Construction Methods and Equipment Management
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Lecture-8
Equipment Life and Replacement Analysis (Part 3)

Hello everyone, I welcome you all to the lecture 8 of this course construction methods and equipment management. So, we are going to continue our discussion on the equipment life and the replacement analysis.

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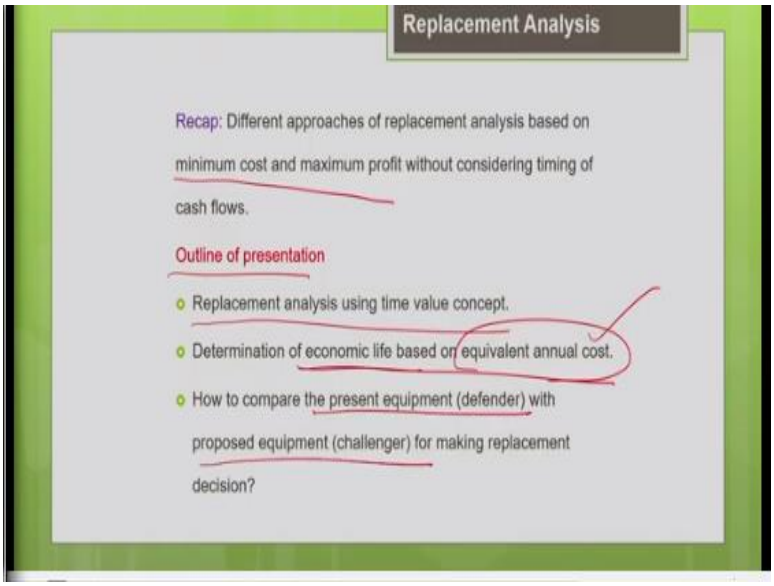

So, let us have a recap of what we learnt in the last lecture. So, we have discussed about different approaches of replacement analysis based on minimum cost and maximum profit. So, it depends upon how are you going to optimize the production with respect to minimum cost or with respect to maximum profit. So, based upon that we have to make a choice of the particular method.

But the demerit of what we discussed in the last class is we did not consider the timing of the cash flows, the illustrations which we have worked out in the last lecture, so that is a major limitation. So, since we did not consider the timing of the cash flows, so the estimate whatever made is only approximate only.

So, that is why in this present lecture, we are going to consider the timing of cash flows also and do the equipment replacement analysis. So, let us see what is the outline of the today's presentation. So, we are going to discuss about the replacement analysis using time value concept in this lecture. We will see how to determine the economic life of the machine based on the equivalent annual cost of the machine.

So, how to consider the equivalent annual cost? We are going to discuss in this lecture. So, basically, we know that the cash flows occur at different time period. So, we need to consider those cash flows which are occurring at different time interval into a particular time period say t = 0. So, we have to convert it into a particular time period and then make the analysis.

So, that is what we are going to see, we are going to use the time value concept and do the replacement analysis. So, in this we are going to work on 2 different types of problems one we will determine the economic life of the machine which will help us to determine what is the optimum replacement type of the machine using equivalent annual cost method. Then we will compare the present equipment that is a defender with the proposed equipment that is a challenger.

And we will see what is the optimum replacement and whether it is suitable to continue with the defender or it is preferable to replace a defender with a challenger. So, we work out a illustration on comparison between defender and the challenger using time value concept. So, these are the 2 types of problems which we are going to work out in this particular lecture.

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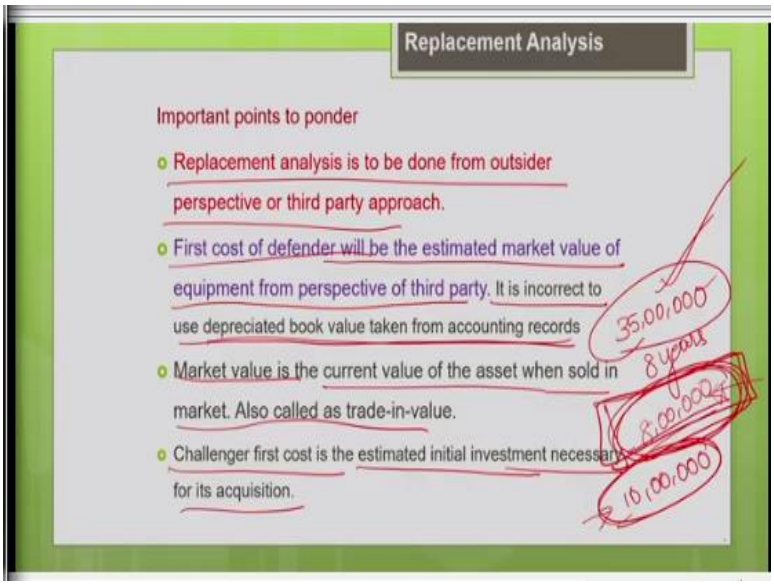

