Financial Accounting
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Lecture – 118
9.2 Economic Order Quantity

In this video, I am going to introduce you to the first technique of inventory control, inventory management. It is called Economic Order Quantity. As the name suggest, the word economic refers to being economical, being more efficient monetarily, in managing your inventory. The order quantity refers to number of units that should be ordered in one go.

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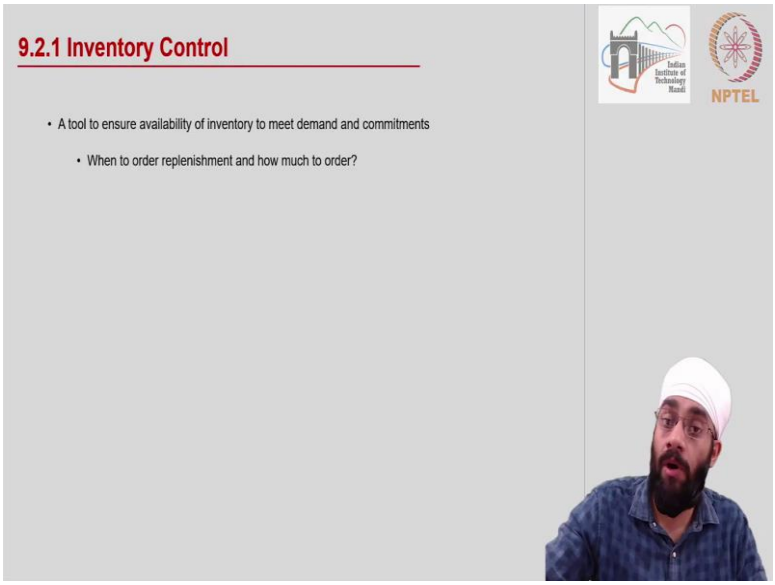

So, we are essentially talking about inventory procurement. Let me put it in a bigger context. We said inventory management or inventory control is about tools which are going to make sure that this stock is available, when it is required so that business should not suffer from stock out etc.

So, we are basically talking about a tool that is going to make sure that you have the stock when it is required. In order for you to have the stock, you have to place an order; in order for you to place the order, you have to know when to place the order, how much time it is remaining before you are going to reach at a stock out level. So, when do you order to replenish the stock and how much should you order, how many units at a go should you order?

So, that is the central question in this discussion. How many units to order in a go and that in fact, leads into another question which is how frequently should you order in a given time perio?. We are going to talk more about it as we move forward.

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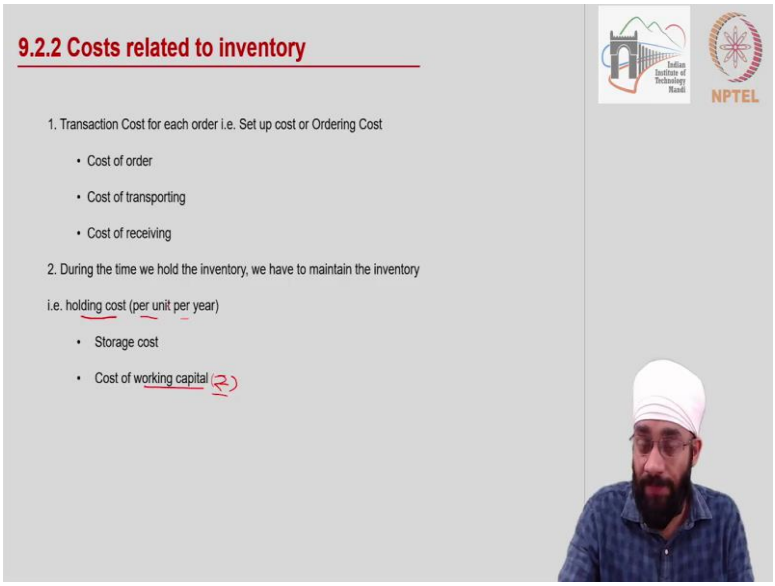

So, there are certain costs that are related to this question of how many units and when to order. So, the first such costs are transaction costs. For example, placing of order can be different in different industries. In more complicated, heavy machinery industries, manufacturing industries, it could involve visiting the manufacturer's or the supplier's site to inspect an item for example. And the travel cost of the person who goes there with the inspection team could also involve monetary cost to it and therefore, that is included in the cost of order. Or if you have to prepare a purchase order you have to do paper work, a certain administrative cost is attached to placing an order.

