Construction Methods and Equipment Management
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Lecture-06
Equipment Life and Replacement Analysis (Part-1)

Hello everyone, I welcome you all to the lecture 6 of this course construction methods and equipment management. So, in this lecture, we will be discussing about the replacement analysis of the equipment. So, let us have a recap of what we learned in the lecture 5. In the lecture 5 we had a discussion on how to estimate the equipment cost using Caterpillar method and the Peurifoy method.

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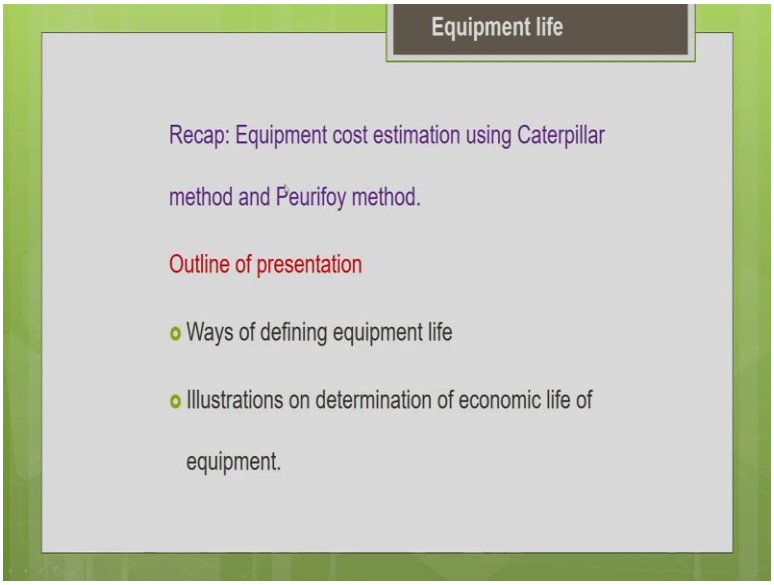

Now, this is outline of the present lecture. So, in this lecture I will be discussing with you what are all the different ways of defining the equipment life and I will also highlight on how to estimate the economical useful life of the equipment. We will be working on some illustrations on how to estimate the economic life of the machine.

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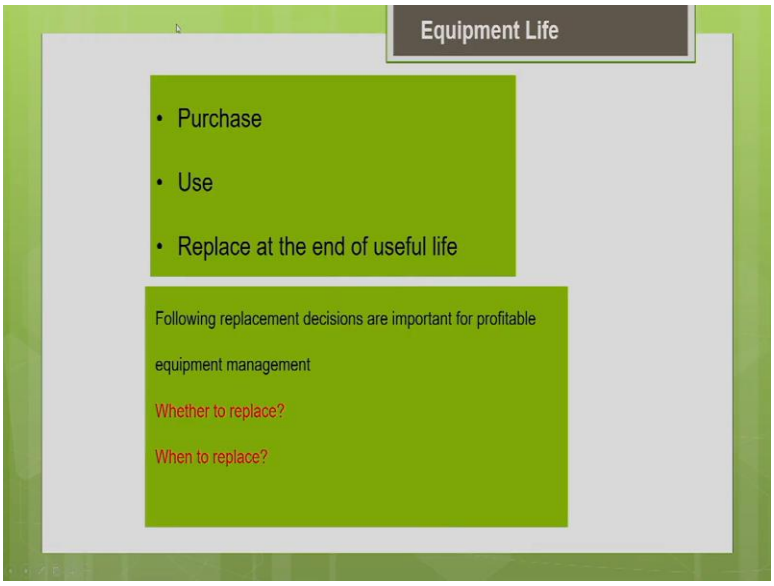

So, equipment life: So, basically there are different phases in the equipment life as everyone knows. So, it starts with the purchase of the machine. We purchase the machine first, then we start using it. As we use it, with age, of the machine ages, you can say that the machine will be subjected to more amount of wear and tear. So, once it is totally worn out, when it comes to the end of the useful life of the machine, we go for the replacement of the machine.

So, generally we replace at a particular point, when the machine is totally worn out. That means it will not be economically feasible for us to economically repair it and use it. So, at that stage what we do is we either abandon it or scrap it or sell it at a reasonable price. And replace the old machine with a new machine. So, these are the common phases in any equipment life. So, for a profitable equipment management, there are certain decisions which are very important.

So, once this decision is a replacement decision. Whether to replace your old machine with a new machine or not, if at all you decide to replace then to make the replacement. So, what is the optimum replacement time? So, these 2 are very important questions or these 2 are the important decisions which are to be made accurately from profitable equipment management perspective. As I told you earlier, we cannot just cling on to the old equipment, just because the old equipment is just doing its function in your project site, we cannot just cling on to it.

Because as the age of the equipment increases, it may have worn out or it might have become totally obsolete because so many new competitive models would have come into the market with a better productivity and even lower maintenance and repair cost and with a lower operating cost. And I can say with better advanced features with more ease of operation, with more safety features with enhanced productivity.

So, more added features are available for the competitive models, which are available in the market. It is not economically advisable to just cling on to the old equipment at the project site. So, we should find the optimum replacement time and replace the old machine with a new machine even though your machine is functioning in the project site. So, just because it is doing its function, we should not just stick on to the old machine.

We should find for the optimum replacement time and replace the old machines with a new machine, which has a better productivity than your old machine. So, to make this replacement decision, so we need some knowledge on how to estimate the economic useful life of the machine.
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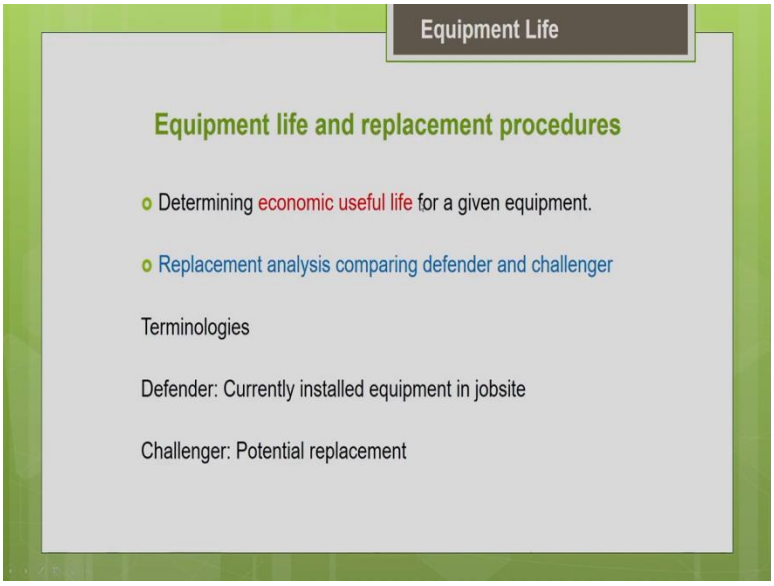

So, what is this economic useful life, I will be discussing more in detail in the upcoming slides. Basically, economic useful life is the time period during which the cost associated with the machine is minimum. The total cost, the cumulative total cost associated with the machine is minimum. If you are going to optimize a production with respect to cost, we talk from minimum

cost point of view, if you are going to optimize the production with respect to profit, then we have to talk from maximum profit point of view.

In that case, we have to define the economic useful life from a profit perspective. That means the economic useful life is a time period during which the profit will be maximum for the particular machine. So, the time period during which the profit is maximum or the cost is minimum, both these things refer to the economical useful life of the machine. So, if you know this economical useful life of machine, at the end of this useful life of machine, we have to replace our old machine with a new machine, because we never want the profit to get reduced.

So, that is a common business policy. We do not want the profit to be reduced, or we do not want the cost of holding the machine to increase. So, we have to determine the economic life and at the end of economic useful life, we have to replace the old machine with the new machine. How to determine that? We are going to discuss that in the upcoming slides. And the next one what we are going to discuss is once you have decided to replace your machine, so, we have to look for alternatives.

What are the alternative machines available in the market to replace my current machine in the project site? So, there are some terminologies we need know. The currently installed machine of the project site that is called as defender, any currently installed equipment or the asset; we call it a defender and the proposed equipment which you are considering for the replacement, the potential replacement that is called as a challenger.

So, these terminologies you should be aware of. So, basically in the replacement analysis, we will compare the cost of the defender and challenger and with that we will justify the replacement of the defender with the challenger. And also, we will find the right time when to replace the defender with the challenger. So, these are the different cases or the problems which we are going to solve in the upcoming slides.

One is we will be determining the economical useful life of the machine. That helps me to decide when to replace the machine. Other one, I will be able to compare my defender the challenger. So,

I can compare it to the different alternatives. So, there are so many analytical models or guidelines available, which help you to make the comparison and to make the decision so, to choose the best alternative for the replacement. So, that is what comes into the replacement analysis, we are going to discuss that in the upcoming slides.

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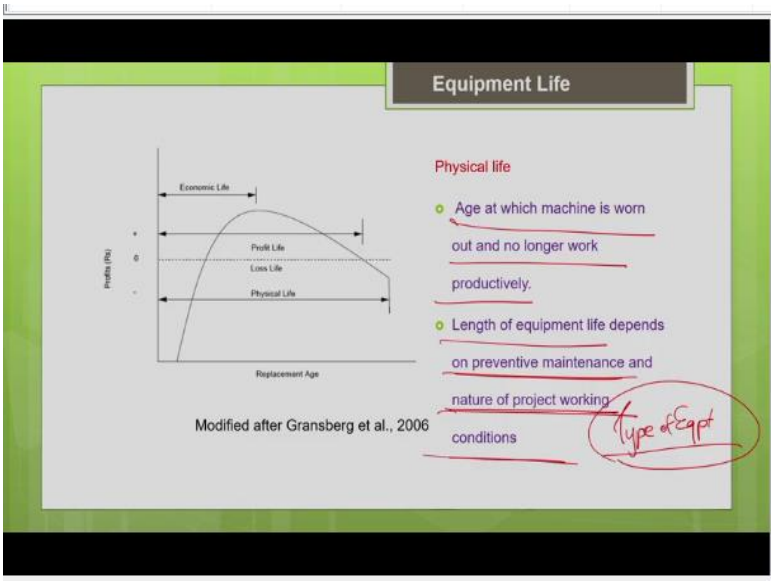

So, now let me define you what is the equipment life? There are different ways to define the equipment life. This graph shows you the pictorial presentation of the equipment life, you can see. So, you have the replacement age in the X axis and you have the profit in the Y axis. So, basically, you can see that this is the physical life of the machine. Physical life refers to the entire life of the machine you can see in the picture.

That means, it is a period between the moment you purchase a machine and the period between the moment you abandon or scrap or replace your old machine with a new machine. So, that refers to the entire life of the machine that is a physical life of the machine. So, when we replace it or when we scrap an old machine, whenever it is totally not economical to hold that machine, it is of no utility value to you. It is totally broken down. So, beyond that, it is not possible for you to repair it and use it economically.