So, let us see what are all the important points which have to be kept in mind in this replacement analysis. So, always this replacement analysis is to be done from the third-party approach or the outsider perspective. That means, say for example if you have purchased equipment say 35,00,000 8 years before. So, your purchase this equipment at the cost of 35,00,000, 8 years before.

So, now that the current value that is the current market value of the machine say it is 8,00,000. So, what is important to the third party or the outsider is only the current value 8,00,000, he is not bother about at what price you are purchasing the machine 8 years before. So, this 35,00,000 is not relevant to him, relevant to the third party. So, that is why in the replacement analysis you have to always visualize from the third-party approach or the outsider perspective.

So, your initial cost of a defender or the current equipment is not relevant in the replacement analysis. So, what is relevant is only the current market value of the machine. So, the first cost of the defender will be the estimated market value of the equipment from the perspective of the third party. So, that will be the first cost of the defender, so you have to forget about the initial cost.

So, what is the first cost of defender, that is the estimated current market value of the machine from the third-party perspective. It is incorrect to use the depreciated book value taken from the accounting records, like you might have estimated the book value using some depreciation accounting method. Say for example, you have estimated the book value to be 10,00,000. So, using

your depreciation accounting method, you have entered in your accounting records that the estimated book value is 10,00,000.

But the current market value of machine is only 8,00,000, what is important is only 8,00,000 to the third party. Your estimated book value is not important to the third party. That is why it is incorrect to use the depreciated book value taken from the accounting records. So, what we have to use in the replacement analysis is only the current value of the asset when sold in the market, it is called as the market value or the trading value, that is only important when the replacement analysis. So, you should forget about the initial cost you should forget about the estimated book value.

So, you should only consider the current market value of the machine or the trade-in-value of the machine, that is only important for the defender, so that is what is given here. So, these are the important things you should keep in mind while doing the replacement analysis. And similarly, the challenger first cost is estimated initial investment necessary for acquiring the particular machine to a project site.

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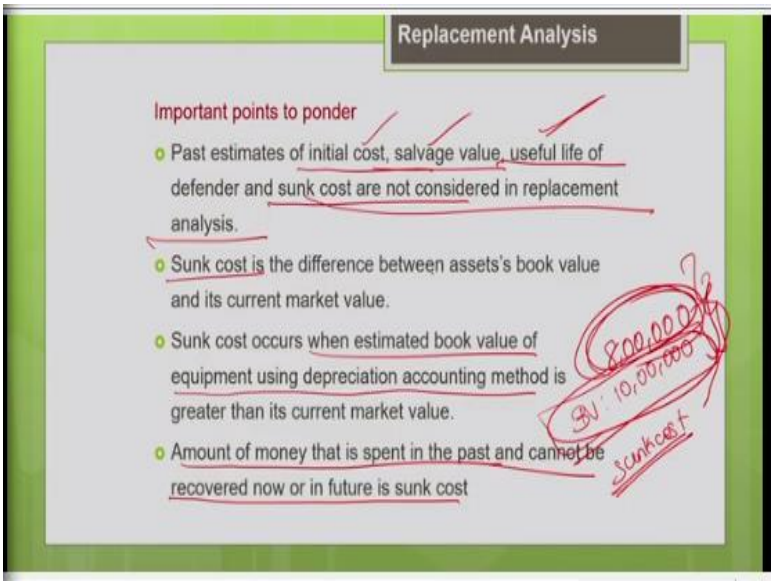

So, what are the other points to be kept in mind? So, as I told you all the other past estimates like your initial cost, your estimated salvage value when you purchase equipment, you might have made some estimate of it is useful life, estimate of the salvage value, all those are past estimates.

Estimate of salvage value, estimate of useful life and the sunk cost, I will tell you what is sunk cost?

All these are not considered in the replacement analysis, these are irrelevant in the replacement analysis. So, what is this sunk cost? Say as I told you earlier, like your current market value of the machine say it is 8,00,000, the current market value of the machine is 8,00,000. Now but you have estimated the book value of the machine as 10,00,000 using your own accounting method, depreciation accounting method.

