what is that value, that value is 35.9 percent, similarly part number A is contributing 18.7 percent, part number two is contributing 16.4 percent. So, similarly we will get that how much amount is being contributed towards the percentage of total value that 35.9 percent is the contribution of part number 9 to the total value. Similarly, we can see from the percentage of total quantity that part number 9 is having 6 percentage of a total quantity and part number 7 is having 17 percent of the total quantity.

So, we can see that, what is the total quantity that is being used by the summation of all the annual usage of all the different parts, so in our case we have 10 different parts and all these 10 different parts we are adding up all these 10 usage of all these 10 different parts to get the total volume and then we are saying what is the individual contribution of each part to that total volume. So, we have seen that part number 9 is contributing 6 percent and part number 6 suppose is contributing 18 percent and then we get the percentage of total quantity.

Finally, we find out the percentage of cumulative, now 6 total part 6 then 11 6 plus 5 11 plus 4 15 15 plus 9 24 24 plus 6 30. So, similarly we find out the percentage cumulative this will help us in order to classify the items in A B and C category. Now, here you can see that part number 9 8 and 2 they are falling under category A, now how they are falling under category A that we need to understand.

Now, we can see, what is the percentage of total value 35.9 18.7 for B and part number 2 is contributing 16.4 percent of the total value. So, if we add up all these things, this will come to nearly about 71 percent, coming onto part B 6 plus 5 11 plus 4 15, so it is into the tune of more than 16, so 16 percent contribution of the total value is being done by part B. So, the items that are falling under part B classification are contributing around 15 to 20 percent to the total value.

Similarly, when we see part C, we can see 4 plus 3 7 plus 2 9 plus 2 11 so may be 11 percent contribution is being done by to the total value by class C items, so we can see if we do the classification on the basis of percentage of total value, we can see around 70 percent of the total value is being classified into A category around 15 to 20 percent of the total value is being classified into B category. And for around 10 percent is being classified into C category.

Similarly, from the point of view of the percentage of cumulative of the total volume or the percentage of total quantity, we can see that part one, A category this is cumulative is 15 percent. So, 71 percent of the total value and 15 percent of the total quantity is being classified into category A type of items. Similarly, category B type, so here we can see top 15 have already gone, so we see that another till 40, so 40 minus 15 around 25 percent of the item are being categorized into B category and then rest is being categorized into C category. So, we will see that what is the percentage contribution towards total value and total volume in the next slide.

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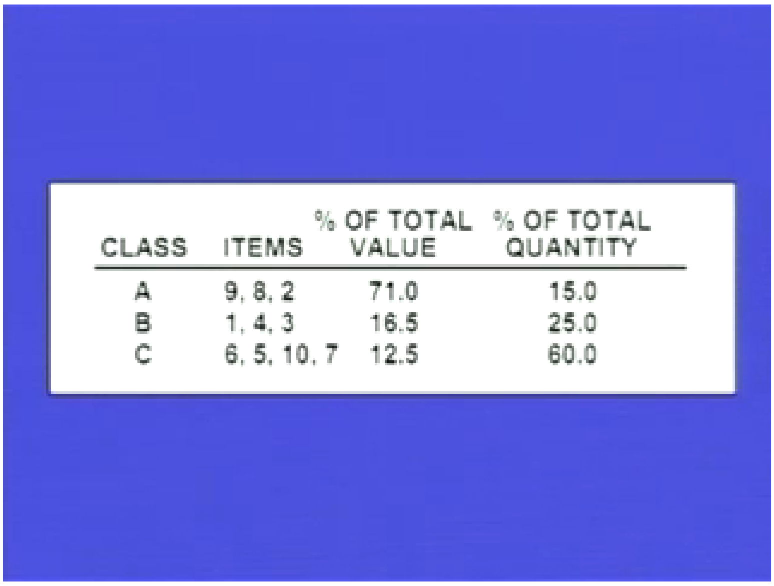

Now, here we can see class A items, so what are class A items, In previous slide we have seen item number 9, 8 and 2 they contribute they have total of percentage of total value of 71 percent and the percentage of total quantity as 15 percent. Similarly, class B items now class B items, which are the total three items that are falling in class B category, they are item number 1, 4 and 3, so 1, 4 and 3 can be classified as category B items.

So, what is their contribution to the total value that is 16.5 and the percentage of total quantity they are having 25 percent of the total quantity, that I have already told when we were discussing the previous slide. Then category C, the percentage of total value contribution is 12.5 and the percentage of total contribution to the total quantity is 60, so the quantity is more here, but the total value or the contribution total value is relatively less that is 12.5 and which are the items that are falling in category C as on your screen you can see 6, 5, 10 and 7.

So, item number 6, 5, 10 and 7 are falling in category C, so we have seen with the help of an example that if we have the information related to the per unit cost of the item and the annual usage of that item, we can very easily classify those items into category A or class A, class B and class C in order to optimize the total cost. So, now there is another point that we have seen in the very first diagram of this lecture that is the economic order quantity.

