**Construction Methods and Equipment Management**
**Prof. Dr. Indu Siva Ranjani**
**Department of Civil Engineering**
**Indian Institute of Technology-Guwahati**

**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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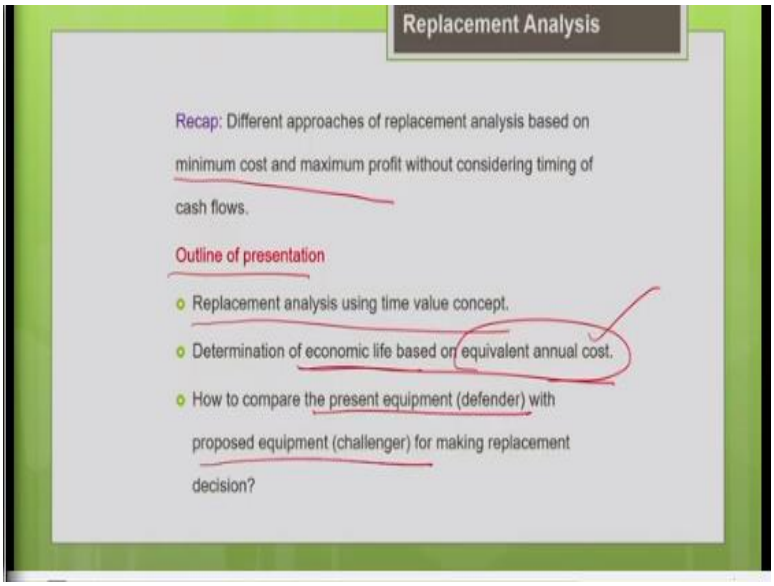


So, let us have a recap of what we learnt in the last lecture. So, we have discussed about different approaches of replacement analysis based on minimum cost and maximum profit. So, it depends upon how are you going to optimize the production with respect to minimum cost or with respect to maximum profit.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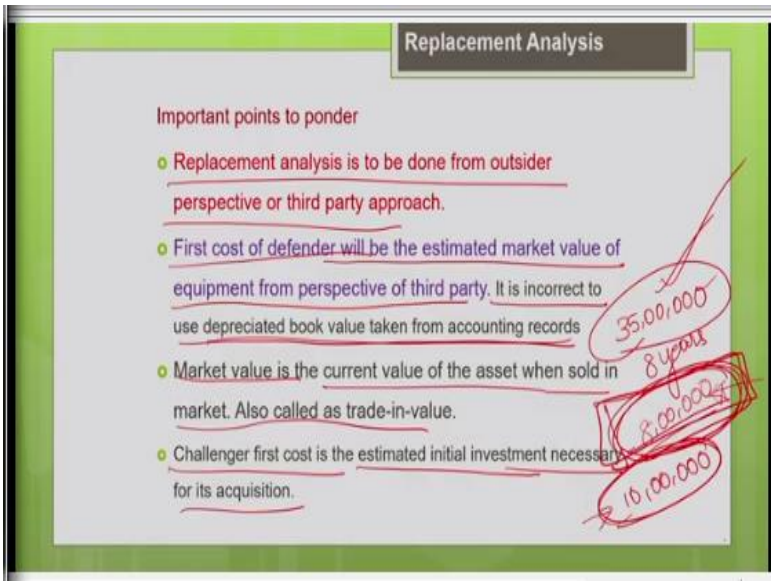


So, let us see what are all the important points which have to be kept in mind in this replacement analysis. So, always this replacement analysis is to be done from the third-party approach or the outsider perspective. That means, say for example if you have purchased equipment say 35,00,000 8 years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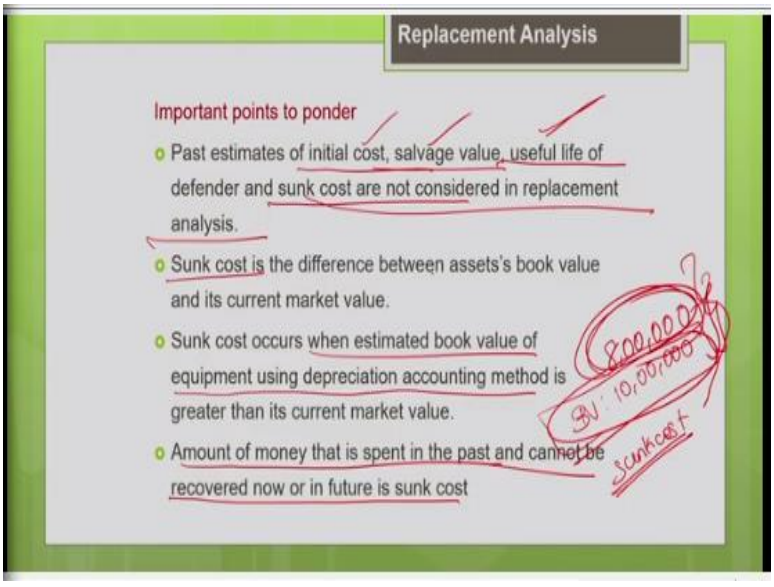