You have estimated the book value entering the account in records, it is supposed to be 10,00,000, but your current market value now is only 8,00,000. So, the difference between these 2 is your sunk cost. This is the amount of money which is spent in the past or it cannot be recovered, the cost which cannot be recovered, that is called the sunk cost. So, you might have estimated the book value to be 10,00,000 but even though your estimated book value is 1000000, your current market value is only 8,00,000.

What is important to me is only this 8,00,000. So, this difference of money is called as a sunk cost which cannot be recovered. Sunk costs is the cost, the amount of money that is spent in the past and cannot be recovered now or in the future, that is called as the sunk cost. So, this sunk cost occurs when the estimated book value of the equipment using depreciation accounting method is greater than the current market value of the machine.

So, when your estimated book value is going to be greater than the current market value, the difference is called as the sunk cost. That sunk costs also should not be considered in the replacement analysis. So, what you should bother about is only the current estimate, so the current estimate is your current market value of the machine. That is only relevant in the replacement analysis with respect to the defender.

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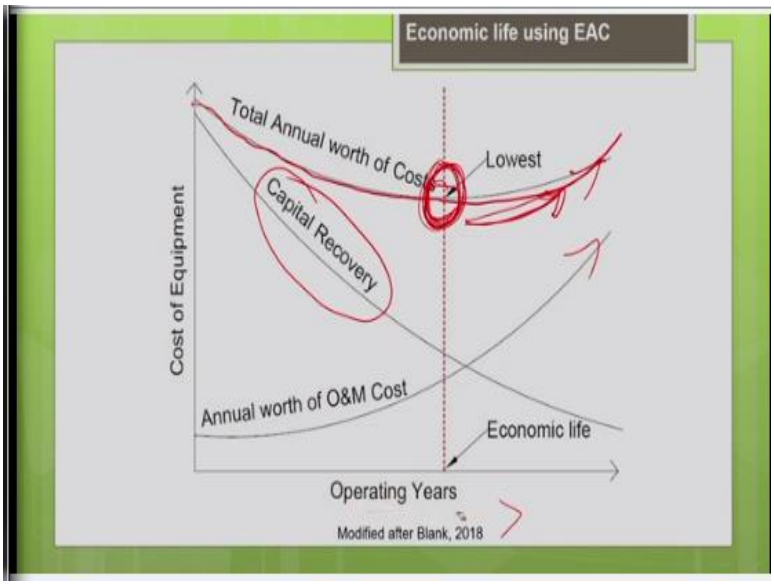

So, I hope you remember this pictorial representation of the variation of the cost of the equipment with the age of the machine. So, you can see that the operating and the maintenance cost you can see it increases, with increase in the life of the machine. As the machine becomes older, your operating in the maintenance cost increases you can see that. And similarly, your capital recovery the ownership cost component, you can see that it reduces with increase in duration of the machine.

As I told you, as the ownership cost it is getting distributed over a larger period it is cost reduces the time. So, when you add both you can see what is happening to the total cost, total cost reduces, reaches a minimum and then again starts increasing. It reaches the minimum and then again starts increasing, why it starts increasing again? Because as the machine becomes older, there will be a significant increase in the repair cost and the maintenance cost and the operating cost, that is why it start in increasing.

So, we are supposed to replace the equipment when the total cost associated with the machine is minimum. So, this time period is called as a economic life of the machine. So, this is the optimum replacement time of the machine. So, any equipment owner, he would like to replace the machine before the cost associated with the machine increases significantly.

So, he has to determine the economic life of the machine and after economic life he has to replace the machine immediately. So, in this we are going to consider the time value concept and we are

going to calculate the equivalent annual cost. So, we are going to calculate the equivalent annual cost of all the cost components.