Now, we will see what it the economic order quantity, this is the classification which is required in order to minimize the total cost of holding an inventory by classifying the items into A B and C category. Now, we shift our attention to the economic order quantity model.

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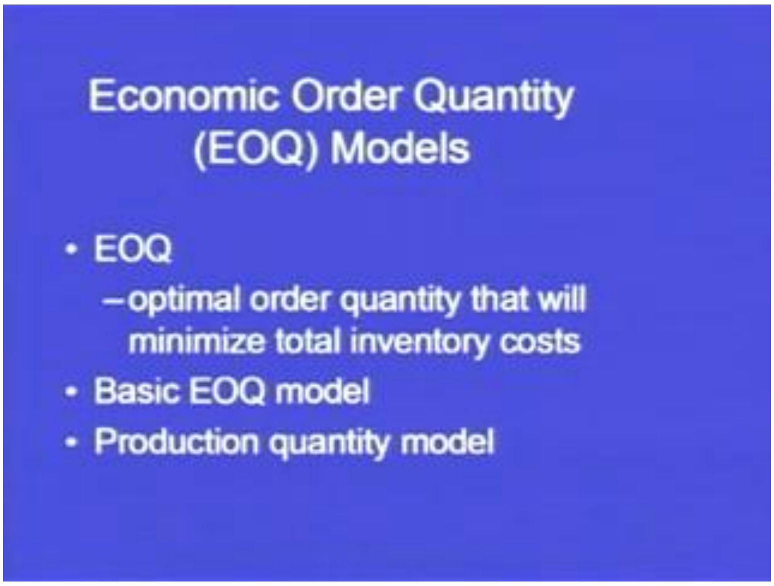

The economic order quantity model, so EOQ which is called as the optimal order quantity that will minimize the total inventory cost, so basically as a materials manager or an executive of the materials management department, it is the duty into minimize the total costs associated with the inventory. So, EOQ is one of the tools that is it gives us the optimal order quantity that will minimize the total inventory cost.

If you remember, in the beginning of the lecture we have seen that the total ordering cost reduces, when the order size increases and the total holding or the carrying cost increases as the order size increases. So, with an increase in the order size, we have seen that the ordering cost is decreasing and the carrying or the holding cost is increasing, so we find out a total cost and the total cost is minimum for a particular order size. So, that order size we call as the economic order quantity.

Now, we will see what is the basic EOQ model and the production quantity model also we will see and what is the difference between these two that we will try to understand. Now, there are certain assumptions that are associated with the basic economic order quantity model.

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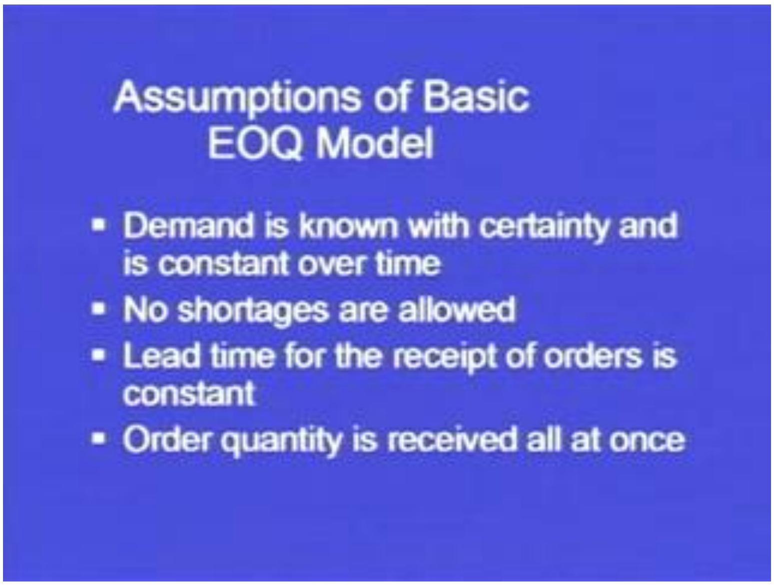

First is that the demand is known with certainty and is constant over time, so with the help of a diagram I will explain what does this means that the demand is constant, for an example we can see that the demand is constant means 10 components are used per day or 500 components are used per week. So; that means, that this demand is going to be constant over a period of time, this is not variable that on Tuesday we require 15 components and on Wednesday we require 30 component and on any other day of the we require some other quantity of the component.

This is not going to be of that nature, the demand is going to be constant with time that is the first assumption of the EOQ model, then we are not considering the shortages here no shortages are allowed. Lead time for the receipt of orders is constant it means that the day we place the order and the day we receive the materials the time in between them is constant. It means lead time is not increasing or decreasing, it is not contracting not expanding, if it is 10 days it means it is 10 days and it is assumed as one of the assumptions of economic order quantity.