So, what are the other points to be kept in mind? So, as I told you all the other past estimates like your initial cost, your estimated salvage value when you purchase equipment, you might have made some estimate of it is useful life, estimate of the salvage value, all those are past estimates.

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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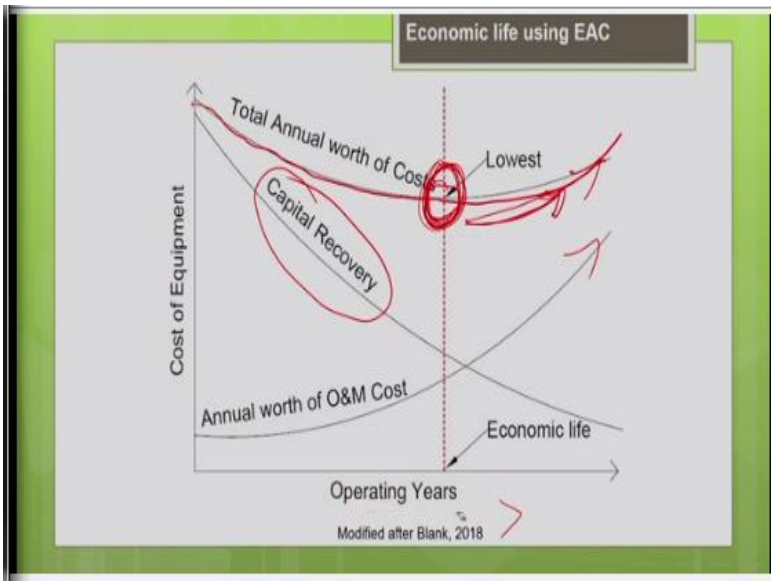


So, I hope you remember this pictorial representation of the variation of the cost of the equipment with the age of the machine. So, you can see that the operating and the maintenance cost you can see it increases, with increase in the life of the machine. As the machine becomes older, your operating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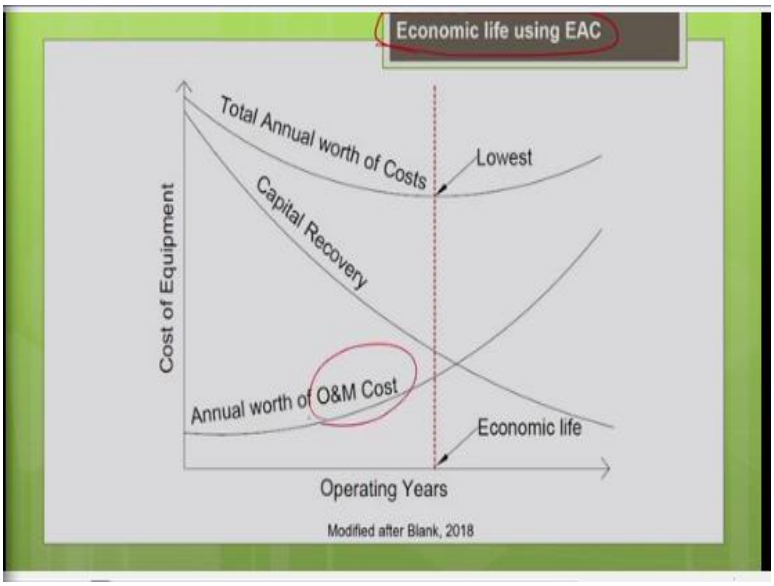


So, economic life using EAC that means equivalent annual cost. So, now how to calculate the equivalent annual cost of the operating and the maintenance cost.