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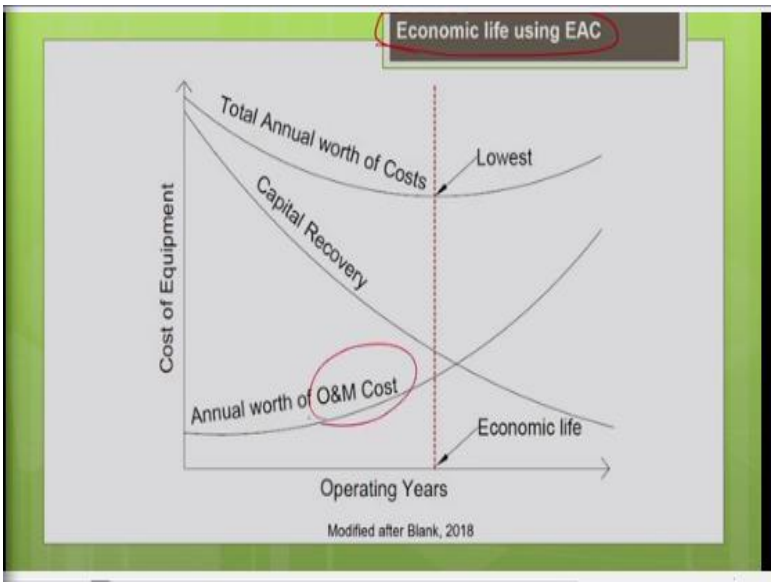

So, economic life using EAC that means equivalent annual cost. So, now how to calculate the equivalent annual cost of the operating and the maintenance cost.

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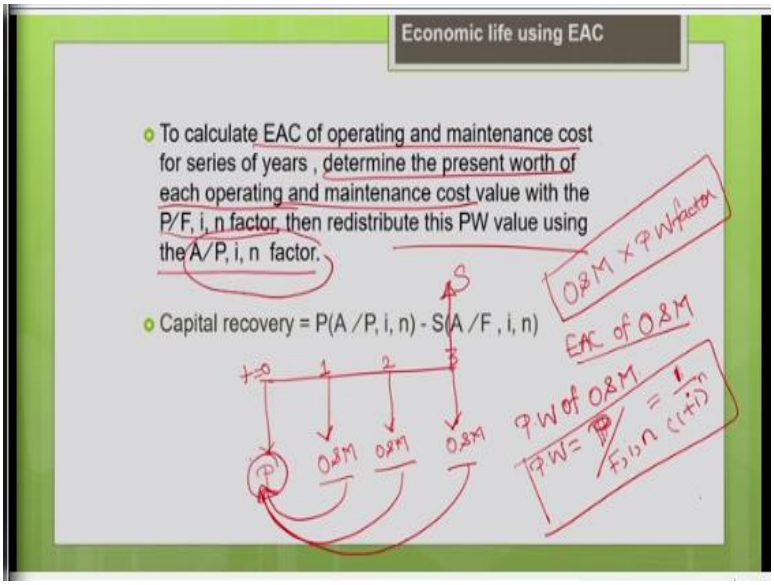

Let us see how to calculate. So, to calculate the equivalent annual cost of the operating and maintenance cost, see we have to find it is present worth first. Say for example let us draw a cash flow diagram. So, this is the purchase price of the machine made a time t = 0. So, these are the operating and maintenance cost which are happening at a particular time period. Say at the end of

the year 1, this is your operating and maintenance cost at the end of year 2, this is your operating and maintenance cost at the end of year 3.

At the end of year 3 say you are going to sell this old machine at the particular salvage value say the salvage value is S. So, now, so we have drawn the cash flow diagram, now let us see how to find the equivalent annual cost of the operating and the maintenance cost. So, this operating and maintenance cost are occurring at different time periods. Now the first thing you are going to do is, you have to convert these cash flows occur in a different time period to a particular time say t = 0.

We have to convert all these cash flows to time t = 0, that means you are going to find the present worth of the operating and the maintenance cost. Find the present worth of the operating and maintenance cost, how to find the present worth? You have to use the present work factor, so how to find the present worth factor? So, you need to find P for the given F, i, n, so for the known future value, known interest rate i for the known period you are going to find the present value, that is the present worth of the machine.

$$\mathbf{P.W} = \frac{P}{F,i,n} = \frac{1}{(1+i)^n}$$

So, this present worth factor, so you have to multiply your operating and maintenance cost with the present worth factor, multiplied by the present worth factor. We will get the present worth of the operating and maintenance cost. The first thing is to determine the present worth of the each operating and the maintenance cost value.

So, with the help of P by F, i, n factor that is present worth factor. Now what you do is after converting the cash flows to time = 0, you redistribute the present value using the uniform series capital recovery factor. So, that means we are going to convert the present value into equivalent annual cost using uniform series capital recovery factor.