Also, when you place an order, transportation cost is involved, when the goods come in you have to receive the goods as well. So, freight and carriage etc., all that cost is also involved when you place an order. All of this is clubbed into one category which is called setup cost or ordering cost, it is together called ordering cost. I will just make use of the screen.

So, ordering costs here and it is set up cost. So, different text books or different study materials call it by different names. But you should understand that any cost relating to placing an order and getting it on site is going to qualify under this category of cost. So, the question of how

many units to order and when to order, the first kind of cost it involves is called the set up cost or the ordering cost.

Now, during the time that we hold the inventory, once you have placed the order, the order has arrived at the location. Now, from this point on to when you sell it further to the either retailer or wholesaler, depending upon who you are, what role you are playing. So, during the time you hold the inventory, you have to take care of the inventory. You have to make sure that the inventory is safe, you have taken measures, you have put in policies, procedures in place, all of that execution, all those procedures is going to incur cost as well. For example, for you to keep the goods, you need space. You have to either rent a godown or you use your own space which of course, incurs other costs. In storage there is electricity or if these are perishable goods, you have to maintain temperature. So, there are different kinds of costs involved as far as storage is concerned.

In addition to that the money has been blocked in the raw materials, in this inventory whatever the nature of this inventory, this is also going to involve working capital. We have to block money into all the units that you have bought and put it into the godown. So, the second bunch of costs is going to be called holding cost, also called carrying cost in some text and it is typically measured per unit per year, but we will talk about units as we move forward.

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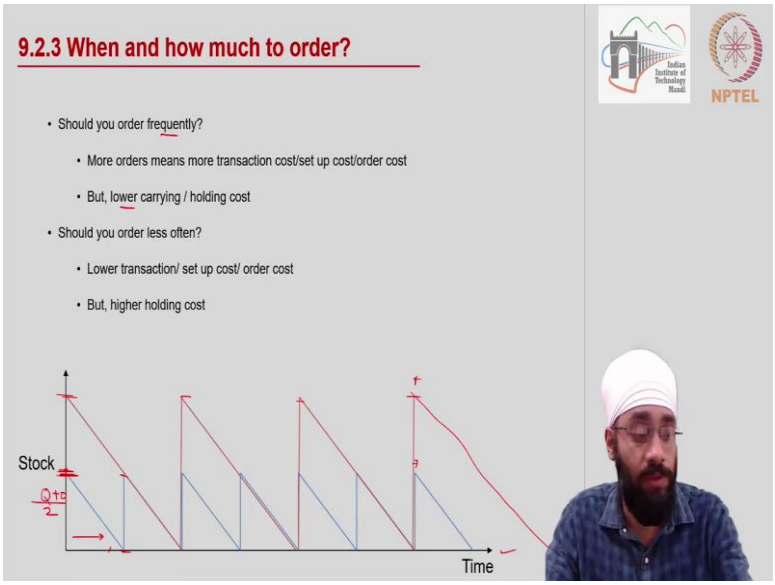

So, we are classifying the costs associated with inventory management into two; the first set is the setup cost meaning you place an order and a cost is associated. There is a second set of

costs which is the carrying cost, the holding cost. Once you have the stock then you have to spend the money. Both these costs are going to help us answer the critical question of when to order and how many units to order. Let us move forward.

So, let us answer the first part of the question which is how frequently, when to order, let us say in a given period of time, one financial year or a calendar year. Now, how frequently should you order, if you order too frequently, and there is the first type of cost which is ordering cost.

Ordering cost means, you place an order and you incur the cost; when you place an order every time you order you have to send an inspection team for example. Every time you place an order you have to send this team of three people; who are going to spend money on travel, stay etc. and other costs as well. Therefore, the higher the number of orders in a year, the more is the setup cost or the ordering cost in this case. But if you place orders very frequently; that means, you are maintaining that stock with you for a shorter period of time or possibly you are maintaining a lower level of stock. Because you are able to place orders frequently therefore, you do not need to worry about maintaining a large amount of stock.

So, if you order very frequently you may have to incur more cost. However, the carrying cost may be lower. Now, there is a tradeoff between the two types of costs. The ordering cost is going to go up as you place more orders; however, the carrying cost, the holding cost is going to be smaller if you order very frequently assuming that if you order too frequently you are maintaining lower levels of stock and hence less money is blocked in the stock.