At that particular point of time, we totally abandon it and replace the old machine with a new machine. So, this refers to the physical, the total life of the machine. So, when is the end of the

physical life, the age at which the machine life is worn out and no longer work productively, we say that machine life has come to the end? So, the machine is totally worn out and it will not work productively for you, its productivity is very poor.

So, in that case, you can say that it has reached the end of the life. And this physical life will vary for different machines. As we discussed earlier also, obviously, it depends upon the type of equipment. There are certain sophisticated equipments, which are not subjected to much wear and tear, an electric motor, it is not subjected to much wear and tear. Say, a simple electric motor, it is not subjected to much wear and tear.

So, those equipments you can see the physical life will be more. Similarly, the equipment's which are subjected to less mobility, those equipments may last for a longer time, its physical life may be longer. So, it depends upon the type of equipment, also it depends upon the nature of the project working conditions. We have discussed this example earlier, the same machine, an excavator, one which is working in the quarry, handling the short rock pieces, the other one which is just handling the ordinary earth in the project site.

So, both will have a different physical life, because the amount of wear and tear to which the both machines are subjected to are totally different. So, the nature of the project conditions is going to decide the length of the equipment life. Another important thing you need to know is the preventive maintenance, the care you show towards your machine. So, if you put some efforts for a preventive maintenance of the machine, then your machine will last for a longer time.

The small amount of efforts we spend for the preventive measures for the preventive maintenance, it will save you from the major breakdown of the machine and it will save you from the major repair and the maintenance costs or major equipment costs. It will save you from the major operating costs of the machine. So, that is why it is always advisable to put some efforts for the regular preventive maintenance.

So, you have to have a maintenance facility, where you have some labour, engaged for the regular maintenance of the machine, there you will be doing the periodic checkup of the machine or the

timely service of the machine. So, you have to do the daily cleaning of the machine. If you are going to take care of a machine in a proper manner, it will last for a longer time. So, the length will vary depending upon the care you show towards the machine. This is what is called as a physical life of the machine. It refers to the entire life, as you see from this picture.

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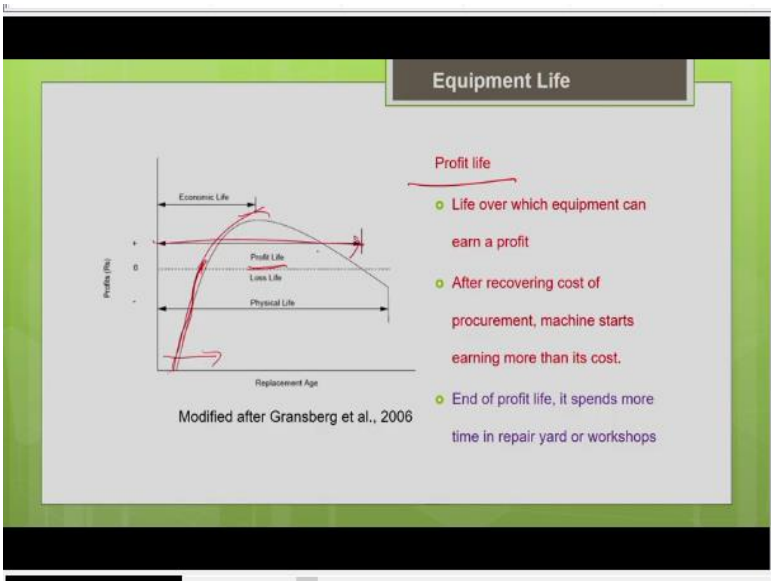

So, the next what you are going to see is your profit life. So, basically, we know that we have spent a lot of money for purchasing the machine. So, we have invested huge amount of money for purchasing the machine. So, during the initial periods, you can see that your machine will be just recovering, it will be just recovering whatever cost you have invested in it for procuring the machine or purchasing the machine.

So, during the initial phase of the equipment, you can see that it will be just recovering whatever cost you have invested in it, depending upon the cost of your machine. But after a particular time, it will start earning more than its associated cost; it will start earning more than its ownership and the operating costs. That means it has entered into the profit zone. So, this is called as the profit life, you can see the profit life of the machine.

So, this is the profit life of the machine. So, you can see that during the initial phase, it is just recovering the cost. What we have invested in. After that, it starts earning more than the cost that means it has entered into the profit zone. Now, it reaches a maximum profit. After that, what

happens your profit starts reducing? Why the profit started reducing? Because as the age of the equipment increases, it is subjected to more amount of wear and tear.

So, it is productivity will start reducing, it is repairs and the maintenance costs will start increasing, so, most of the time it will be spending in the repair yard. So, you can see that its profit will start reducing and finally at the end of the profit life, you can see that it will start entering into the loss zone. So, it is entering into the loss zone, you can see. So, below this 0 is your loss zone. So, it has entered into the loss zone, because it spends most of its time in the repair area or it is repair and the maintenance cost has increased.

So, basically, in a business, we always try to be in the profit zone only. So, generally they advice that before the machine enters into the loss zone, we have to replace the old machine with a new machine, when it is major parts are functioning. So, that I can sell the equipment at reasonable price to someone who is interested in buying it. So, before it enters into the loss zone it is basically advisable to replace the old machine with the new machine.

So, profit life is nothing but the life over which an equipment can earn a profit. So, as I told you, after recovering the cost of its purchase, the machine starts earning more than its cost. That means it has entered into the profit zone. So, the end of the profit life you can see, it spends more time in the repair yard. So, that means it will enter into the loss zone. So, before that it is better to replace an old machine with a new machine.

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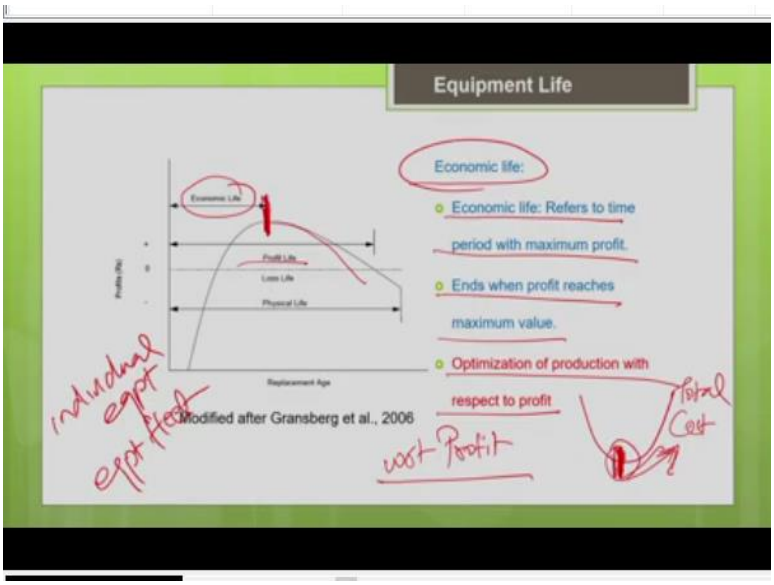

So, the next important thing, what we are interested in is economic life, which I discussed in the initial part of this lecture also. Economic life, here I am going to discuss with respect to profit. So, here I am talking about optimization of production with respect to profit. So, economic life is a part of profit life. Economic life ends when the profit is maximum, you can see the economic life ends when the profit is maximum. Generally, the equipment owners from the business perspective, we can see that we never want our profit to get eroded.

So, we want to always have the maximum profit; we do not want the profit to get eroded. So, that is why your economic life ends when the profit is maximum. So, if you wanted to maximize the profit, it is better to replace your machine at the end of the economic life itself. So, before your profit gets reduced due to increase in maintenance and repair costs, before that itself replace the machine.

Replace the machine or the end of the economic life of the machine. So, basically, economic life refers to the time period with maximum profit, if you are going to optimize a production with respect to profit. And the economic life ends when the profit reaches a maximum value because I do not want my profit to get reduced at all. I do not want my profit to get eroded at all. So, in that case, at the end of economic life itself let me replace my old machine with the new machine.

So, here I am talking about optimization of production with respect to profit. The same economic life, I can discuss with respect to cost, in that case the graph will be inverted. So, whenever the cost is minimum, so this is the cost curve, the total cost curve. So, whenever the cost is minimum that time period I have to replace the machine. So, I do not want to hold my machine beyond a particular period, where the total cost associated with the machine is going to increase beyond this.

So, I do not want to hold it beyond the economic life. Whenever the cost is minimum itself, I will replace my old machine with the new machine. So, these are the different approaches. But one thing we have to notice is the optimization with respect to profit is a little bit difficult, because it is generally difficult to extract the profit data of individual equipment, individual equipment from the entire equipment fleet.

It is difficult to extract the profit data as well as from the total project it is difficult to extract the profit data of equipment alone. So, that is why people always prefer to optimize, because they find it convenient to optimize with respect to cost, the cost estimation is easier when compared to the profit estimation.

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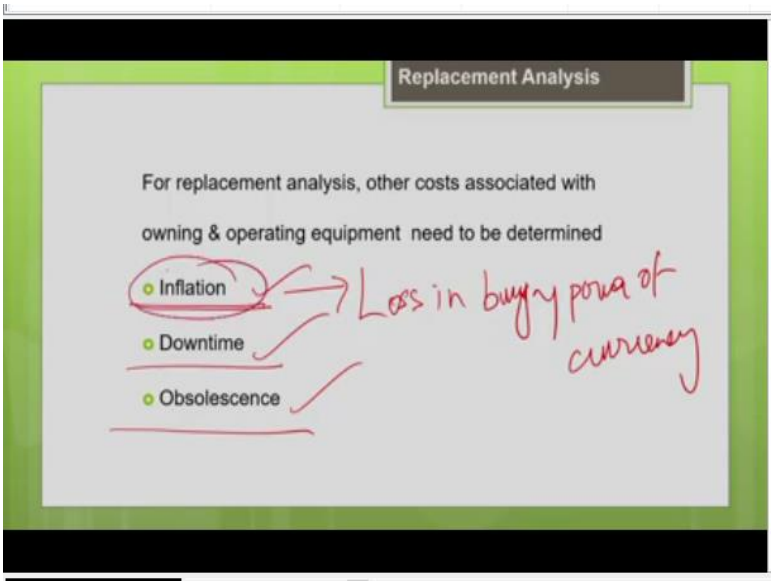

So, coming to the replacement analysis. So, now we are going to estimate the economic life of the machine, we will be working on some illustration on how to estimate the economical life of a particular machine. So, as I told you, to make an accurate estimation of the economic life. To do

the accurate replacement analysis, I need to include all the cost components. So, we have discussed about different components of the ownership costs and the operating costs.