Similarly, the order quantity is received all at once, it means that today we place a order after 10 days we receives, suppose the lead time is 10 days, so after 10 days when we receive the material it will be received all at once. Suppose we have ordered 500 components, so after 10 days we will receive all those 500 components in one lot only means it will not be received in number of lots over a period of time, so this is one of the assumptions, which is relaxed for production quantity model. Mind it, please keep it in your mind that this is one of the important assumptions which is relaxed in case of production quantity model in which we receive the material at a rate,
It is not received all at once it is received over a period of time.

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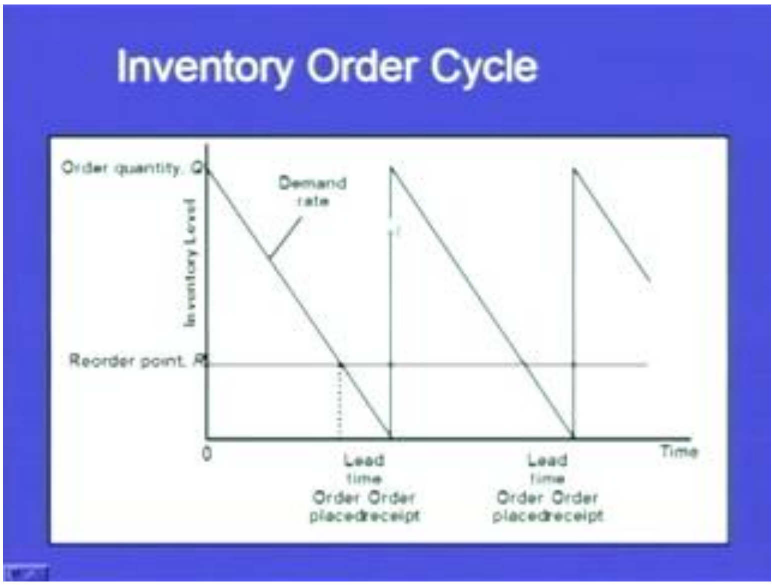

Now, this is the inventory order cycle on your screen, you can see that this is the order quantity Q that we have ordered, this is the demand rate this slope, this is the demand rate at which the inventory or the stock of items is being utilized or used. So, you can see this is constant over a period of time it is not variable, it is not changing like this haphazardly that diagram also we will see. It is not changing haphazardly, it is constant over a period of time.

Now, this is the daily demand rate, so this is the inventory level we will see that the inventory level is depleting, now Q is the order quantity that we have received, suppose it is 100 now it is decreasing from 100 and suppose at 20 we have decided that it is going to be the reorder point. So, 20 is our reorder point at which we are again going to place an order, now the at this movement of time, this is the point where we have placed the order and this is the point where we have received the order, so the time between placing an order and receiving an order is called the lead time.

So, we have seen the last assumption of economic order quantity model that all the things or all the components or all the order or all the lot is received at once, so as soon as we receive the material here it is received in a complete lot. Suppose, we have Q is equal to suppose 500, so all 500 we have received here, so we will see this will again on the same day, this will again the inventory level rise to 500 and again we will start using it.

So, suppose I have taken in the previous example Q as 100 and at 20 we are reordering, once we received the order again the Q will become 100 and again we will start reusing it at 20. Again we will place an order, after suppose the lead time we will receive the order and all the order will be received at once and this will again the inventory will again rise or the level of inventory will again rise and again it will become 100. So, in this way the inventory order cycle will keep on going with time in case of economic order quantity model. Now, this is the economic order quantity model.

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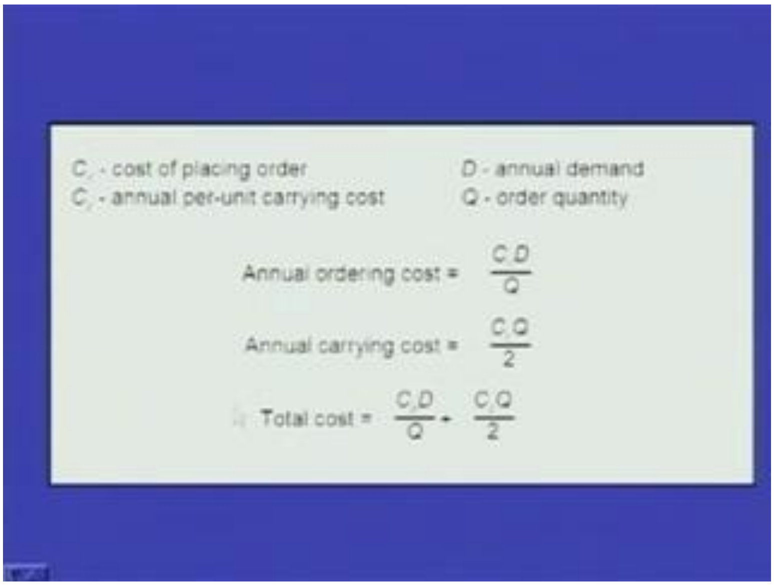

Now, see we can see Co it is the cost of placing an order, D is the annual demand, Cc is the annual per unit carrying cost, Q is the order quantity as in the previous diagram we have seen that Q is the order quantity, whatever we are ordering. So, the annual ordering cost is given by Co that is the cost of placing an order multiplied by the annual demand divided by the order quantity.