What happens if you order less often? Well, if you order only twice or thrice a year, that means, the ordering cost will go down, ordering cost is per order. So, per order cost multiplied by the number of orders I am ordering only twice a year. So, the ordering cost is less. However, at one go I will have to place a large order, so that I do not suffer from stock out.

So, I have to maintain that level of stock with me and when I have to maintain a large level of stock with me, I have to spend on holding costs. I have to block more money in the stock which is being maintained and also subsequently the storage, the insurance and other expenses that I have to spend on making sure this stock is safe that also goes up.

So, it turns out that these two costs are inversely related, they move in opposite directions depending upon the frequency of the order and the size of the order. So, here is an illustration of the same. For example, this is the level of the stock that you order at a go and on the x-axis

you have time. So, as you move further in time, you keep on selling the stock or whatever is the next stage, if you are a manufacturer or retailer based upon that. But let us say you order the stock, the stock is with you now, then you use the stock in the sales and then you are at this level which means that stock is out. However, before you are here you place an order, somewhere here at this point in time and then you get the stock by this point in time when the previous stock is exhausted and so on. So, during a given time period you are placing 7 orders for example. So, here whatever is the ordering cost ,you are going to be spending 7 times that.

And, now, on the screen you see another pattern, which says you order only once, twice, thrice and 4 times in the given period although the chart is not complete this is going to be like this. But here you place orders for a greater number of units, so you are blocking more money.

However, the number of times you place an order is going to be less because you are ordering higher stock value, the number of units in the stock at a given point in time. So, this is how these two types of costs are going to move.

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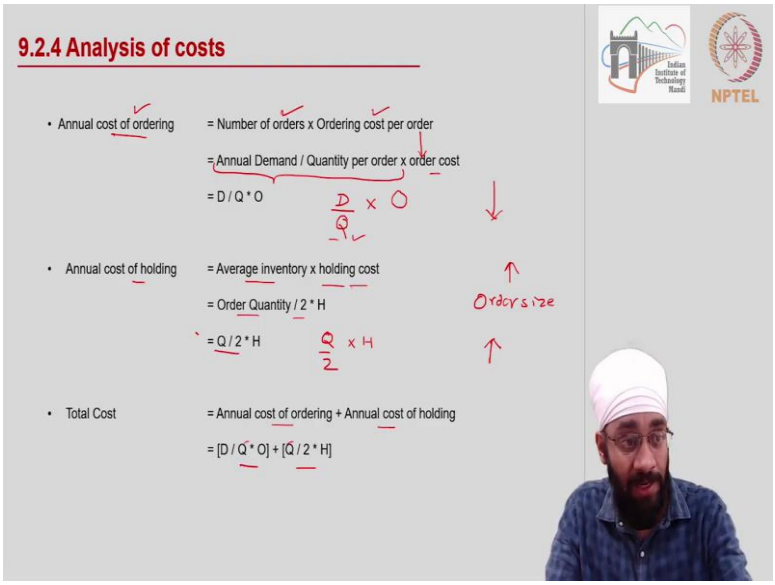

We will deep dive into each type of cost as well, but before we go there understand the arithmetic, the algebra behind this. So, we are talking about the annual cost of ordering. Let us take one period of time. Let us say 1 year within that, what is going to be the cost of ordering? Obviously, it is going to be a multiplication, a product of the number of orders and ordering cost per order.

Now, the number of orders is going to be calculated using this equation here, this expression. Annual demand divided by the quantity per order obviously, multiplied by the ordering cost per order. So, this is the same thing although worded differently, but this is the per order cost.

Now, annual demand is represented by D and this is going to be divided by Q and Q is the order size. So, Q is the quantity per order, size of the order. So, D by Q is going to give us a number of orders and multiply this by the ordering cost which is given by O. This is one expression. This is the relationship between the total annual cost of ordering and the quantity that you order. As you order more units per order, your ordering cost is going to come down as the denominator goes up. The end result of this equation is going to be lower and lower. So, if you want to reduce the ordering cost you increase the quantity per order.

Let us look at holding cost H. Holding cost is average inventory ,what is the amount of stock that is available with you on average during the year, multiply that by holding cost. And holding cost is again an estimation typically given as a percentage of the stock value that you have.