So, we have to consider all the costs involved in the equipment cost estimation. So, some of these costs we have not discussed earlier, we are going to discuss now. One is the inflation cost, other one is it downtime, other one is obsolescence cost. Inflation everyone knows it is nothing but the loss in the buying power of a currency. Say for example, if I have purchased a machine for 10 lakh rupees 5 years before, the same machine, I cannot purchase it at 10 lakh now.

Obviously, the cost of the machine would have increased with time. So, that is the effect of inflation. So, whenever we consider about the replacement, when you plan for the replacement, when we do the replacement analysis, this increase in cost with time due to inflation should also be involved, incorporated in the cost estimation. So, we have to consider the inflation effect on the cost estimation. So, other one is downtime, you are going to see now.

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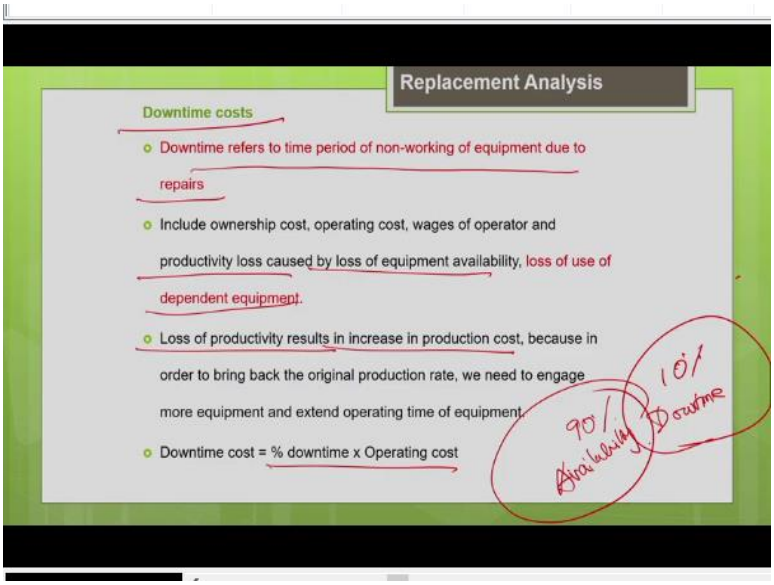

Downtime is nothing but your machine is not available for working productively. Either it is broken down it has been sent to the repair yard for the repair. So, this generally refers to the time period of non-working of the equipment due to repairs. Basically, as the age of the machine increases, it gets worn out. So, many parts get worn out. So, many times you can see it will be sent to the repair yard for the service.

So, with increasing age, you can see that the downtime costs will also increase, it is obvious. So, when the machine is sent to the repair yard when it is not available, also we are incurring the cost. So, this is what I told you in initial part of the lecture also that even when the equipment is idle, we are incurring some costs associated with the machine. We always incur we have to bear this ownership cost.

Whether the equipment is operated or whether the equipment is idle. Irrespective of whether it is operated or idle, we are going to bear some fixed ownership costs associated with the machine. So, that has to be taken into account. Other one is the operating cost, even though the machine is in the repair yard, you have to pay the wages for operator. So, we are baring some operating costs.

And another thing is your productivity loss. Since the machine is not available for the productive job, we are facing the loss of productivity. So, because of that there will be some increase in cost. So, that is another important thing. So, basically to explain that more clearly, say for example, your machine has spent some sufficient time in the repair yard. So, because of that, we are going behind our production schedule.

So, once the machine comes back from the repair yard to the project site to resume the service. So, we are already behind the schedule. So, what we have to do, we have to now increase your number of operating hours or you have to increase the operating time, you have to extend the working hours, you have to hire more labour, or even you have to employ more machines, so that I can bring back my productivity level to the original level of productivity.

So, for that, I have to incur some additional cost that cost is taken under the loss of productivity. So, the laws of productivity results in increase in the production cost, because in order to bring back the original production rate we need to engage more equipment and extend the operating life of the equipment. So, that results in the additional costs. This is what we are going to estimate in the upcoming illustration, how to estimate the cost associated with the loss of productivity of the machine, because of the downtime of the machine.

Another important thing which we should not overlook is the loss of the use of dependent machines. Say for example, when the machines are working in team, say for example, your excavator and the truck, they are working together. If the excavator breaks down, so the truck will also be idle. So, the ownership cost, the operating cost and the operator wages cost of the truck and the loss and productivity of the truck, everything should be taken into account when you estimate the downtime costs of the excavator, because they are dependent machines.

Similarly, a scraper and a pusher, which are working in team. When the scraper breaks down the pusher will be idle. So, the associated costs of the pusher should be taken into estimation of the downtime cost of the scraper. Similarly, you have a concrete mixer machine. If the concrete mixer machine breaks down, so what will happen, the dependent machines are your pumps, your transit mixer, your RMC transit mixer, all these are dependent machines. So, when this breakdown all these associate machines will be idle.

So, their costs should be accounted when you estimate the downtime cost. So, all these things that we should keep in mind when we estimate the downtime costs associated with the machine. So, basically, the downtime cost is usually expressed as a percentage of the operating cost. So, in different literature, they express a different way as a percentage of the operating costs or the percentage of the equipment rental charges, or the percentage of the equipment cost.

So, it is expressed in different ways in different literature. But basically, what you need to know is what is downtime? It is a time the machine is not available for a job. Say for example, your machine availability is 90% of the total time, if its availability is 90% then obviously, the downtime will be 10% of the total time. I am talking about time. So, if the availability of the machine is 90%, then the downtime, it is not available is 10%.

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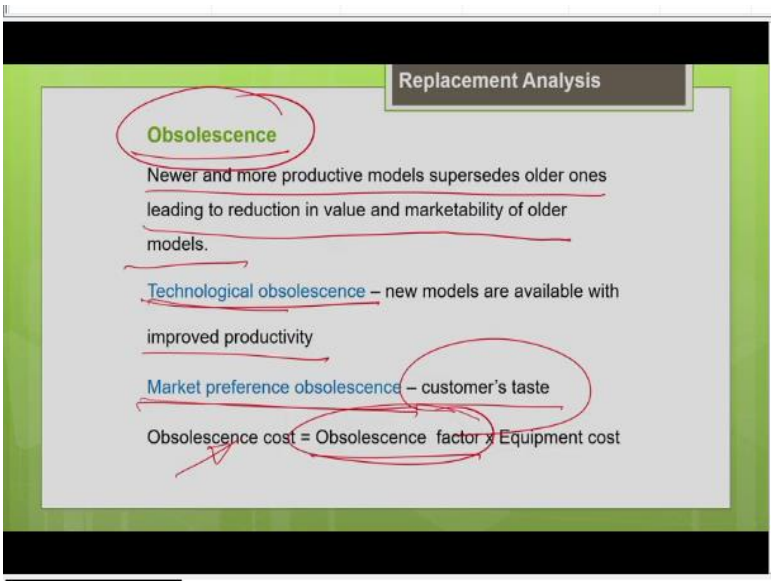

So, the next important cost, which we should consider when we do the replacement analysis, is the obsolescence cost. So, this we discussed earlier also as a machine gets older, it becomes obsolete, why it becomes obsolete? Because it is worn out already, its productivity would have been reduced; its maintenance and repair costs would have increased. At the same time, you can see in the market there are competitive models in the market, which have better productivity at lower operating costs.

And also, maybe there are so many advanced features which gives you more ease of operation, more safety features with enhanced productivity. So, when there are so many models available in the market competitive models available in the market and despite that, when you are sticking to your old machine, which have low productivity, then we are facing actually some loss. So, there is some increasing cost associated with it that is called as obsolescence cost.

So, newer and more predictive models supersedes the older ones leading to reduction value of the machine and the marketability of the old machine. So, basically it refers to the obsolescence, refers to the loss in value of the machine with time. So, due to depreciation as well as the loss of marketability of the machine. So, this obsolescence can be either technological obsolescence or market preference obsolescence.

Technological just know I told you due to the loss of productivity. There are many competitive models with better productivity in the market, but you are sticking to the old machine with a very low productivity. So, what is the cost associated with it, what is the loss we are facing because of that? That is technological obsolescence. The other one is little bit difficult to quantify because the customer's taste changes with the time.

So, when they say for many advanced features, new models, their taste changes with the time, even though your machine may be performing well, but the customer tastes would have changed. So, that is market preference obsolescence. So, there are different types of obsolescence. So, basically this obsolescence value is expressed as a percentage of equipment cost. So, this factor, I can get it from literature for different types of equipment, for different operating conditions, for different conditions, I can get the obsolescence value.

So, we can make use of that for estimating this obsolescence cost. So, we have discussed about the different components of the equipment cost estimation from the replacement analysis perspective. So, as I told you earlier, for replacement analysis, we should consider all the competence of the equipment cost. So, that we can accurate estimation of the replacement timing.

So, we should consider all the components of equipment costs including the downtime cost, obsolescence cost, the effect of inflation, everything should be considered. So, that we can get an accurate picture of what will be the optimum replacement time. So, now, let us work out a illustration, so that we can have a better understanding on how to estimate the economic life of the machine.

So, hope you remember, what is the economic life of the machine? Economic life is nothing but the time period during which the cost associated with the machine is minimum? So, if you are going to optimize your production with respect to cost, then you have to go for the minimum cost. If you are going to optimize the production with respect to profit, then you have to go for the period with maximum profit.

So, basically that is what is this economic life. Economic life means it is a time during which the cost of holding the machine will be minimum. So, beyond the economic life you can see that there will be increasing costs associated with the machine, either due to increase in the operating cost that is repair and the maintenance costs or increase in downtime costs or increasing obsolescence cost.

All these things will be resulting in the shooting up of your total cost of the machine. So, which is not desirable that is why when the cost is meaning of itself, we should try to replace the old machine with the new machine. So, that we do not enter into loss. So, now, let us work out an example.

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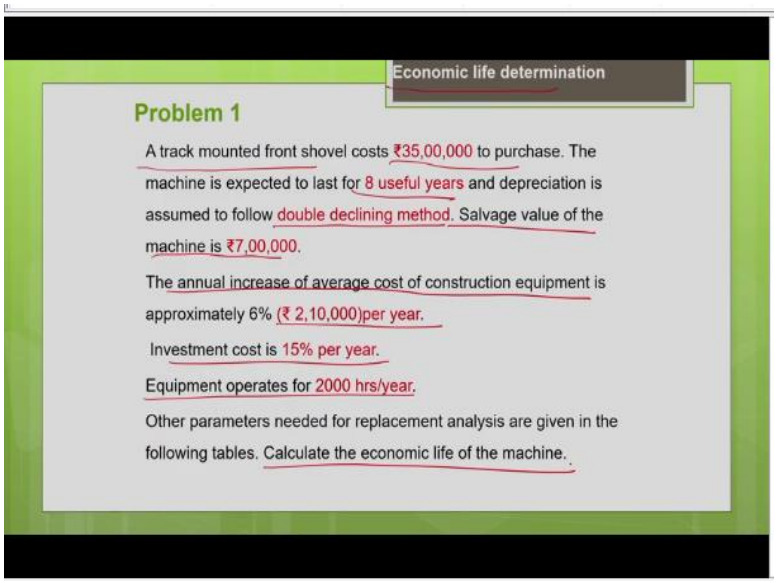

In this example, we are going to see how to estimate the economic life of the machine. So, basically, so, here we are going to estimate economic life for a track mounted front shovel. The purchase price is 35,00,000. So, the machine is expected to last for 8 useful years and the depreciation is assumed to follow double declining balance method. So, we are going to follow double declining balance method to estimate the depreciation.