And the annual carrying cost is given by the carrying cost multiplied because the Cc is per unit, we can see annual per unit carrying cost, per unit carrying cost is multiplied by the total quantity and it is averaged out and it is divided by 2. So, in this we find out what is the total cost, now total cost as we have seen in one of the diagrams again we will see that same diagram with the help of a little bit of animation that what is the total cost and how it is made up of. The total cost is made up of the ordering cost plus the carrying cost, so ordering cost, this is the ordering cost and this is the carrying cost. Ordering cost plus carrying cost will made up the total cost are will make up the total cost.

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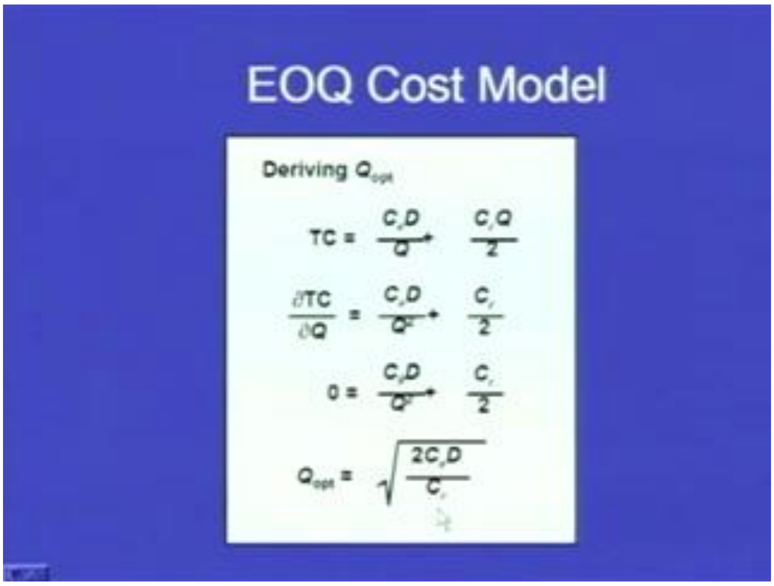

Now, the EOQ cost model we will see, how we can derive Q optimum, now Q optimum we can find out, total cost we know that it is the summation of the ordering cost plus the carrying cost. So, if you differentiate and put it to 0 we will be able to find out the value of Q optimum, Q optimum will be equal to the square root of 2 times Co multiplied by the annual demand divided by the carrying cost. So, we should know ordering cost, we should know carrying cost per unit, we should know what is the annual demand and very easily we can find out the Q optimum.

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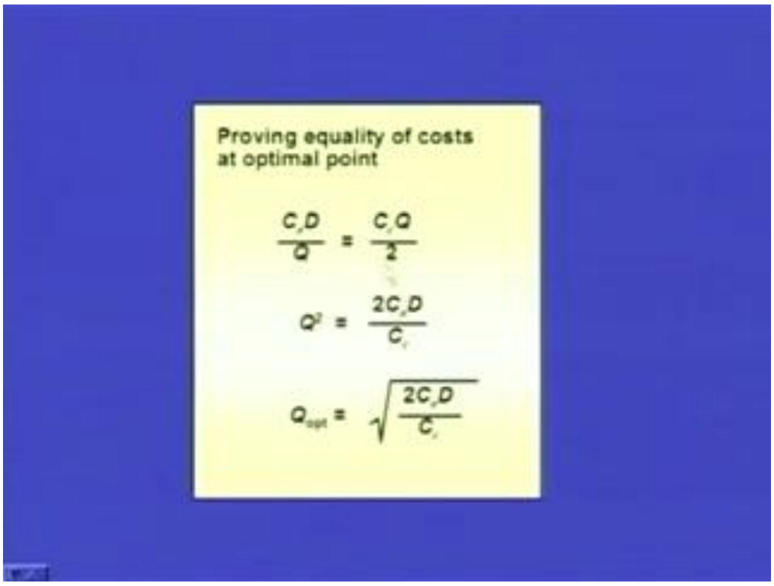

Then there is another method of finding out the proving the equality of cost at optimal point this we will see with the help of a diagram, there are total cost is minimum, wherever this carrying cost is equal to the ordering cost. So, whenever we put this is the ordering cost on your screen, this is the carrying cost on your screen. So, wherever the carrying cost is equal to the ordering cost, we can very easily find out Q optimum and in order to find out Q optimum we should know what is the ordering cost, what is the carrying cost, what is the annual demand. If we know all these three parameters very easily, we can find out that what should be the economic order quantity, which would minimize the total inventory cost. Now, this we will try to understand with the help of a diagram.