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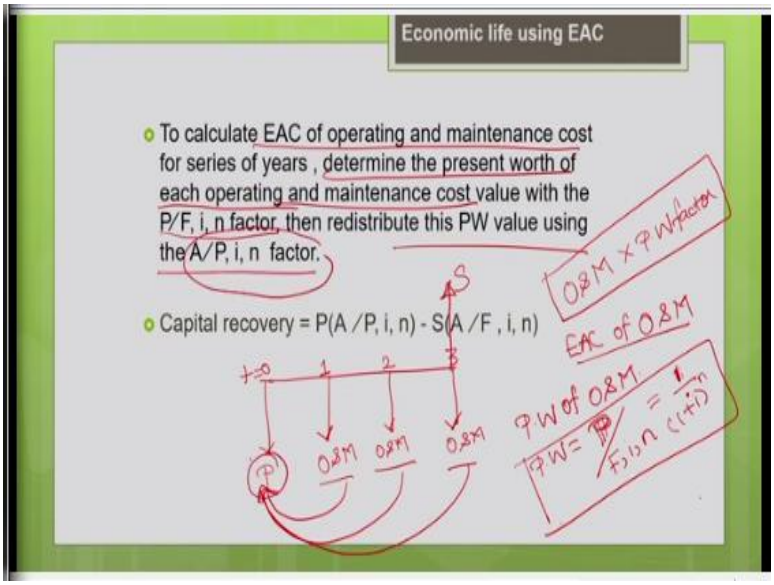


Let us see how to calculate. So, to calculate the equivalent annual cost of the operating and maintenance cost, see we have to find it is present worth first. Say for example let us draw a cash flow diagram. So, this is the purchase price of the machine made a time t = 0. So, these are the operating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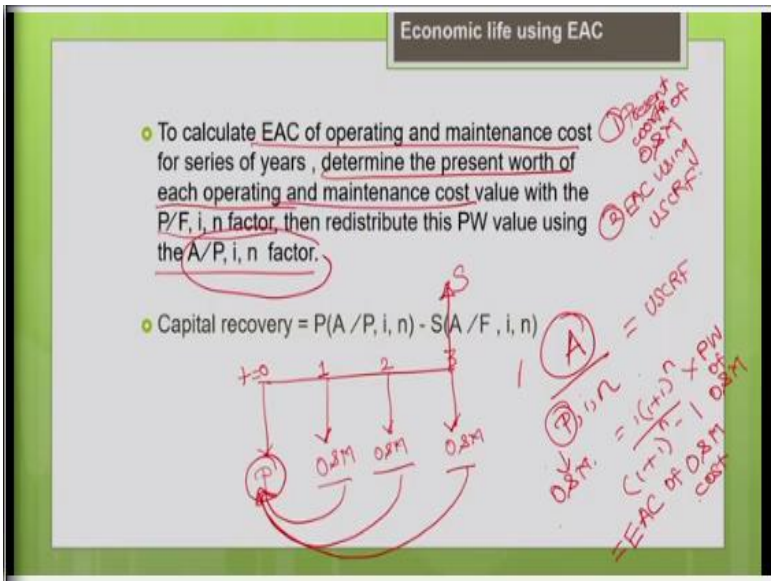


So, let me find what is A for the given P, i, n. So, that means we are going to find the equivalent annual cost of the present value of your operating and the maintenance cost. So, this is your present value of your operating and the maintenance cost, we have already calculated the present worth of the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

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

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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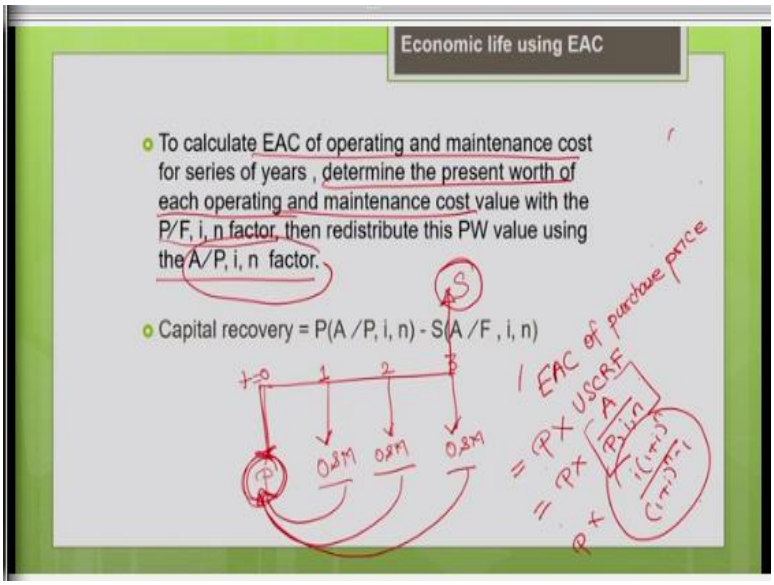