And at the end of the 8 years you will be able to sell the machine at the cost of rupees 7,00,000. That means the salvage value of the machine is 7,00,000. So, due to inflation, you can see that annual increase of the average cost of the equipment is approximately 6%. That means, the

machine cost is going to increase by 2,10,000 every year, due to the effect of inflation. So, this also needs to be considered during the replacement analysis.

And the cost of investment is 15% per year. So, this you can consider it as a percentage of the book value of the machine, then the equipment is going to operate for 2000 hours in a year. So, the annual usage is given 2000 hours. So, the other parameters needed for the replacement analysis are given in the following tables, we are going to discuss that. So, we have to estimate the economic life of this machine.

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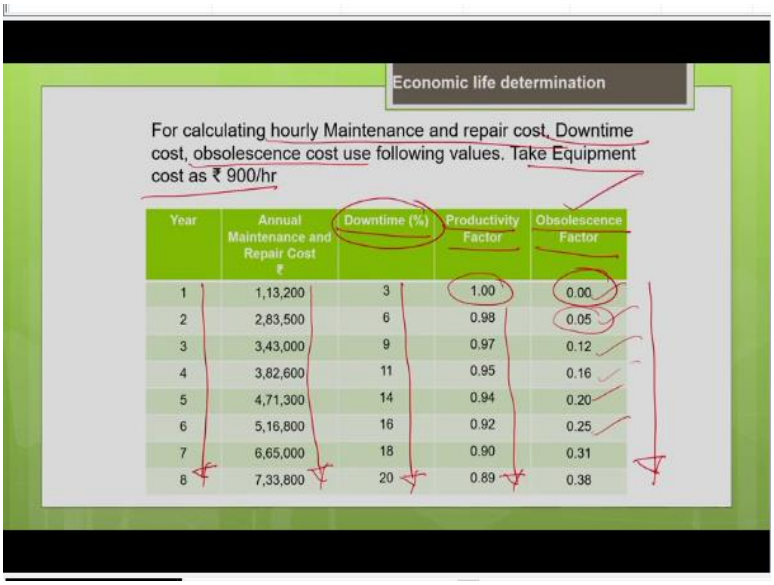

So, what are the other parameters needed for the replacement analysis which are given as input data for this problem, let us see. So, for calculating the hourly maintenance and the repair cost, downtime cost and the obsolescence cost of the machine, we have to use the following values and the equipment cost is given approximately as rupees 900 per hour. So, every year maintenance and repair costs is given for the entire useful life of the machine.

So, you can see that the annual maintenance and repair costs is increasing with the age of the machine, as the age of the machine increases, you can see that maintenance and repair cost is increasing. And another thing I hope you remember what is downtime? Downtime is nothing but the non availability of your machine for the productive work. So, it may be either due to the breakdown of the machine.

So, mostly it is due to the breakdown of the machine, machine may be spending its time in the repair yard and it will not be available for the productive job. So, that time is called as a downtime of the machine. So, in order to estimate the downtime costs, we express it as a percentage of the operating costs of the machine or the equipment cost of the machine. So, you can see that, with the increase in age of the machine your downtime costs is also increasing.

As the machine becomes older, you can see the time it spends in the repair yard will be more. So, the downtime percentage is more and another thing as I told you, when the machine is not available for the productive job, so you will be facing some loss in productivity. So, that productivity factor is also given. So, maybe for the first year there is no change in productivity, but from the second year onwards you can see that there is loss in productivity of the machine with the increase in the downtime of the machine.

So, all this loss in productivity is going to result in increase in the cost of the machine. We are going to estimate in the upcoming slides. So, another thing to be noted is the obsolescence cost is also important as the age of the machine increases, it becomes obsolete you know that. So, there may be different reasons for the obsolescence either due to technological obsolescence, that is due to wear and tear, its productivity may get reduced, or it may be even due to market obsolescence.

The customer tastes would have changed, the customer will be opting for more advanced machines with more ease of operation, with more safety features, with more updated technology. So, it means if your machine is obsolete. There are so many competitive models on the market which are having updated technological features. So, these obsolescence factors are available from the literature for different types of equipments.

And you can see that with increase in age your obsolescence factor is increasing. For the first year, it is 0, it means machine is not obsolete. By the end of second year you can see there is a percentage of obsolescence. And your obsolescence factor increases with the age of the machine,. It is clearly evident; you can get this data from the literature for different types of equipment. This we are going to use it in the estimation of obsolescence cost.

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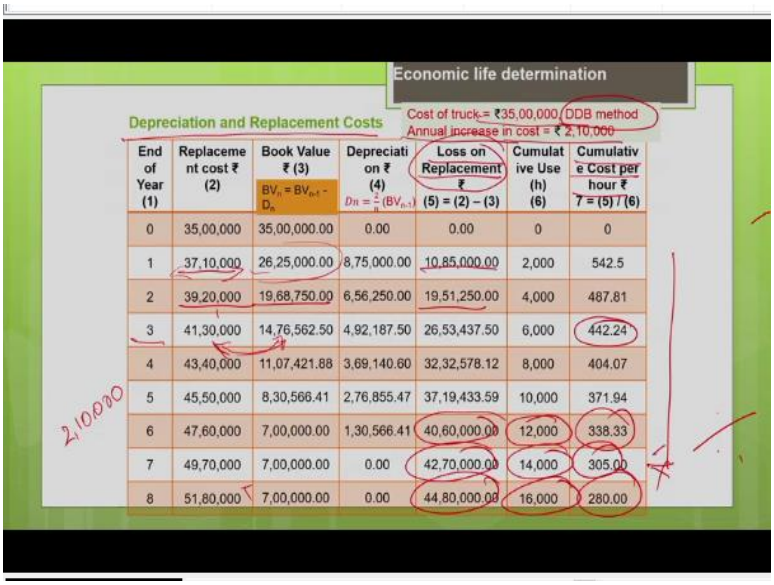

So, now let us work out the cost associated with the machine from the replacement analysis perspective. So, as I told you, we are supposed to consider all the components of the cost associated with the machine, so that you can have an accurate estimation of the optimum replacement time. So, first we are going to estimate the depreciation and the replacement cost associated with this machine.

So, as I told you due to inflation, there is an increase in cost of the machine every year. So, it is given as input data in the problem that the initial cost of the truck is 35,00,000 and the annual increase in the cost you can see that it is 2,10,000 every year, annual increase in the cost is rupees 2,10,000, due to the inflation. So, after 1 year, if you want to replace the particular machine, the increase in the cost will be 2,10,000. So, initial cost is 35,00,000, at the end of one year if we want to replace a machine, so, we have to spend 37,10,000 to replace the machine.

Replacement Cost for 1st year = 35,00,000 + 2,10,000 = 37,10,000 rupees

Replacement Cost for 2nd year = 37,10,000 + 2,10,000 = 39,20,000 rupees

Replacement Cost for 3rd year = 39,20,000 + 2,10,000 = 41,30,000 rupees

So, like that every year the cost increases by 2,10,000 due to inflation, this you have to take into account when you do the replacement analysis. Another important thing you need to see is, every

year the machine is depreciating, there is a loss of book value. So, in this problem we are going to estimate the depreciation using double declining balance method. So, I hope you remember what was the formula used for the double declining balance method to estimate the depreciation.

$$D_n = \frac{2}{n} \times (BV_{n-1})$$

Say, for the first year, I have to estimate the depreciation now, D 1 is nothing but 2 by n into book value of the previous year, book value at the end of the previous year, it is nothing but the book value at the beginning of the current year. So, both are same, book value at the end of the previous year is same as the book value of the beginning of your current year, for which you are calculating the depreciation.

$$D_1 = \frac{2}{8} \times (35,00,000) = 8,75,000 \text{ rupees}$$

$$BV_1 = 35,00,000 - 8,75,000 = 26,25,000 \text{ rupees}$$

You subtract both, you will get the book value at the end of first year, it is nothing but 26,25,000. So, book value at the end of the first year. So, to get that you have to subtract the book value of the beginning of the first year and these 2 and depreciation for the first year, if you subtract these 2 you will get the book value at the end of the first year. So, this is how you calculate. So, that is why it is given, here you can see the book value for the current year is nothing but book value at the end of the previous year minus a depreciation for the current year.

So, book value at the end of the previous year is same as the book value at the beginning of the current year. Now let us calculate the depreciation for the second year.

$$D_2 = \frac{2}{8} \times (26,25,000) = 6,56,250 \text{ rupees}$$

$$BV_2 = 26,25,000 - 6,56,250 = 19,68,750 \text{ rupees}$$

So, if we subtract both we will get the book value for the second year as 19,68,750, So, this is the book value the at the end of second year. So, hope you understand. So, how are you calculating that? So, basically, if you subtract the book value at the end of the first year minus depreciation for the second year you will get the book value at the end of the second year. So, one more example, sample calculation will show so that your understanding will be better. So, now, we are going to calculate the depreciation for the third year.

$$D_3 = \frac{2}{8} \times (19,68,750) = 4,92,187.5 \text{ rupees}$$

It is nothing but book value at the end of second year minus depreciation for the third year.

BV_3 = 19,68,750 – 4,92,187.5 = 14,76,562 rupees

So, this is how you are going to estimate the book value and the depreciation for the 8 years. So, the remaining calculations you can do. Now, let us say what is the loss associated with the replacement? As I told you due to inflation, there is an increase in costs every year. So, at the end of first year I told you there is an increase in cost of 2,10,000.

Now, your new cost is 37,10,000, there is an increase in costs, there is a loss actually. Similarly, there is a decrease in value of machine due to depreciation with time. So, at the end of first year, the book value is 26,25,000, that means from 35,00,000 it has gone down to 26,25,000. Similarly, the initial price has increased from 35,00,000 to 37,10,000. If you subtract both these 2 you can find the loss of replacement.

So, basically you can see here, see basically the end of first year if I wanted to replace the cost of the machine is 37,10,000 due to inflation from 35,00,000 it has increased by 2,10,000. But at the end of the first year, if I replace my old machine with a new machine, the inflow I can get is only 26,00,000 because your machine has depreciated 26,25,000.