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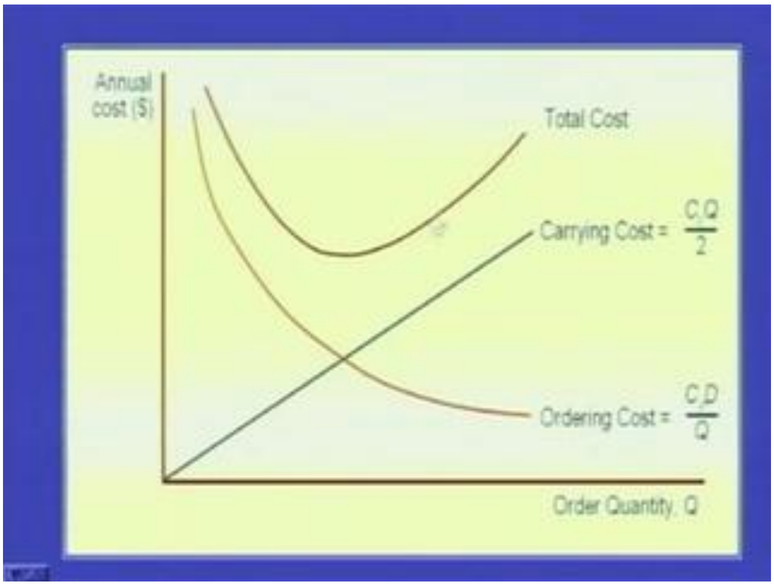

Now, suppose this is the total cost, we will see the total ordering cost will decrease as the order quantity will increase, similarly the carrying cost will increase with an increase in the order quantity. So, we can see ordering cost is decreasing with the order quantity increase and the carrying cost is increasing when order quantity is increasing. So, we can see that summation of the carrying cost plus the ordering cost will give us the total cost, so the total cost is this curve which is shown here.

So, the total cost curve is having a local minima, which is going to give us the economic order quantity and this will pass through this point, where the carrying cost is equal to the ordering cost. Now, we will have an example of EOQ we have seen that what is ordering cost, what is carrying cost, now suppose we want to find out the economic order quantity, what is going to be the order size for that we require basically three important input parameter that is the carrying cost per unit, the ordering cost, as well as the annual demand. So, let us do an example in order to have a better understanding of the economic order quantity.

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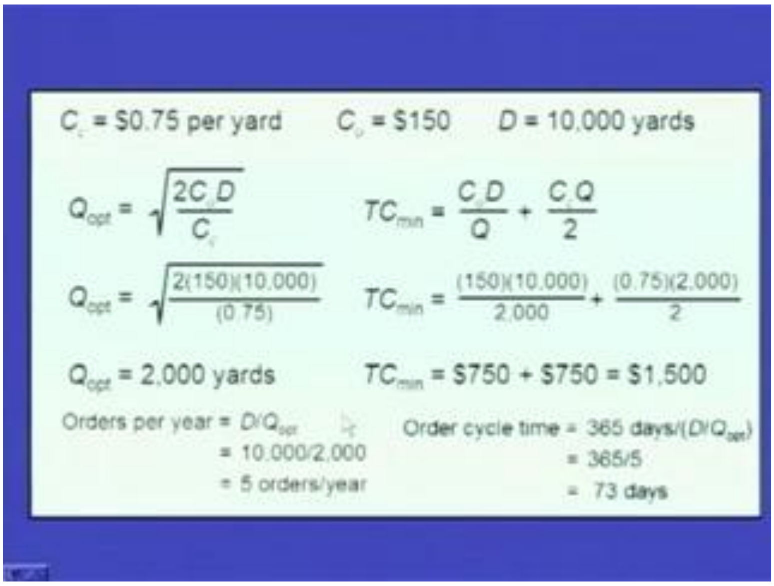

Now, here we see this is carrying cost, this is given us dollar 0.75 per yard, the ordering cost is dollar 150 the annual demand D is given by 10000 yards, so we can very easily find out the Q optimum this is using the same formula that we have derived. So, Q optimum we can find out 2 multiplied by 150 multiplied by 10000 divided the carrying cost which is 0.75, so we find out that the Q optimum is 2000 yards. So, we should order 2000 yards in one order if we want to optimize the total cost or to minimize the total cost.

So, the total cost minimum for this Q equal to 2000 is given by, by this expression summation of the ordering cost and the carrying cost for 2000 yards, so we see Q is 2000 here, again Q here we are used as 2000 and the total cost that is giving us the minimum is dollar 1500. So, the total minimum cost our total cost of holding an inventory is 1500 dollars. So, how many times we need to place an order that also we can very easily find out, now optimum order size is or the optimum order quantity is 2000.

So, orders per year because we require 10000 yards per years, so 10000 divided by 2000, we find out that we have to place orders 5 times in a year, now order cycle time also we want to find out that when we should place an order. Now, if 365 days are considered in one particular year, 5 times we have to place an order, so we can say every 73 days we have to have an order, in order to have annual or in order to meet an annual demand of 10000 yards.