It involves everything from the cost of working capital blocked, the opportunity cost of the working capital blocked; meaning the amount that is blocked in the stock if you would have deposited that in the bank, what interest would you have earned. So, the earnings that have been foregone and so on. Whatever other costs are involved, but we are not deep diving into that right now. So, holding costs multiplied by the average inventory. So, what is average inventory? The average inventory is order quantity divided by 2. If you remember the previous graph I will just try to go there. So, during a given period of time you are holding maximum this inventory and minimum this inventory. And, this maximum inventory is actually the order size that we have which is Q, this is the order that we place at one go and the minimum is 0. So, Q plus 0 over 2 gives us the average stock that we maintain at any point in time and using this we have arrived at this expression of Q by 2. This gives me the average stock that I maintained with me in the business throughout the year; multiply this by H which is the holding cost, some estimation which can be calculated that is another discussion. So, this is how you get to the annual cost of holding.

Now, if Q increases the annual cost of holding increases. So, this is what I was theoretically explaining in the previous slide and now it is being explained through algebra that as Q, the order size, goes up, the cost of ordering goes down. However, if the order size goes up, the cost of holding also goes up; there is an inverse relationship between these two types of costs.

So, the total cost of course, is made up of these two types, two expressions, within the same equation. So, one is the cost of ordering the other one is the cost of holding and Q is present in both the expressions and as Q moves to either direction one of the expressions goes up the other one goes down. So, given that relationship we are looking at minimizing the total cost. So, what should be our Q so that the total cost is minimum? That is how we answer this question.

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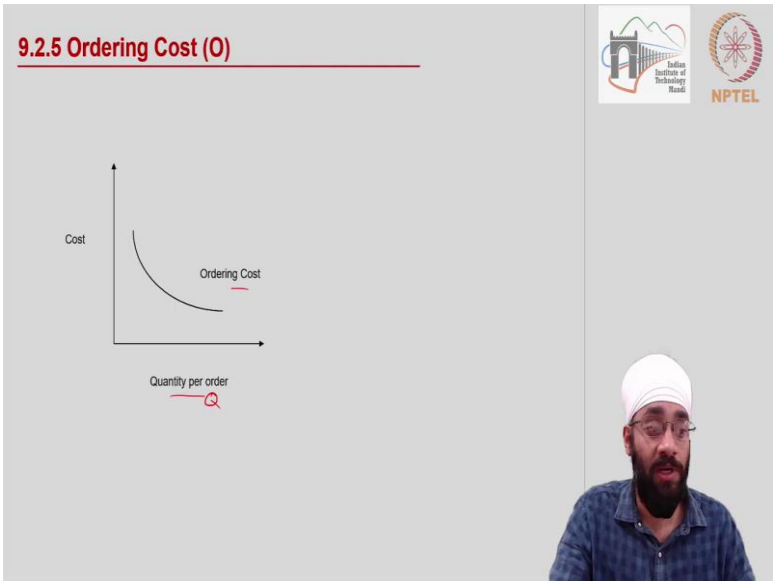

So, here is the graphical representation of this cost if this is still not clear. This is the ordering cost as you increase Q, the size of the order, the ordering cost is going to come down.

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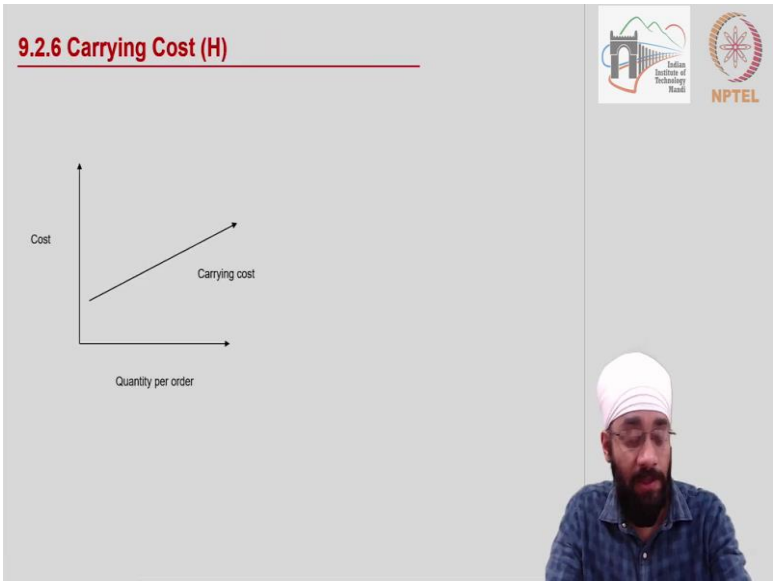

However, the opposite is true in case of the carrying cost.