So, this purchase price which is made at time 0, your purchase price, you are going to convert it into equivalent annual cost. So, now let us calculate the equivalent annual cost of the purchase price of the machine. So, how to calculate the equivalent annual cost of the purchase price of the machine? 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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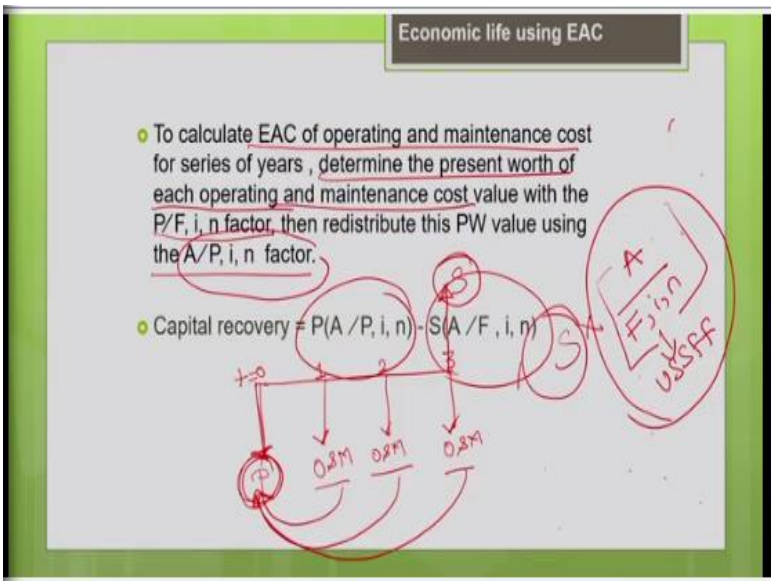


So, you know the salvage value S multiply by, so you are going to find the equivalent annual cost of the salvage value A. For the known future value interest rate i and n, so this is your uniform series sinking fund factor. So, we have discussed about all these factors in the earlier lecture on time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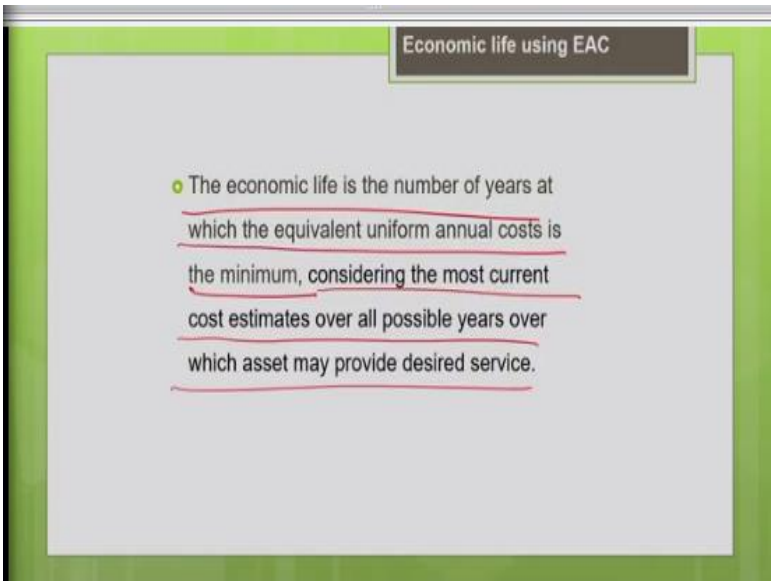