So, with this simple example, we have been able to find out that we require 10000 yards and we know what is the ordering cost, what is the carrying cost, we can very easily find out that what should be the optimal order quantity. Now, we come on to another EOQ model or the inventory management model that is the production quantity model.

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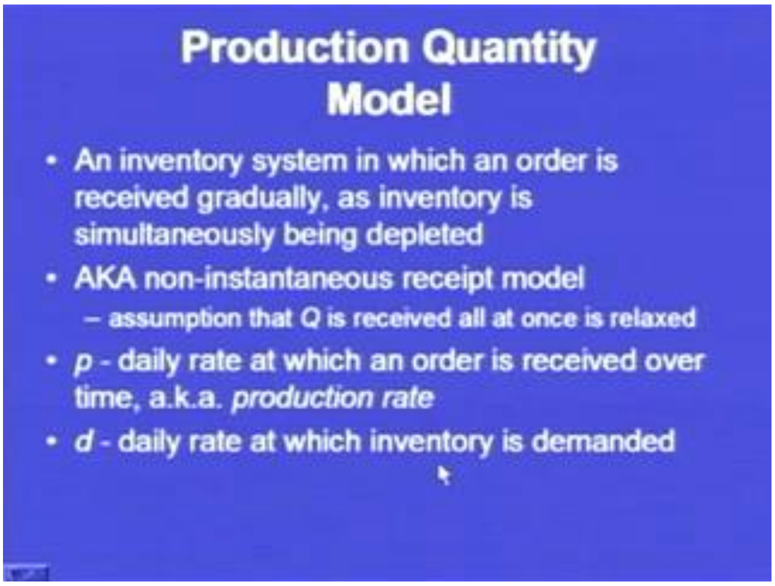

So, I will just read it for you, an inventory system in which an order is received gradually as inventory is simultaneously being depleted, so in first case we have seen that the order is received all at once, but in this case the order is not received all at once, it is received in stages or with passage of time we will keep on receiving the order or we can say it is non-instantaneous receipt model. So, the receipt of the materials or the lot or the components will not be at once.

It will be over a period of time, this we will be able to understand with the help of an example, so the assumption that Q is received all at once is relaxed, now p is the daily rate at which an order is received over the time that is the production rate. This I will explain with the help of an diagram d is the daily rate at which inventory is demanded, so here also, we are assuming that the inventory is demanded at a constant rate. So, the demand rate is constant and a production rate is there at which we are receiving the material.

So, the material is not received all at once, but over a period of time. Now, here we can see this is the inventory level.

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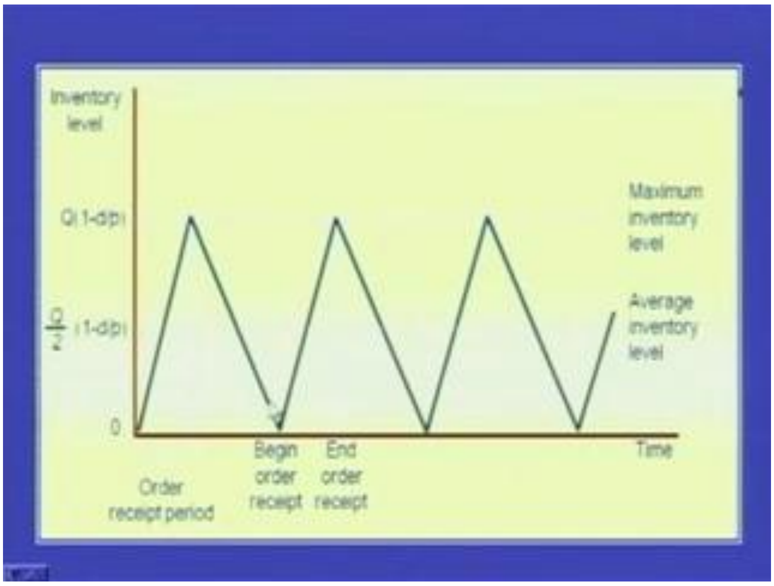

Suppose, this is the total inventory level, so here this is the rate at which we are receiving the order, In previous case it was a straight line like this, but here we are receiving the order like this and this is the rate at which we are using again we are receiving, again we are using. So, we are in this in, in between this time we are receiving also and we are using also, so the rate at which this curve is increasing represents a difference between which we are the difference between the rate at which we are using the equipment or the item or the inventory and the rate at which it is being added.

So, this can be very easily explained with the help of a water tank, so in a water tank suppose we are adding water from one side and we are taking out water from the other side. So, water is coming from one side and it is taken out from one side, so if the rate at which the water is coming is more from the rate at which the water is going out then there will always be an increase in the level of water in the tank, but if the rate at which the water is coming and the rate at which the water is going is nearly same then there will no addition in water.