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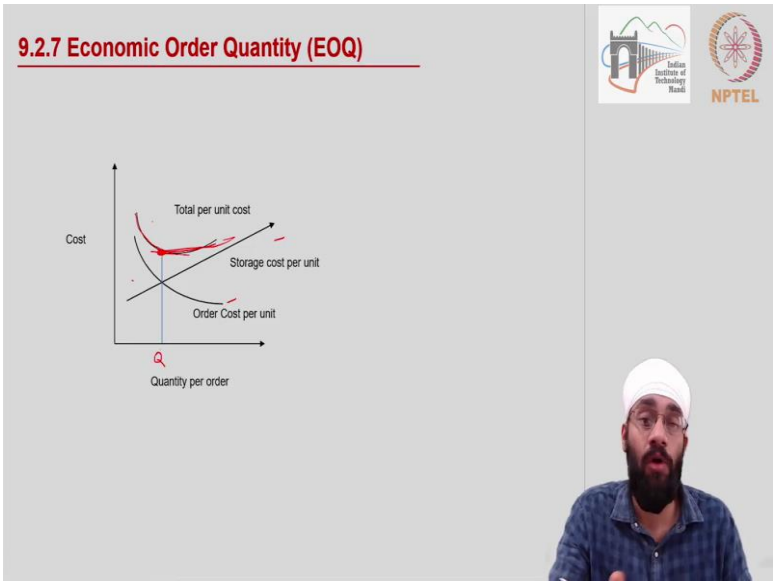

And, you are looking at minimizing the cost. So, I am going to club both the graphs on this slide. This is the ordering cost and this is the storage cost and approximately the total cost curve is going to look like this. It comes down and then slowly starts to go up.

So, the minimum point on this curve is probably going to be somewhere here, but imagine the curve is a little bit like this and then it lifts up, this is the minimum point here. So, at this point in time this is the Q that you are looking for. At this Q, if you order this quantity, then your total cost is minimum and mathematically it has been proven that this is a point where your ordering costs and your storage costs are equal. So, this is the graphical representation of economic order quantity. This Q gives you the economic order quantity; economic in the sense the total cost is going to be minimum and the quantity is the size of the order, units in the order.

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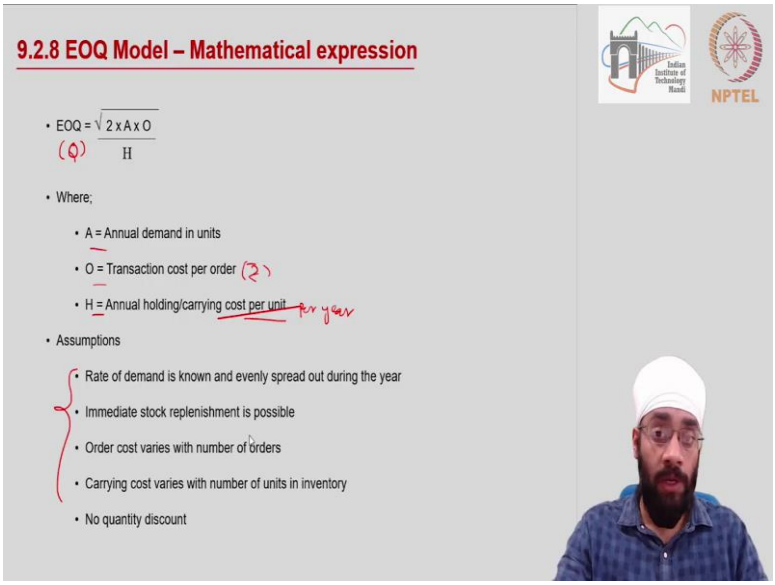

And, this is the mathematical expression using which the equation can be solved for Q.

Q= (2AO)/H

Where, A is the annual demand in units,

O is the transaction cost per order, monetary value, and

H is the holding cost; this is sometimes given to you per unit basis, sometimes given in percentages but ultimately what you are looking for the units of H should be per unit per year, that is also important. This is per unit per year.