So, basically economic life is the number of years at which the equivalent annual cost, uniform annual cost is minimum. So, we are going to calculate the equivalent uniform annual cost. So, at which a particular time period it is minimum, we are going to find, that is your economic life of the machine. 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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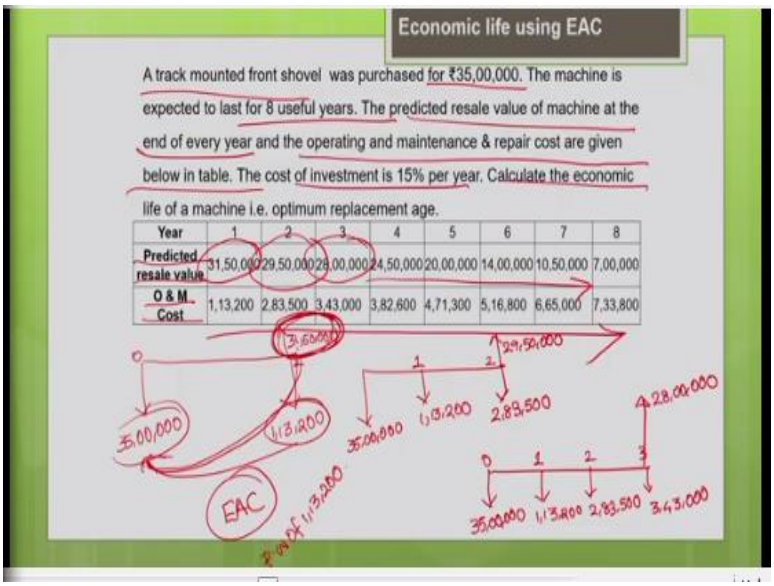


So, now, let us workout a problem. So, we are going to determine the economic life of a particular machine using the equivalent annual cost method. So, here we are going to consider the equipment track mounted front shovel. So, this machine was purchased for a purchase price of 35,00,000. So,

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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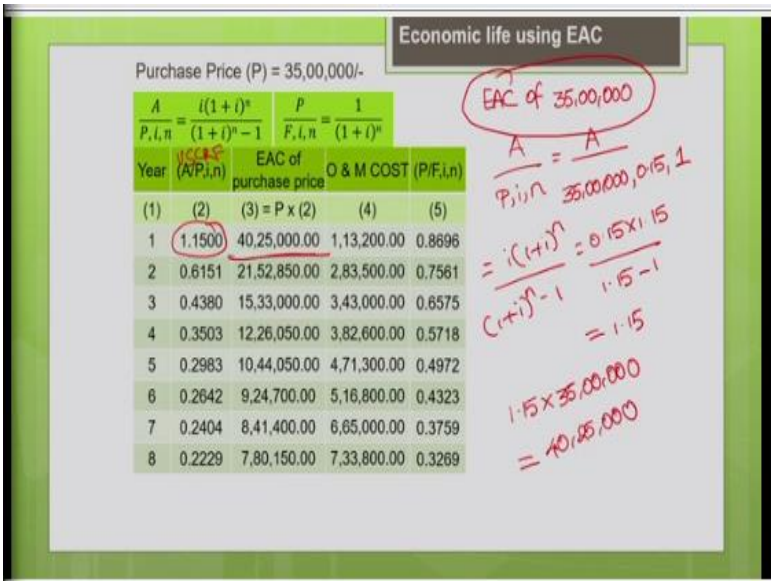


So, first is prepare a table, the first column indicates the year the age of the machine, the second column we have estimated the uniform series capital recovery factor. So, this is nothing but your uniform series capital recovery factor, I have estimated for different ages, for different years I have 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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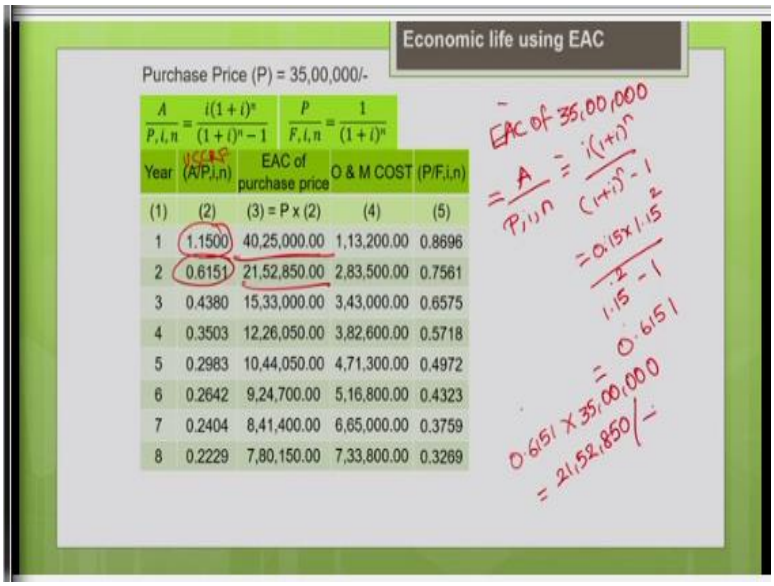