Loss for year 1 = 37,10,000 – 26,25,000 = 10,85,000 rupees

Loss is nothing but 10,85,000. This is your loss, loss on replacement, if I replace the machine at the end of first year. Similarly, if I replace machine at the end of second year, at the end of second year, you can see the machine has increased in cost by 39,20,000 due to inflation, and the book value has gone down to 19,68,750. So, this is your inflow actually. So, actual loss will be for the replacement at the end of second year will be 19,51,250.

Loss for year 2 = 39,20,000 – 19,68,750 =19,51,250 rupees

So, this is a loss on replacement at the end of second year. Similarly, you can calculate for the third year

Loss for year 3 = 41,30,000– 14,76,562 = 26,53,437 rupees

So, already this is on cumulative basis only. Now, you find the cumulative use of the machine every year you know the machine is being used for 2000 hours.

The annual usage of machine every year is 2000 hours. So, you find the cumulative use of the machine say for second year, 2000 + 2000 it is 4000, for third year 4000 + 2000 it is 6000. Now, for the fourth year the cumulative use will be 6000 + 2000 hours it is 8000 hours. Like that you find the cumulative use of the machine. This entire replacement analysis will be on cumulative basis, I will explain you later, we have to do it on cumulative basis only.

So, I will explain the reason later. Now, you find what is the cumulative cost per hour? Cumulative cost per hour is nothing but the cumulative cost on replacement. So, the cumulative cost on replacement. So, you can see here the cumulative cost on replacement,

Cumulative cost on replacement, end of the first year = $\frac{1085000}{2000}$ = 542.5 rupees per hour

That means, at the end of the first year the depreciation and the replacement cost associated with the machine is 542.5 per hour. Similarly, at the end of second year if we wanted to find. So, the depreciation on the replacement cost you can see that it is 19,51,250. At the end of second year the cumulative use is 4000 hours. So, the replacement costs associated with this machine per hour is 487.81 for 2 years.

Cumulative cost on replacement, end of the second year = $\frac{19,51,250}{4000}$ = 487.81 rupees per hour

So, the replacement costs associated with this machine per hour is 487.81 for 2 years. We are calculating on the cumulative basis. Similarly, for the third year,

Cumulative cost on replacement, end of the third year = $\frac{26,53,437}{6000}$ = 442.24 rupees per hour

You can see the cost per hour associated is 442.24 per hour for the past 3 years. So, like this you calculate the depreciation the replacement costs for 8 years, so the entire useful life of the machine.

So, one thing you can see that the depreciation and the replacement cost is decreasing with time, as the usage of the machine increases, as the cost is distributed over a greater period, as the cost is distributed over a greater period, you can see that the costs per hour is getting reduced. So, mostly the ownership cost is getting reduced with time because as the usage increases, because the cost is getting distributed over a greater period.

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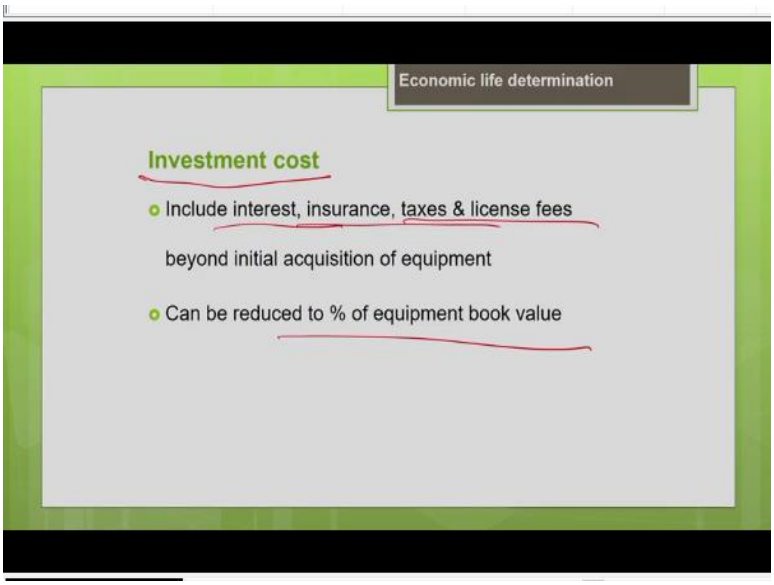

Now comes the investment cost. So, this investment cost includes all the costs associated with the investment, like the interest you pay for the loan, your insurance taxes, license fees, everything we are adding under investment. So, it can be calculated as a percentage of the equipment book value. So, in this problem, the cost of investment is given as 15% per year.

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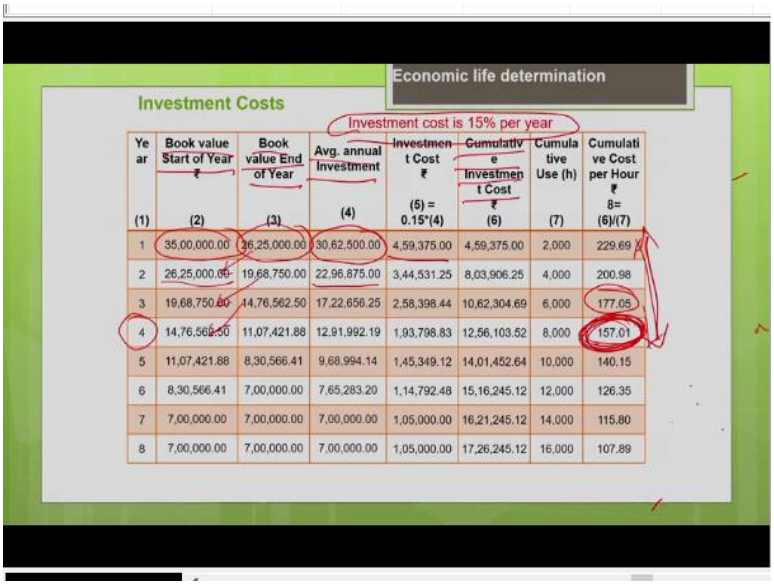

Year (1)	Book value Start of Year ₹ (2)	Book value End of Year (3)	Avg. annual Investment (4)	Investment Cost ₹ (5) = 0.15*(4)	Cumulative Investment Cost ₹ (6)	Cumulative Use (h) (7)	Cumulative Cost per Hour ₹ 8= (6)/(7)
1	35,00,000.00	26,25,000.00	30,62,500.00	4,59,375.00	4,59,375.00	2,000	229.69
2	26,25,000.00	19,68,750.00	22,96,875.00	3,44,531.25	8,03,906.25	4,000	200.98
3	19,68,750.00	14,76,562.50	17,22,656.25	2,58,398.44	10,62,304.69	6,000	177.05
4	14,76,562.50	11,07,421.88	12,91,992.19	1,93,798.83	12,56,103.52	8,000	157.01
5	11,07,421.88	8,30,566.41	9,68,994.14	1,45,349.12	14,01,452.64	10,000	140.15
6	8,30,566.41	7,00,000.00	7,65,283.20	1,14,792.48	15,16,245.12	12,000	126.35
7	7,00,000.00	7,00,000.00	7,00,000.00	1,05,000.00	16,21,245.12	14,000	115.80
8	7,00,000.00	7,00,000.00	7,00,000.00	1,05,000.00	17,26,245.12	16,000	107.89

Investment cost is given as 15% per year. Now, we are going to calculate the investment costs for the entire useful life of the machine. And we will calculate the investment costs as a percentage of the book value of machine. Here we are taking the average book value for every year, you are

going to calculate. So, I need to know the book value at the beginning of the year and book value at the end of the year to find the average book value of the particular year.

So, obviously book value at the beginning of year is a purchase price 35,00,000, book value at the end of every year, you can get from the previous table, we have calculated the book value at the end of every. So, this column you can use it for this investment calculation book value the end of every year can be obtained from this table. So, we are going to use it and another thing as I told you book value the end of first year is same as the book value to the beginning of the second year.

Similarly book value at the end of second year is same as the book value at the beginning of third year. So, it goes on like this. Now, you find the average book value for every year, average book value for every year is nothing but

Average for year 1 = 35,00,000 + 26,25,000 = 30,62,500 rupees

Average book value for the first year is 30,62,500. Now, you calculate the investment cost. So, investment cost is nothing but 15% of average book value of the particular year.

Investment cost for year 1 = 0.15 × 30,62,500 = 4,59,375 rupees

So, this is how we have to calculate the investment costs for every year. So, one more sample calculation I will show, so that you will understand better. Now, the average book value for the second year,

Average for year 2 = 26,25,000 + 19,68,000= 22,96,875 rupees

So, this is your average book value for this you calculate the investment cost. So, investment costs is nothing but 15% of the average book value,

Investment cost for year 2 = 0.15 × 22,96,875= 3,44,531.25rupees

So, this is your investment cost for a second year. So, like this you can calculate the investment costs for all the years. Now, you find the cumulative investment. So, you can easily find the cumulative investment. So, investment for the first year added to the second year you will get you will get cumulative investment at the end of second year.

So, cumulative investment at the end of second year added to the third-year investment, you will get the cumulative investment at the end of third year. So, like that you keep on adding you will get the cumulative investment. Now, the cumulative usage now, every year the usage is 2000 hours

add 2000 + 2000, 4000 + 2000, 6000. So, keep on adding it you will get the cumulative usage of the machine for every year.

So, the entire replacement analysis is on cumulative basis only. So, now you can see the cumulative cost per hour. So, how do you find the cumulative investment cost per hour? So, cumulative investment costs is

$$\textbf{Cumulative Investment cost, end of the first year} = \frac{4,59,375}{2000} = \textbf{229.69 rupees per hour}$$

So, this is your cumulative cost per hour for the first year. Similarly, find the cumulative cost per hour for the second year.

$$\textbf{Cumulative Investment cost, end of the second year} = \frac{8,03,906.25}{4000} = \textbf{200.98 rupees per hour}$$

$$\textbf{Cumulative Investment cost, end of the third year} = \frac{10,62,304}{6000} = \textbf{177.05 rupees per hour}$$

So, basically so what I am trying to say is if you are going to hold your machine with you for 3 years, say for example, 3 years, the cumulative investment cost per hour for the 3 years is 177.05. Similarly, if you are going to hold your machine with you for 4 years, the cumulative investment cost per hour for the 4 years will be 157.01. So that is why we are trying to find cumulative basis so that we can get a clear picture for the replacement. So, this value indicates a cumulative investment cost for the past 4 years per hour.