And, of course, this is a mathematical model and any model is based on some assumptions. So, there is a set of assumptions that this model makes that the rate of demand is known and the consumption is even: we have seen the graph earlier as well. We assume that the consumption pattern is smooth over a period of time and also immediate stock replenishment can be done or you know stock out time and therefore, you can predict perfectly the lead time as well. So, that you can place the order and get the stock in time. Order cost varies with number of orders; carrying cost varies with number of units in the inventory and there is no quantity discount if you are placing a large order. Using these assumptions is how the EOQ model is able to give you the economic quantity that you should order in a single go.

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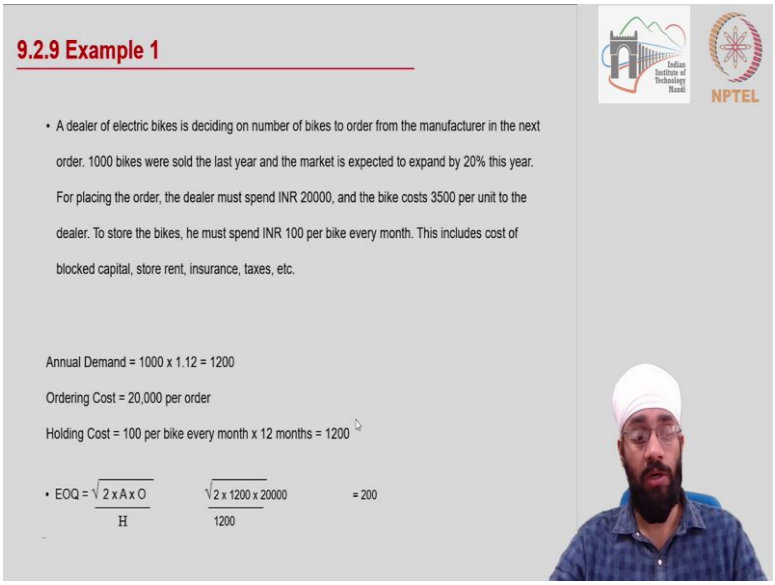

Let us take a quick example and try to see this in action: how do we use this mathematical expression to calculate economic order quantity. So, here is the question. A dealer of electric bikes is deciding on the number of bikes to order from the manufacturer in the next order. 1,000 bikes were sold last year and the market is expected to expand at 20 percent this year.

So, deterministic demand pattern, for placing an order the dealer must spend 20,000. So, this is the per order cost and the bike cost 3,500 per unit. This is the price of the article of the unit. To store the bikes, he must spend 100 per bike every month. This is on a monthly basis. We know that we have to get per unit annual cost of storing and this can be multiplied by 12 easily and we can arrive at the annual holding cost or the carrying cost per unit.

This includes the cost of blocked capital, store rent, insurance, taxes, etcetera. Assuming that the back-end work has been done, on calculating the per unit holding cost and the order cost ,all of that has been worked out and the final numbers have been given to us.

So, what we need for economic order quantity is the annual demand, the ordering cost and the holding cost – these three components are required. Therefore, we have the annual demand 1000 multiplied by 1.12. This is the expansion in the market this year. So, a total of 1200 units are expected to be sold. Ordering cost is 20,000 per order; this is to be taken as it is.

And, the holding cost is 100 per bike every month multiplied by 12 gives you 1200. Now, all you have to do is just use this formula of 2 multiplied by annual demand multiplied by ordering

cost divided by the holding cost. So, we use these numbers and we get to an economic order quantity of 200.

So, at one go, the dealer should place an order for 200 bikes; 200 bikes at one go means that he will place 6 orders in the year. So, you could do those calculations as well to calculate the annual cost of carrying the stock as well. Just to do a robustness check on this we could do the following.