So, now we are going to find the equivalent annual cost for year 2 of 35,00,000

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

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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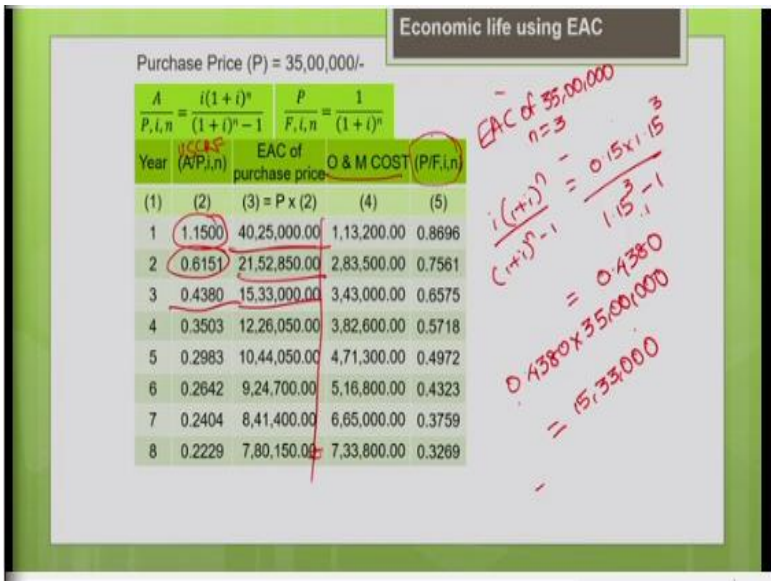


So, now we have to find the equivalent annual cost for the third year of the purchase price 3500000 for year 3,

$$\textbf{USCRF} = \frac{A}{(3500000, 0.15, 3)} = \frac{i(1+i)^n}{(1+i)^n-1} = \frac{0.15(1+0.15)^3}{(1+0.15)^3-1} = 0.4380$$

$$\textbf{EAC} = 0.4380 \times 35{,}00{,}000 = 15{,}33{,}000 \text{ rupees}$$

So like this you are going to calculate for all the years. Now let us find the equivalent annual cost of the operating and the maintenance cost. So, how to find the equivalent annual cost let us go back to the cash flow diagram. So, this 1,13,200 is operating and maintenance cost at the end of year 1. Now you convert it into t = 0, how to convert it into t = 0, find the present worth?

So, find the present worth of 1,13,200, so that is a first step. Once you find the present worth of 1,13,200 then you can find it is equivalent annual cost using uniform series capital recovery factor. So, the first step is we will find the present worth of the operating and the maintenance cost, so for that you have to go for the present worth factor.

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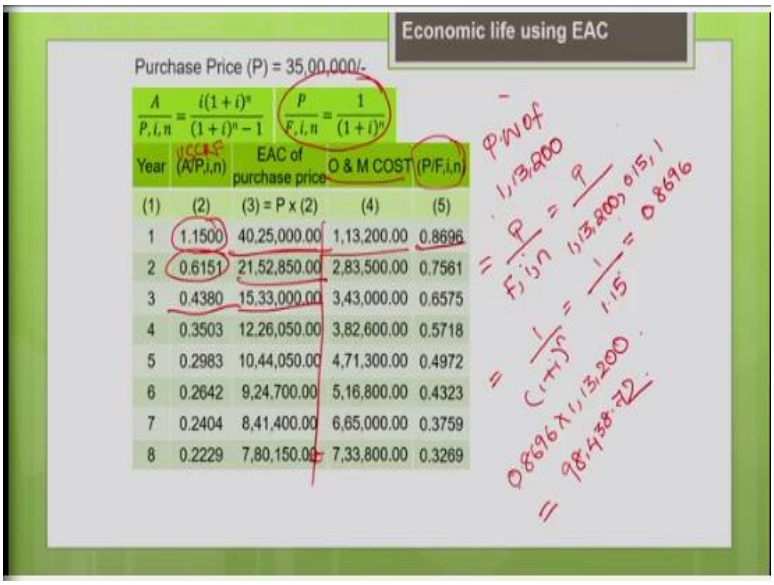