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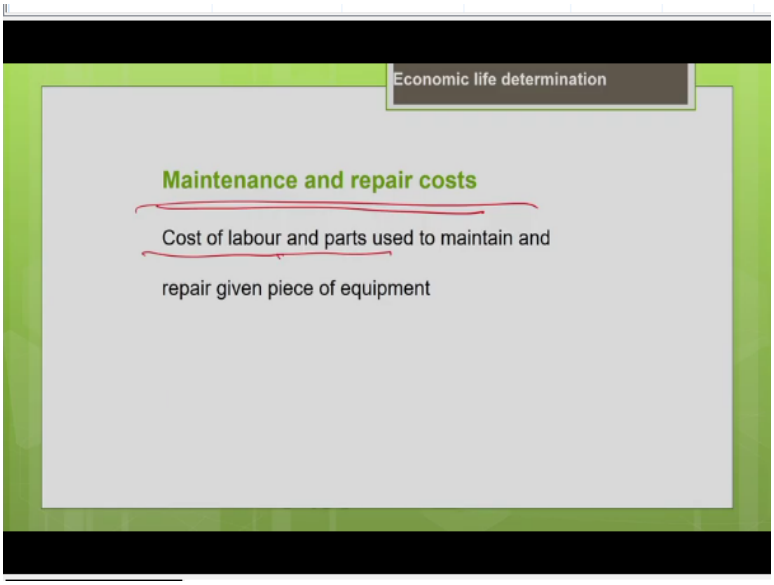

Now, let us calculate the next important component of the equipment cost. It is nothing but your maintenance the repair cost. So, as you know all the costs associated with the repair and the maintenance like the cost of the labour you engage for the repair work and the replacement parts, the costs associated with the replacement parts, everything will come into the maintenance and repair.

So, basically for a very big project site, you may have your own maintenance yard, you have a maintenance facility and you might engaged a labor for doing the regular maintenance or the periodic maintenance for your machine. So, the costs associated with those things will be included under the maintenance of the repair cost. So, as you know, with increase in the age of the machine, you can see that the maintenance and the repair costs will increase.

But in the previous table do remember. So, the investment cost you can see with increase in age of the machine, your accumulated cost per hour is decreasing, as I told you the reason, so, when the investment cost is distributed over a greater period, when the cost is distributed over a greater period, you can see that the cost will reduce. As the usage is increasing, you can see that the cost is reducing with the time.

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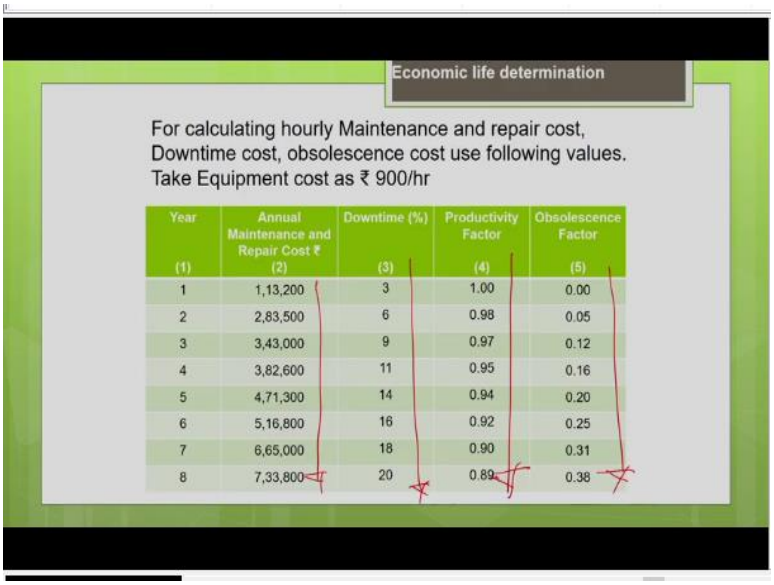

But in the case of operating costs, the maintenance and repair costs, downtime costs, you can see that your costs will increase with the age of the machine. So, the thing you have to noted very

carefully. Now let us calculate the maintenance and repair costs. So, this table I showed you already, this is the input table, input value is given in the question, every year maintenance and repair costs is given, you can see that the maintenance of the repair costs is increasing with the time duration.

Downtime cost is also given, it is increasing with the age of the machine, the productivity loss is increasing, there is a loss of productivity with age of the machine and the obsolescence factor is increasing with the age of the machine. Let us calculate all these costs in the upcoming slides.

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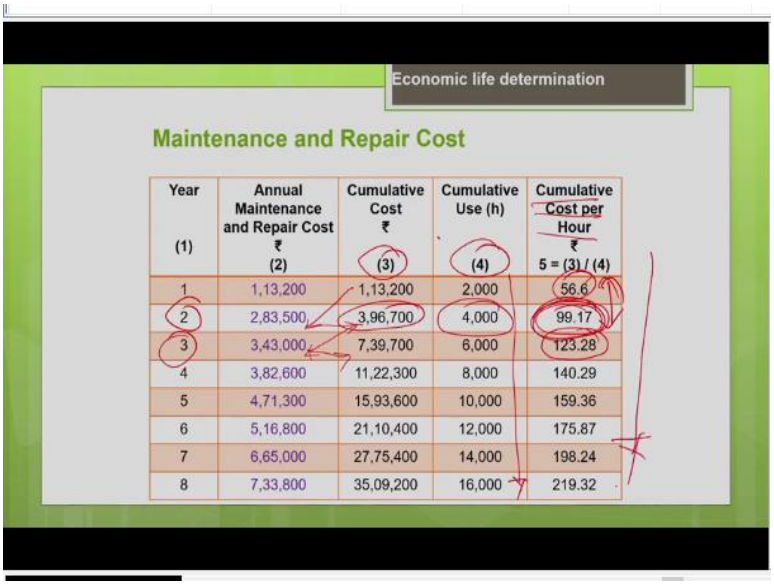

Year (1)	Annual Maintenance and Repair Cost ₹ (2)	Cumulative Cost ₹ (3)	Cumulative Use (h) (4)	Cumulative Cost per Hour ₹ 5 = (3) / (4)
1	1,13,200	1,13,200	2,000	56.6
2	2,83,500	3,96,700	4,000	99.17
3	3,43,000	7,39,700	6,000	123.28
4	3,82,600	11,22,300	8,000	140.29
5	4,71,300	15,93,600	10,000	159.36
6	5,16,800	21,10,400	12,000	175.87
7	6,65,000	27,75,400	14,000	198.24
8	7,33,800	35,09,200	16,000	219.32

The first one we are going to calculate is your maintenance and the repair cost. So, every year annual maintenance and repair cost is given. Now, you find the cumulative cost because everything is done on cumulative basis. Find the cumulative maintenance and the repair costs for every year, you just add it. The first year the cost with the second year cost, you add it. So, you are going to add the first year maintenance and repair cost. So, with this second year cost, if you add you will get cumulative cost at the end of second year.

Similarly, cumulative costs at the end of second year add it with the cost of third year you will get the cumulative cost the end of third year. So, like that to keep up the calculating you know the cumulative usage of machinery every year it is 2000 hours, we can add it. Now similarly, you find

the cumulative cost per hour, you are going to divide the third column by the fourth column to get the cumulative cost per hour,

$$\textbf{Cumulative cost, end of the first year} = \frac{1,13,200}{2000} = \textbf{56.60 rupees per hour}$$

Similarly, for the second year,

$$\textbf{Cumulative cost, end of the second year} = \frac{3,96,700}{4000} = \textbf{99.17 rupees per hour}$$

So, if you are going to hold your machine for 2 years, your accumulative repair and maintenance costs will be 99.17 rupees per hour for the past 2 years. Similarly, if you are going to hold it for 3 years, your cumulative repair and maintenance will be 123.28 rupees per hour for the past 3 years.

So, that is way we are calculating in the cumulative basis. And you can clearly see that your maintenance and the repair cost is increasing as the age of the machine increases.

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Now we are going to calculate the downtime costs of the machine. So, because of non availability of the machine for a productive job, what is the cost associated with that we are going to calculate. So, the downtime percentage is given, the input as the input data for this problem. So, we are going to calculate the downtime costs as a percentage of the equipment cost. So, equipment cost has given as approximately 900 rupees per hour. So now you calculate the downtime cost.

So, downtime cost per hour equal to 3% of your equipment cost. Equipment cost is nothing but 900 rupees per hour.

$$\textbf{Downtime cost per hour} = \frac{3}{100} \times (900) = 27 \textbf{ rupees per hour}$$

your machine is going to operate in a year for 2000 hours. So, what is your yearly downtime cost? Yearly downtime costs for the first year is,

$$\textbf{Downtime cost per year} = 27 \times 2000 = 54{,}000 \textbf{ rupees}$$

This is your per year, per year in the sense for the first year, 54,000 rupees for the first year is your downtime cost. Similarly, calculate the downtime costs, let us calculate for the second year, in the second year the downtime percentage is 6%. So, downtime cost is 6% of your equipment cost, equipment cost is 900 rupees per hour.

$$\textbf{Downtime cost per hour} = \frac{6}{100} \times (900) = 54 \textbf{ rupees per hour}$$

$$\textbf{Downtime cost per year} = 54 \times 2000 = 1{,}08{,}000 \textbf{ rupees}$$

So, 1,08,000 rupees is your downtime costs for the second year. Similarly, you calculate a downtime cost for all the years for the entire life of the machine. Now, you find the cumulative down time cost. Everything is done on cumulative basis. So, find the cumulative downtime cost by adding it.

So, 54,000 + 1,080,00 gives you 1,62,000, 1,62,000 + 1,62,000 gives you 3,24,000 for the third year, So, like that you keep on adding it you will get the cumulative cost. So, now, you know the cumulative usage, every year it is going to be 2000 hours, add it. Now the cumulative cost per hour you can calculate by dividing the 6th column by the 7th column values

$$\textbf{Cumulative cost, end of the first year} = \frac{54{,}000}{2000} = 27 \textbf{ rupees per hour}$$

That will give you the cumulative downtime cost per hour as 27 per hour for the first year. Similarly, for a second year, it is

$$\textbf{Cumulative cost, end of the second year} = \frac{1{,}08{,}000}{4000} = 40.5 \textbf{ rupees per hour}$$

So, like that you calculate these values for all the years. We are just going to divide the 6th column with the 7th column value you will get this the cumulative cost per hour.

Now, you have to account for the loss in productivity. So, the loss in productivity is also going to result in increase in the downtime cost of the machine. So, as we discussed earlier the loss of productivity results in increase in production cost because the machine has spent the time in the repair yard. So, after the service when it comes back to the project site we will be behind the project schedule. So, to bring the productivity back to the original production rate we need to engage the machine for more number of operating hours or we need to even increase the number of machines or we need to increase the number of workers.

So, to bring back the productivity to the original production rate. So, for that we have to increase, we have to spend some more cost, some more money we have to spend. So, that results in some increase in cost due to downtime. So, that is what is called as productivity adjusted cumulative downtime costs per hour that is what we are going to find here. Productivity adjusted cumulative cost per hour we are going to find that.