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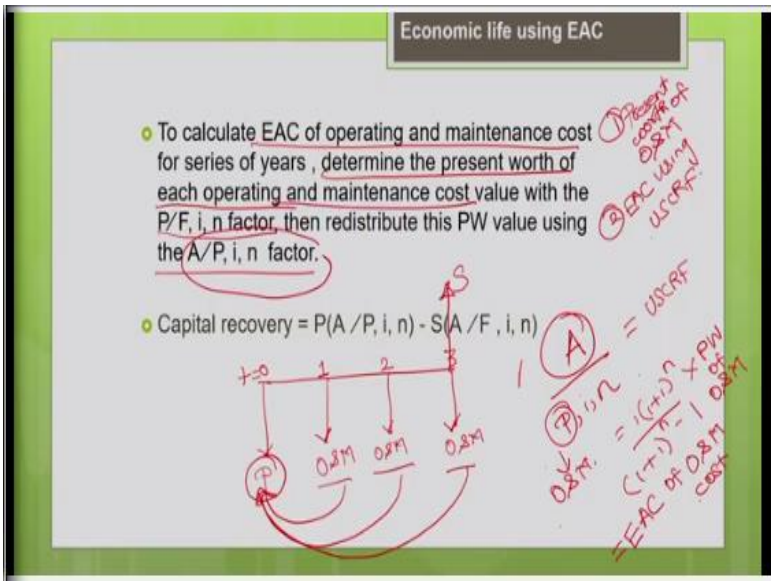

So, let me find what is A for the given P, i, n. So, that means we are going to find the equivalent annual cost of the present value of your operating and the maintenance cost. So, this is your present value of your operating and the maintenance cost, we have already calculated the present worth of the operating and maintenance cost using present worth factor. Now we are going to find the equivalent annual cost using uniform series capital recovery factor.

$$\textbf{USCRF} = \frac{\boldsymbol{A}}{\boldsymbol{P,i,n}} = \frac{\boldsymbol{i(1+i)^n}}{\boldsymbol{(1+i)^n-1}}$$

So, you multiply this factor with the present worth of your operating and the maintenance cost. So, this will give me the equivalent annual cost of the operating and maintenance cost. So, first thing what we are going to do is, you find the present worth of operating and maintenance cost using present worth factor.

Now you find the equivalent annual cost of this present operating and maintenance cost using uniform series capital recovery factor. So, this is how we are going to convert the operating and maintenance cost into equivalent annual cost. Now similarly let us see how to find the equivalent cost of the purchase price and how to find the equivalent cost of the salvage value.

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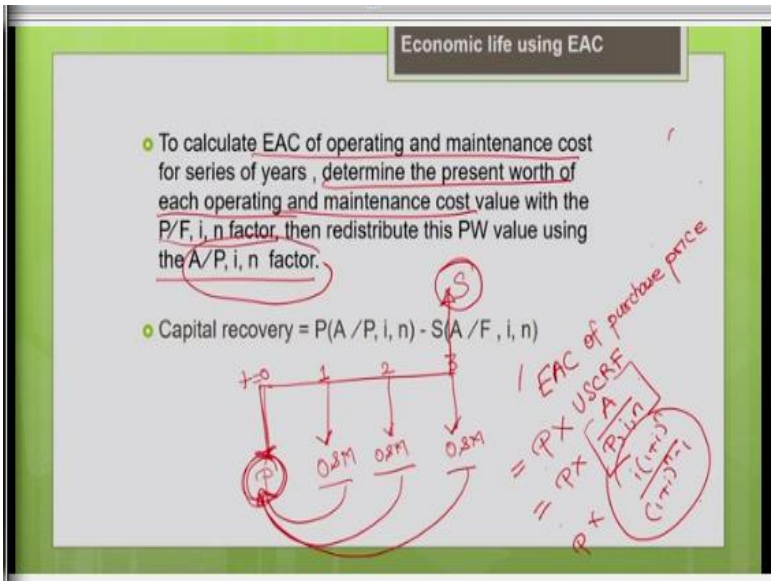

So, this purchase price which is made at time 0, your purchase price, you are going to convert it into equivalent annual cost. So, now let us calculate the equivalent annual cost of the purchase price of the machine. So, how to calculate the equivalent annual cost of the purchase price of the machine? You know the purchase price of the machine multiplied by the uniform series capital recovery factor.

$$\textbf{EAC of purchase price} = \textbf{P}\times\textbf{USCRF} = \textbf{P} \times \frac{A}{P,i,n} = \textbf{P} \times \frac{i(1+i)^n}{(1+i)^n-1}$$

we will get the equivalent annual cost of the purchase price. Similarly, the salvage value, you have to convert the salvage value which is occurring at the future date into equivalent annual cost. So, for that you can make use of the uniform series sinking fund factor. So, how to use the uniform series sinking fund factor?