So, here in this production quantity model we are assuming that the rate p, at which the components are being added to the inventory is much more as compare to the rate at which the items are demanded by the process. Therefore the difference in between the production rate and the demand rate will keep on adding in the inventory, so the inventory is being added during the production run, so the inventory is demanded also it is added also.

So, the maximum inventory level will be this much and average inventory will be somewhere here and it will be given by Q by 2 multiplied by in bracket 1 minus d by p, now d is the demand rate and p is the production rate. So, the maximum inventory level is given by Q that is the order quantity multiplied by one minus d by p. D divided by p the d is again the demand rate and p is the production rate, now we can see that this is the point where we have started to receive the order.

And this is the point of time where we have received the complete order, so here we are receiving the order over a period of time and the instantaneous receipt of order the assumption of instantaneous receipt of order is relaxed in the production quantity model. Now, we can see that is the production quantity model again we can find out that what is going to be the Q optimum the expression is given here.

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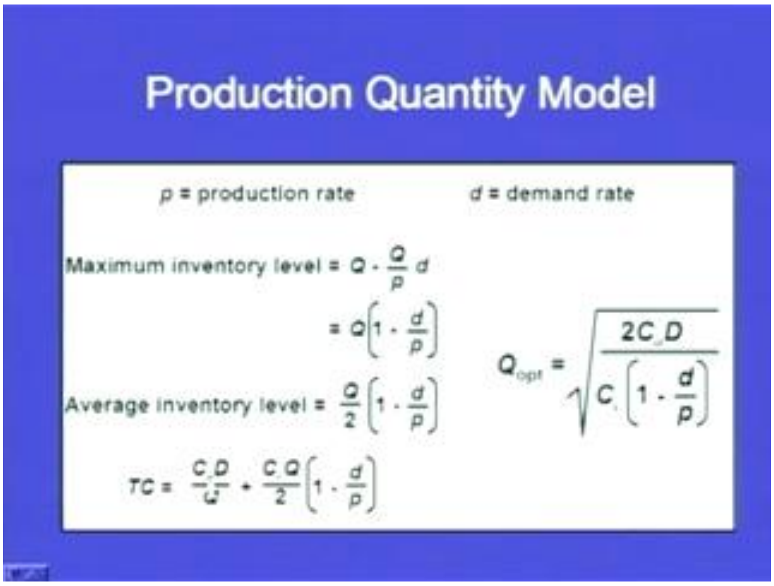

So, in order to find the Q optimum in this case, we need three different types of quantity, that is we need the ordering quantity or the ordering rate or Co, we require the carrying cost, we require annual demand also we require what is going to be the demand rate, we also want what is going to be the production rate. So, we want in order to find out Q optimum we require the ordering cost, the carrying cost, the annual demand, the demand rate at which the inventory is required by the factory or the shop and the production rate at which the material is being supplied by the supplier or the vendor.

So, production rate, demand rate, ordering costs, carrying cost and annual demand is required in order to find out the Q optimum. Similarly, the total cost will also change, it will be the summation of the ordering cost plus the summation of the carrying cost. We can take an example of production quantity model.

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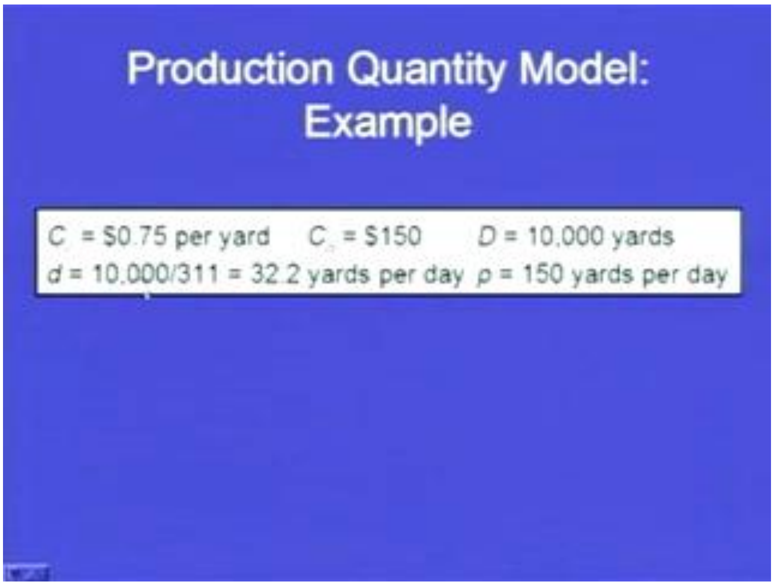

Now, suppose this is the input that is available with us, this is similar to the example that we have taken, but here this is being solved using the production quantity model. So, Cc is the carrying cost 0.75 dollars per yard, ordering cost is dollar 150 same as the previous example, demand rate is 10000 yards the d that is the demand rate that is required in production quantity model this is 10000 divided by 311, now 311 is a figure which we may not be able to understand.