So, you know that the productivity factor is given as the input data in this problem. So, for the first year there is no change at all, but for the second year there is loss in productivity, 0.98. So, I want to say 40.5 is my cost per hour, the productivity corresponding is 0.98, to bring back this productivity to 1, I need to spend some additional cost,

$$\textbf{Productivity adjusted cumulative cost, first year} = \frac{40.5}{0.98} = \textbf{41.33 rupees per hour}$$

So, this is an increase in cost I am facing due to the downtime to bring back my productivity to the original production rate, I need to spend some more efforts on cost. So, that is what is productivity adjusted downtime cost, so you are going to find that by dividing this 8th column by 9th column, you will get this,

$$\textbf{Productivity adjusted cumulative cost, second year} = \frac{54}{0.97} = \textbf{55.67 rupees per hour}$$

$$\textbf{Productivity adjusted cumulative cost, third year} = \frac{65.25}{0.95} = \textbf{68.68 rupees per hour}$$

So, this gives you productivity adjusted cumulative cost per hour. So, we have calculated it downtime cost. So, let us now move on to the next cost, which is nothing but your obsolescence cost.

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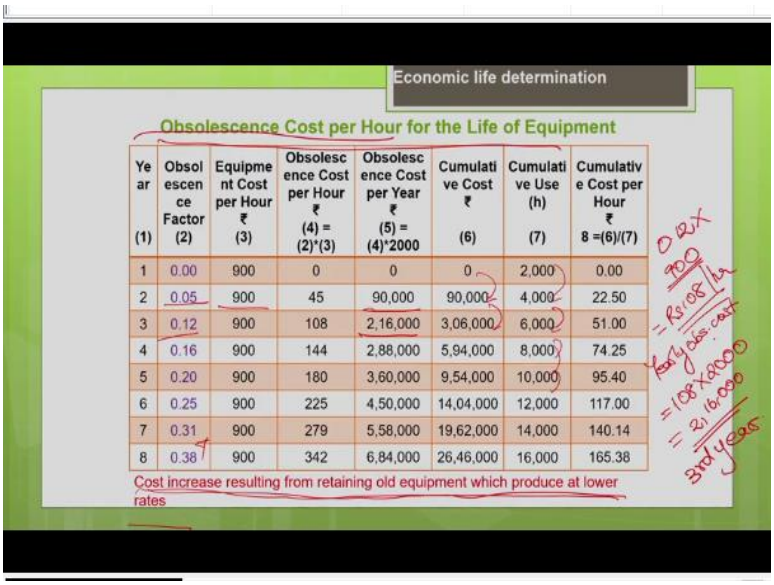

So, every year your obsolescence factor is increasing as machine is becoming more obsolete. So here we are trying to calculate the cost increased resulting from retaining the old machine with us, which is producing at a lower productivity rate. So, your machine is being subjected to wear and tear as the age of machine is increasing. So, because of that there will be some loss of productivity of the machine, there will be increasing maintenance and repair costs associated with the machine.

But there may be many competitive models in the market available with a better productivity at a lower cost and even with better advanced technological features. So, instead of switching over to the new machine as we are just clinging on to the old machine what is the increasing cost we are facing that is what is the obsolescence cost, that is what we are calculating now. Costs increased resulting from retaining the old equipment which produces lower rate.

So, that is what we are going to calculate here. So, this obsolescence factor is also calculated as a percentage of a equipment cost. Equipment costs you know, approximately 900 rupees per hour we are going to use a value here. So, calculate obsolescence cost for every year, first year obsolescence is 0. So, let us calculate it for second year it is nothing but obsolescence factors is

Obsolescence cost per hour = 0.05 × 900 = 45 rupees

So, this is hourly basis. Now, you have to calculate for the entire year. So, yearly obsolescence costs for the second year

Obsolescence cost per second year = 45 × 2000 = 90,000 rupees

Now, similarly, calculate the obsolescence cost for the second year. The obsolescence factor is 0.12

Obsolescence cost per hour = 0.12 × 900 = 108 rupees

This is your obsolescence cost. Your equipment cost is 900 per hour, but your obsolescence cost is 108 per hour. Now find the yearly obsolescence cost yearly obsolescence cost is

Obsolescence cost per third year = 108 × 2000 = 2,16,000rupees

This is for the third year. Now, you find the cumulative obsolescence cost. You add it you will get the cumulative obsolescence cost for every year. You know the cumulative usages for every year it is 2000 hours. So, you can add it. Now similarly, you find the cumulative cost per hour. So, the cumulative cost per hour is going to be nothing but column 6 divided by column 7, as we did for the earlier cost, the same methodology we are going to follow here.

$$\textbf{Obsolescence cumulative cost in second year} = \frac{90{,}000}{4000} = \textbf{22.50 rupees per hour}$$

Similarly, for the third year, it is nothing,

$$\textbf{Obsolescence cumulative cost in third year} = \frac{3{,}16{,}000}{6000} = \textbf{51 rupees per hour}$$

If you are going to hold your machine with you for 3 years, your obsolescence cost per hour for 3 years will be 51 rupees. So, that is what you mean on cumulative basis. So, the same way you calculate the cumulative cost per hour for the entire life of the machine. So, you can see that the obsolescence cost is increasing with the time. Similarly, your downtime cost also the table you can see it is increasing with the time increasing with the age of the machine. Now, let us summarize all the costs we have calculated so far.

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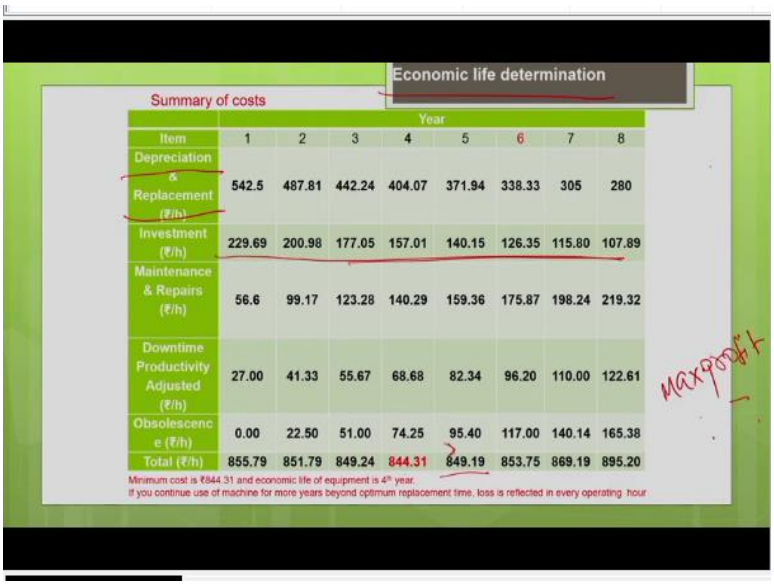

So, that we can estimate what is the optimum replacement type of the machine or what is the economic life of the machine? So, the first is depreciation of the replacement cost. So, I have just summarized the values we have estimated for the 8 years. Similarly, the investment cost, similarly the maintenance and repair cost for all the 8 years, downtime cost for all the 8 years, then the obsolescence costs for all the 8 years. So, one thing to note here is your depreciation cost it is decreasing, with the age of machine.

Investment cost is also decreasing with the age of machines, as the investment cost is getting distributed over a greater life, greater usage, your cost is getting reduced per hour. But your maintenance and repair costs as machine gets older it is increasing. Similarly, downtime cost is increasing and your obsolescence cost is increasing with increasing age of the machine. Now, when you add all the total costs, what is the trend we will see?

So, for the first year the cost is high 855.79. Now, the cost is reducing 851.79 for the second year, now still reducing 849.24 for the third year, for the 4th year it is minimum. Now, again what is happening cost starts increasing again? From 844 it is increasing to 849. So, you can see that you are getting a trend like a parabola. Initially the cost is high then the cost reduces it reaches a minimum point then again it starts increasing, why it starts increasing you know that, because the increase in the age of the machine your maintenance and repair costs is increasing, downtime cost is increasing, your obsolescence cost is increasing.

So, there is an increase in the cost of machine after a particular point, significant increase you can see. So, beyond 4th year your cost is increasing. So, now the economic life means the period during which the cost associated with the machine is minimum, that is it economic life. So, during the 4th year the cost is minimum. So, at the end 4th year it is advisable to replace your machine.

So, the economical life of the machine is 4th year, because the minimum cost is 844.31. So, the equipment owner will not prefer to hold the machine when cost associated with the machine is going to be high. So, beyond the 4th year it is increasing. So, at the end of 4th year, it is better to replace old machine with a new machine. So, if you are not going to replace the old machine with a new machine, if you are still going to hold it for 1 more year say 5th year.

So, this difference will be the loss, this 849.19 minus 844.31. So, this difference is going to be your loss. So, this loss per hour, it will be reflected for the entire 5 years. So, the loss per hour is going to be reflected for the entire 5 years, that is what is the main thing when we do it on the cumulative basis. So, I hope you understand. So, this loss is not reflected, not just in the past 1 year, loss per hour is going to be reflected in the entire 5 years of the machine.

If you are going to retain the machine for 5 years, even beyond the optimum replacement time of the 4th year, if you continue use of the machine for more years, beyond the optimum replacement time the loss is reflected in every operating hour till you the hold the machine. So, that we have noted. So, this is how we estimate the economic life of the machine. So here we have optimized the productivity with respect to cost.

That is why we are going with minimum cost approach. If you are going to optimize the productivity with respect to profit, then you have to go for maximum profit approach. You have to find the time period during which the profit is maximum. So, even that approach we will be discussing in the next lecture.

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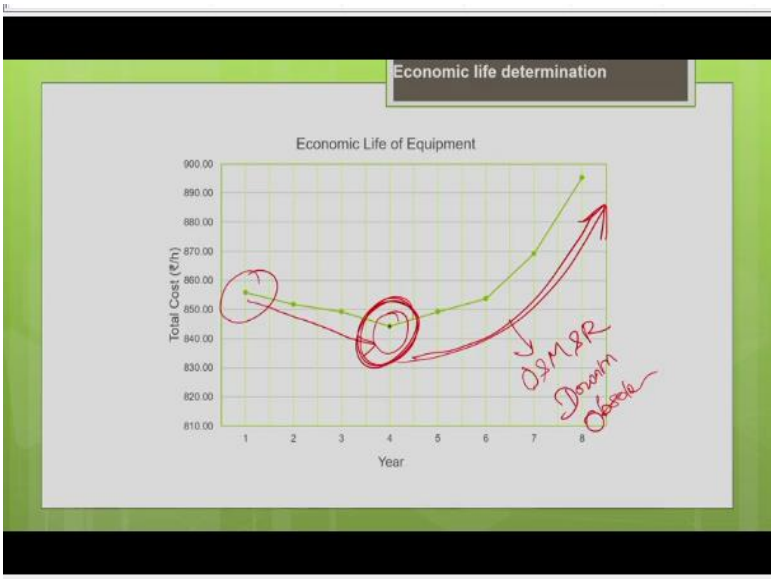

So, this picture, it just shows you the pictorial representation what I discussed in the earlier slide. So, during the initial period, you can see that the cost associated with the machine is slightly high, then the cost starts reducing as the cost is distributed over a greater period, it starts reducing. Now it reaches a minimum point and after that it starts significantly increasing, why this significant increase?