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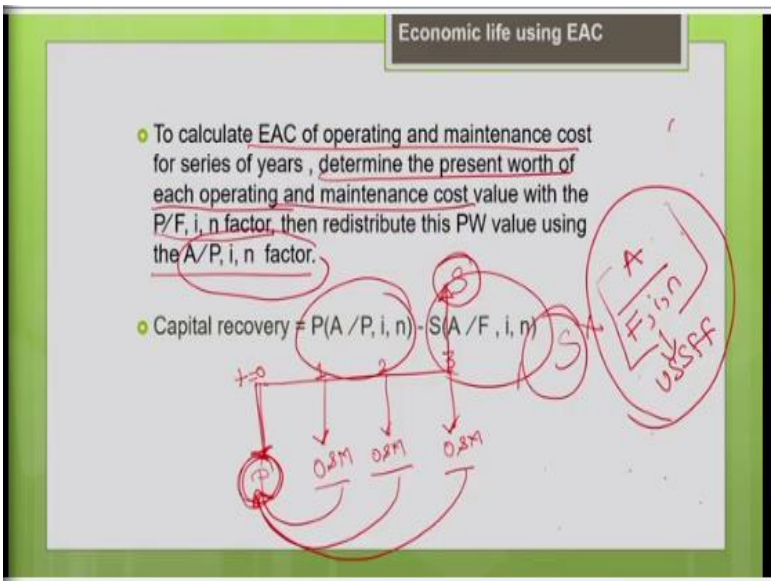

So, you know the salvage value S multiply by, so you are going to find the equivalent annual cost of the salvage value A. For the known future value interest rate i and n, so this is your uniform series sinking fund factor. So, we have discussed about all these factors in the earlier lecture on time value method. So, you can recollect the topic by going through this particular lecture.

$$\textbf{EAC of salvage value} = S \times USSFF = S \times \frac{A}{F,i,n}$$

So, we are going to multiply the salvage value with the uniform series sinking fund factor, we will get the equivalent annual cost of the salvage value. Now the equivalent annual cost of purchase price minus the salvage value gives you the capital recovery. So, when we work out the problem we will understand better.

$$\textbf{Capital recovery} = P \times \left(\frac{A}{P,i,n}\right) - S \times \left(\frac{A}{F,i,n}\right)$$

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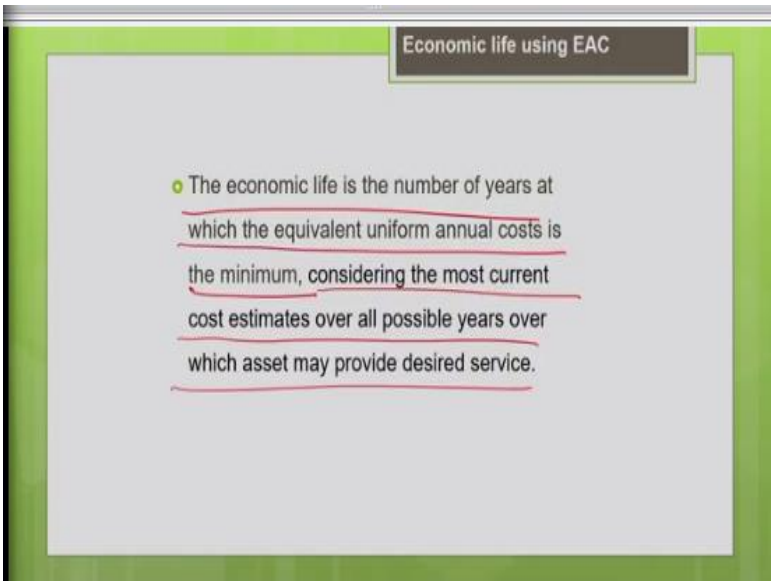

So, basically economic life is the number of years at which the equivalent annual cost, uniform annual cost is minimum. So, we are going to calculate the equivalent uniform annual cost. So, at which a particular time period it is minimum, we are going to find, that is your economic life of the machine. So, you have to consider the most current cost estimates over all the possible years over which your asset may provide you desired service. So, consider all the possible current estimates to get the accurate picture of the replacement time.