311, we are assuming as the number of days for which the factory is working, so per day we require 32.2 yards similarly the production rates, so whenever we will place an order we will receive the order add to the tune of 150 yards per day. So, all the order we are not going to receive all at once, it will be will it will be received over a period of time at a rate of 150 yards per day, now again we can find out what can be the optimal quantity for this type of a model and what can be the production run. Now, here we can see the optimal, Q optimal can be find out the formula was given.

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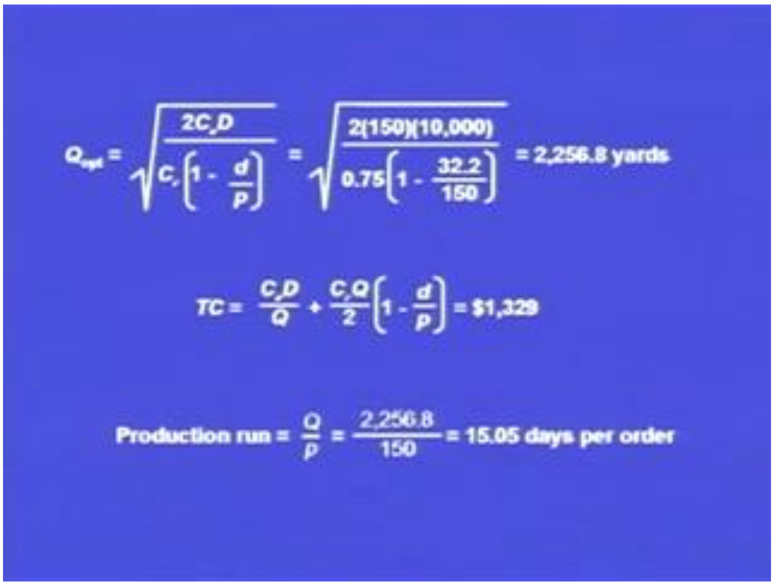

So, if we put all the values like the ordering cost, the carrying cost, the demand rate, the production rate and the annual demand, we will be able to find out what is the optimal quantity or economic order quantity. Similarly, we can find the total cost also in this case and production run we can find out that for how many days, we will keep receiving the order. So, 150 when we divide by 2256 which is the Q optimum, we will be able to find out that for many days the production run will continue. So, if we have all these input parameters available with us, we can take advantage of these type of formulations in order to achieve to a quantity which will optimize or which will minimize the total cost of holding an inventory.

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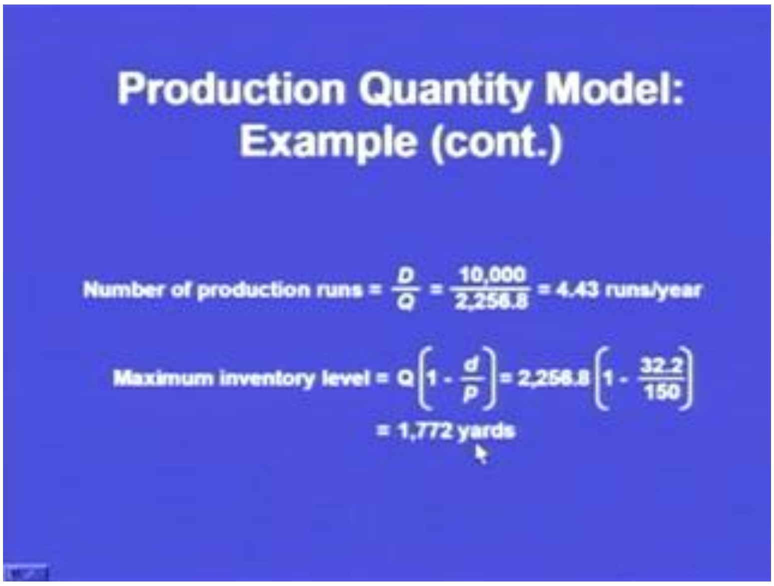

So, also we can find out the number of production runs that would be required to meet the annual demand of 10000, now in one particular production run we are having this much 2256 is this the economic order quantity and this will be received. So, 10000 is required, so we require 4.43 runs per year or we can say 5 runs per year. Similarly, we can find out what will be the maximum inventory level that we will achieve, so that can also be found out and we can say at any given moment of time, the maximum inventory that can be achieved is 1772 yards.

So, we can see that if we have certain input parameters, we can very easily find out our or very easily, we can formulate the purchasing or we can say, we can easily find out what should be the order quantity that we should order and at what moment of time we should order in order to minimize our total cost. So, in these two lectures on materials management we have covered different aspects of materials management.

We have seen that what is the scope of materials management, what are the responsibilities of materials management, then we have seen two important models like economic order quantity model and production quantity model in which we can find out that what is the economic order quantity and when we should place an orders. Also we have seen the ABC classification, in order to classify the whole inventory into different classes on the basis of total value and the total volume.

Thank you.