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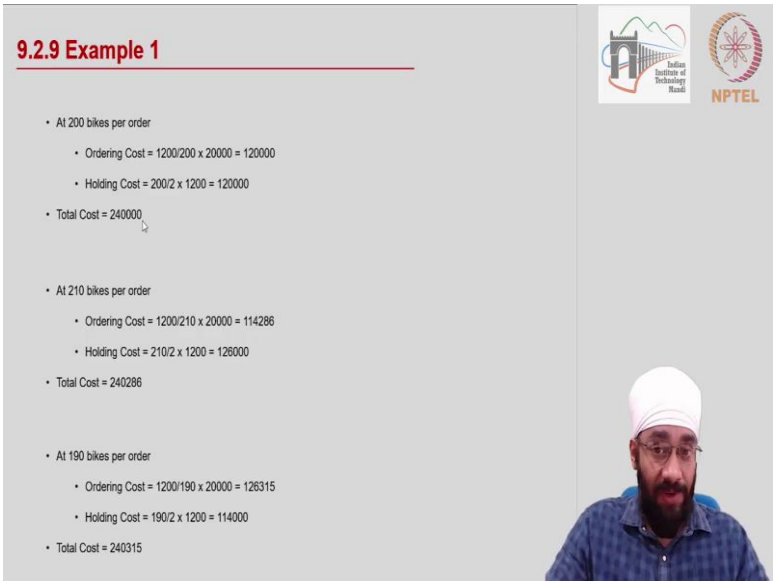

We could say that at 200 bikes per order, which is the economic order quantity, what is the ordering cost and what is the holding cost, and we know from the you know graph that we saw earlier that ordering cost and holding cost should be equal. They should be the same at the economic order quantity and that is what we have here. The ordering cost is 1,20,000 and the holding cost is the same.

The way I calculate these two is as follows. So, 1,200 is the annual demand. So, 1,200 divided by 200 is the EOQ. So, I have 6 orders during the year multiplied by per order cost of 20000 gives me 1,20,000 as my annual ordering cost. For holding costs I have 200 divided by 2.

Now, 200 is my EOQ, the ordering quantity. I am dividing this by 2 because I want to figure out what is the average number of bikes that I hold during the year. And as discussed earlier the average stock is equal to opening stock plus closing stock divided by 2.

The opening stock that we have is the maximum order that you place at a given point in time. Just for quick reference I will run back to the figure where we saw this here. So, the maximum quantity that we have with us throughout the year at any point throughout the year maximum amount available to us is the Q, the economic order quantity that the order that you place and the minimum is 0 and that is when you quickly get the next set of stock coming in.

So, Q plus 0 by 2 gives you the average stock during the year and hence we use this number here on this 2. On this slide 200 by 2 multiplied by 1,200 and 1,200 is coming from here – the holding cost 100 per bike every month multiplied by 12 months gives you 1200 per bike per annum.

So, the annual holding cost multiplied by the average number of bikes that we hold. So, this tells us that the ordering cost and holding cost are equal and as we saw graphically this should be the economic order size economic order quantity and the total cost is 240,000 on this economic order quantity.

Now, let us do another check. Let us increase the economic order quantity just to check now if we were to order 210 bikes in a go, then what is going to be the ordering cost? So, all I am doing here is I am replacing this 200 with 210. When I do this, my ordering cost is lower than the holding cost because I am ordering more bikes, I have to place less orders and therefore, my ordering cost goes down.

However, because I increase the number of bikes in an order my average inventory that I hold goes up therefore, the money blocked in this inventory goes up and therefore, the holding cost increases from 120,000 to 126,000. So, this is not equal and the total cost is 240,286 compared to 240,000 earlier.

So, there is a certain increase in the total cost. Therefore, 210 is not the most economic size of order that we can place; 200 right now is the economic order quantity. Now, let us say if we were to reduce the economic order quantity to 190, then what happens? So, when you do that ordering cost again in the same expression, I am replacing 200 with 190 that is all.

So, when we do this our ordering cost comes out to be 126,315. This is because now I am procuring less units per order therefore, I will have to place more orders proportionately. My ordering cost has to go up. So, instead of 120,000 I have 126,315 this is my total ordering cost in the year.

The holding cost however, has to come down because I am maintaining on average 190 and by 2 that is the average inventory that I maintain multiply this by 1200 and I have 114,000 as my annual holding cost. The total cost however, still is higher than the total cost which we got when we had an economic order quantity size of 200.

So, even if you reduce the economic order quantity, the total cost is going up and if you increase the economic quarter quantity the total cost is still going up. And this is the most economic size of the order because this is minimizing your total cost. Now, you could try it out with 199 units or 201 units, you will still see that the minimum cost is at 200 bikes per order.

So, that is how the economic order quantity helps you answer an important question about the procurement of the inventory taking into consideration the cost of ordering and also the cost of maintaining carrying that stock with you. This is one of the few techniques that are used for inventory management.

I will see you in the next video with another technique of inventory management.