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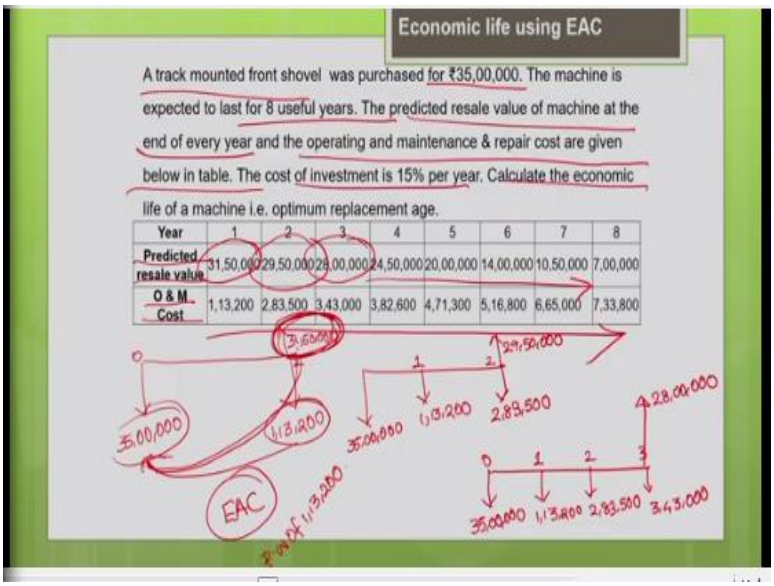

So, now, let us workout a problem. So, we are going to determine the economic life of a particular machine using the equivalent annual cost method. So, here we are going to consider the equipment track mounted front shovel. So, this machine was purchased for a purchase price of 35,00,000. So,

the machine is expected to last for 8 useful years, so the duration the useful life of the machine is expected to be 8 years.

The predicted resale value of the machine at the end of every year and the operating and the maintenance and repair cost are given below the table. So, for every year, so at the end of every year what is your resale value and the operating and maintenance cost is given for the entire useful life of the machine. And the cost of investment is 15% per year, now calculate the economic life of the machine.

That means we are going to find the optimum replacement time of the particular machine. So, you can see that at the end of the year 1, if you sell your machine it is resale value will be 31,50,000. At the end of year 2, we are going to sell it is 29,50,000, at the end of year 3 it is 28,00,000, that means your resale value is reducing with time. Similarly, you can see your operating and maintenance cost of the machine is increasing with time.

So, why it is increasing with time? As the machine becomes older, you know that operating and the maintenance cost will increase with the time. Now we are supposed to find the economic life of this particular machine. So, let us draw the cash flow diagram and understand this problem better. Say the cash flow diagram for the year 1, your purchase price of the machine is 35,00,000. So, the end of year 1 the operating and the maintenance cost is 1,13,200.

So, it is salvage value, if you are going to sell this machine at the end of year 1, see this is year 1, this is time = 0. At the end of year 1 if you are going to sell it, the salvage value will be 31,50,000, so this is the cash flow diagram for year 1. Now let us draw the similar cash flow diagram for year 2. So, the purchase price is 35,00,000 your operating and the maintenance cost at the end of year 1 is 1,13,200, at the end of year 2 it is 2,83,500.

So, if I am going to replace my machine, I mean if you are going to sell the machine at the end of year 2, my resale value is 29,50,000. Similarly draw the cash flow diagram for the third year, it will be 35,00,000 the purchase price, this is year 1, this is year 2. So, now year 1 it is 1,13,000 is your 13,200 is the operating cost, year 2 it is your 2,83,500, year 3 it is going to be 3,43,000.

At the end of year 3, if I am going to sell a machine, your salvage value, the resale value is 28,00,000. So, similarly you can draw the cash flow diagrams, and using this cash flow diagrams you can estimate the equivalent annual cost associated with the machine. So, we are going to tabulate in the form of table, so that it will be easier to understand, and we will also take the help of this cash flow diagrams.