It is mainly due to the increase in the operating costs or the maintenance and the repair cost, your downtime cost, your obsolescence cost, everything is increasing significantly, that is why you can see there is a significant increase in costs with increasing age of the machine. It is better to replace the machine at the end of the 4th year. So, the economic life for this machine is 4th year.

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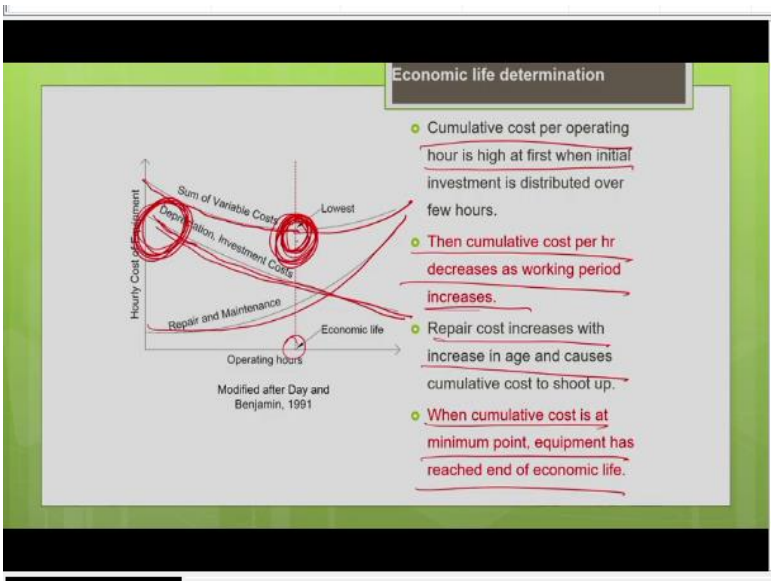

So, this picture shows you are the breakup of all the costs trend. So, we are finding the variation between the costs of the machine with the usage of machine. So obviously your depreciation, your investment costs, all your ownership cost is decreasing with the time. As I told you earlier, as these costs are getting distributed over greater usage, over greater hours, the cost per hour is getting reduced.

So, your repair and the maintenance cost, as the machine gets older, you can see that the cost starts increasing significantly. Similarly, when you add both, this is your ownership cost. This is your operating cost, when you add both you get your total cost, this is your total cost. So, if you see the total cost curves, initially it is high, it reduces, reaches a minimum point then again starts increasing.

So, this is your economic point, minimum point, this is the economic life of the machine, you are supposed to replace the machine at the end of this time. So, that is what is explained here, the cumulative cost per operating hour is high at the first, when the initial investment is distributed over a few hours. So, you can see that the initial investment it is distributed over a few hours, the cost is high.

So, then as the cumulative cost per hour decreases, as the working period increases, as the working period increases, you can see the cumulative cost is decreasing. So, the repair cost increases, with

increasing age, it is increasing with increasing age. So, when the cumulative cost is minimum point, it means the equipment has reached the end of the economic life. So, it has reached a minimum point here. So, this is your economic life. So, this is optimum replacement time for your machine.

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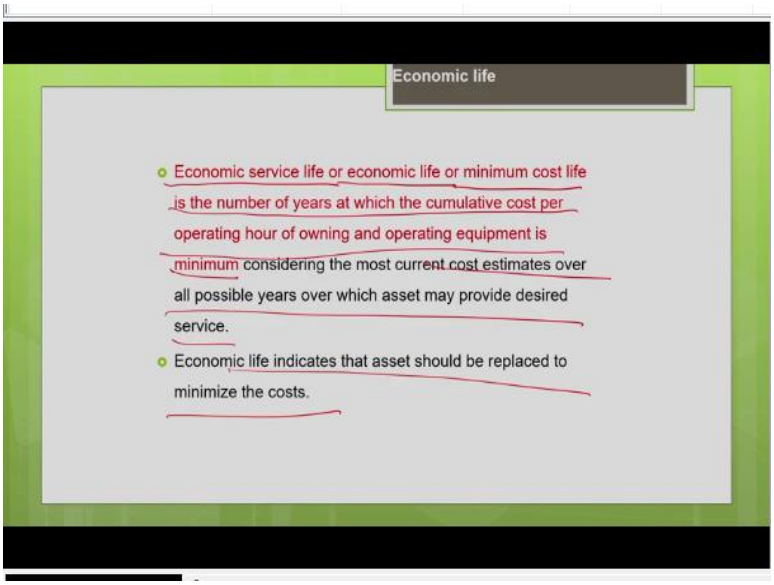

So, what is economic life? There are different terminologies used, we can call it as economic service life or economic life or minimum cost life. So, this is the number of years at which the cumulative cost per operating hour of the owning and operating equipment is minimum. Considering the most current costs estimates over all the possible years, over which the asset may provide desired service.

As I told you, you should consider all the components associated with the cost, so that we can make an accurate estimation of the replacement time of the machine. So, the economic life indicates that the asset should be replaced to minimize the cost associated with the machine.

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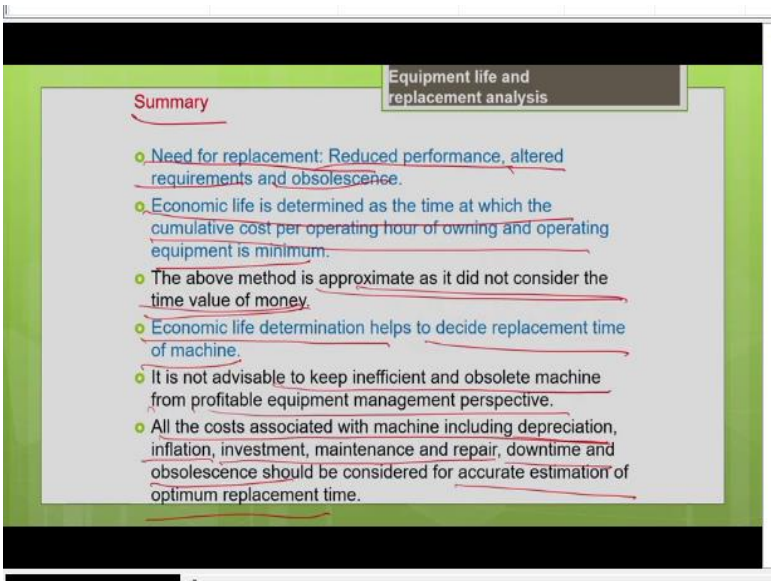

So, we have come to the end of this lecture 6. So, let me summarize what I have discussed so far. So, basically, we know the need for replacement of the machine. So, why should we replace the old machine with a new machine? Because your old machine because of the wear and tear, it may be showing reduced performance, reduced productivity and there may be a sudden increment in your productivity requirement in your project site.

So, there may be some altered requirement, you may face some increment in the production requirement. So, for that you have to replace the old machine with a new machine, which has a better productivity than your old machine. And obviously, your machine would have become obsolete because of many competitive models available in the market. So, there are different reasons which justifies the replacement of the old machines with a new machine.

So, economic life is a time at which your cumulative costs per operating hour of the machine is minimal. So, that is what we have discussed. And one thing we have to note here, though, we consider most of the costs associated with your machine, but one thing what we have missed in the previous analysis is we did not consider the time value of money. When you do not consider the time value for money, obviously, your cost estimate or the decision is going to be only approximate.

So, as we discussed earlier lectures, we should consider the timing of the cash flows and convert all the cash flows, which are occurring at different time interval into equal cash flows at a particular time period and make a rational comparison. So, that only it gives you an accurate estimate. So, this method we are going to do in the upcoming lecture. So, to get an accurate estimate, we have to consider the timing of the cash flows.

So, the main objective of determining the economic life is to decide the optimum replacement time of the machine. It is not advisable to keep inefficient and obsolete the machine, even though your machine may be functioning at your project site. It is not totally broken down even though it is functioning it is not advisable to just continue with the usage of old machine. So, from profitable equipment management perspective, we should not just cling on to the old machine, when its productivity is less.

We should see for the optimum replacement time and replace it with a newer productivity model, newer model which is available in the market with a better productivity. So, for the equipment replacement analysis, we are supposed to consider all the costs as I mentioned earlier, include the depreciation cost, effect of inflation, investment costs, maintenance and repair downtime, obsolescence, everything should be considered for the accurate estimation of the optimum replacement time.

So, these are the points we should keep in mind when you do the replacement analysis. So, these are the references, these are textbooks which I recommend for the preparation related to this topic.

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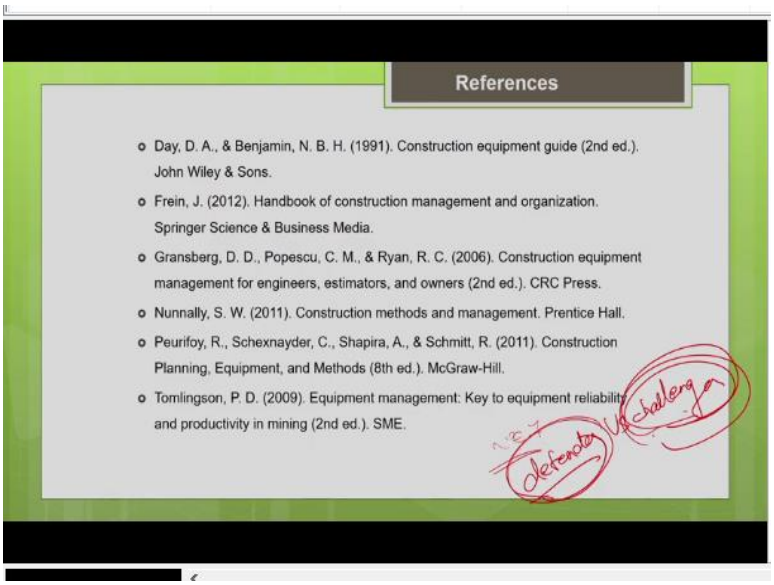

So, basically in the lecture 7 in the upcoming lecture, I will be discussing on the equipment replacement analysis. So, we will be discussing some more different approaches like how to compare the defender and challenger. So, hope you remember what is defender and challenger, defender is a current machine, what which are the processing of your site and challenger is your proposed machine which are planning for replacement. So, now we have determined what is the optimum replacement time for the current machine?

Now, you have to see what is the best alternative available for the replacement? Whether the challenger is suitable for replacement or not that we have to compare. So, by comparing the cost of defender and the challenger, we will decide whether the challenger is suitable for replacement or not and you will also see what is the optimum replacement of the defender with the challenger. So, other different approaches under replacement analysis will be discussed in the upcoming lecture. Thank you.