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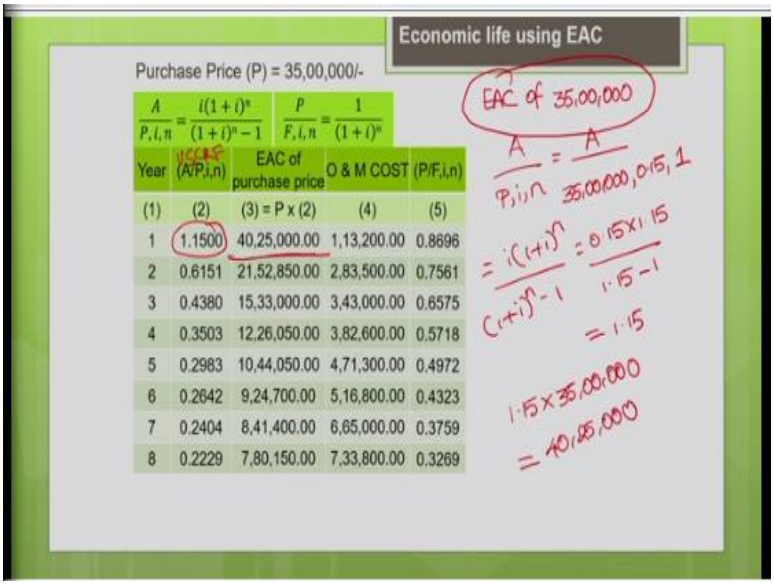

So, first is prepare a table, the first column indicates the year the age of the machine, the second column we have estimated the uniform series capital recovery factor. So, this is nothing but your uniform series capital recovery factor, I have estimated for different ages, for different years I have estimated the capital recovery factor. So, the first thing I am going to do is, I am going to estimate the equivalent annual cost of the purchase price of the machine.

It is nothing but 35,00,000, so 35,00,000 is the purchase price of the machine. So, how to calculate? So, you can see this is the cash flow diagram for the year 1, you are going to find the equivalent annual cost of associated with this purchase price. So, you have to use the uniform series capital recovery factor. That means, so you need to find A for given P, i, n, so we are going to find A for the known P,

$$\textbf{USCRF} = \frac{A}{(3500000, 0.15, 1)} = \frac{i(1+i)^n}{(1+i)^n-1} = \frac{0.15(1+0.15)^1}{(1+0.15)^1-1} = 1.15$$

So, this is my capital recovery factor for the year 1. So, now to find the equivalent annual cost of 35,00,000.

EAC = 1.15 × 35,00,000 = 40,25,000 rupees

You can see this is a equivalent annual cost for the year 1 of the purchase price. Similarly, you have to estimate it for all the years.

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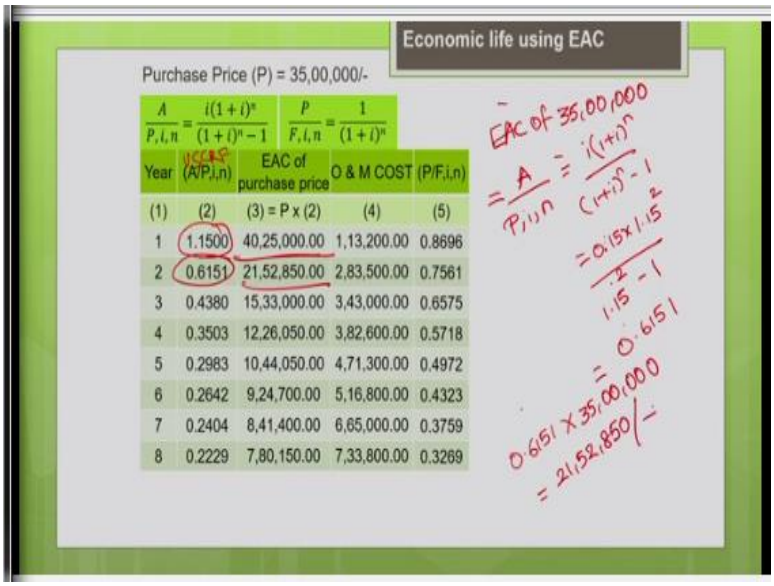

So, now we are going to find the equivalent annual cost for year 2 of 35,00,000

$$\textbf{USCRF} = \frac{A}{(3500000, 0.15, 2)} = \frac{i(1+i)^n}{(1+i)^n - 1} = \frac{0.15(1+0.15)^2}{(1+0.15)^2 - 1} = 0.6151$$

for year 2, how to do that? So, basically, we are going to find A for the given P, i, n, is

EAC = 0.6151 × 35,00,000 = 21,52,850 rupees

This is the equivalent annual cost of purchase price for year 2. So, for one more year to calculate, so that you will understand better.

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