So, we are going to find the present worth of 1,13,200 that is your operating cost. So, you need to find P for the known F, i, n,

$$\textbf{P.W} = \frac{P}{113200, 0.15, 1} = \frac{1}{(1+0.15)^1} = \textbf{0.8696}$$

This present worth factor you multiply it by the operating and maintenance cost

**Present worth value = 0.8696 × 1,13,200 = 98,438.72 rupees**

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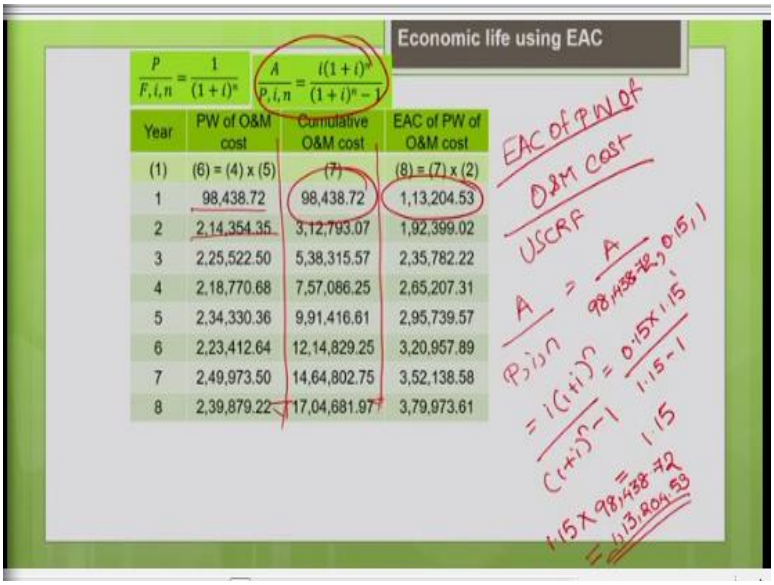


So, like this you are going to calculate the present worth of all the operating and maintenance cost. So, let us workout for one more trail, so that you will understand better.

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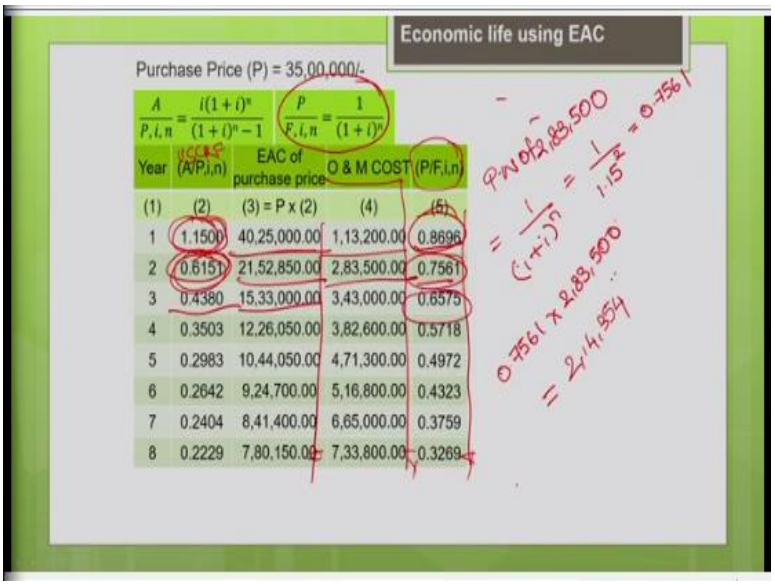


So, this is your operating and maintenance cost, we are going to find the present worth of 2,83,500,

$$\textbf{P.W} = \frac{P}{283500,0.15,2} = \frac{1}{(1+0.15)^2} = 0.7561$$

**Present worth value = 0.7561 × 2,83,500 = 2,14,354 rupees**

So, this is how you have to calculate the present worth of the operating and maintenance cost. So, like this you are going to find the present worth factor for all the years and multiply the present worth factor by the operating and maintenance cost and we will get the present worth of the operating and maintenance cost for all the years. Now you add the cumulative, so find the cumulative operating and maintenance cost. So, now, next thing is we are going to find the equivalent annual cost of the present worth of the operating and maintenance cost so how to calculate that?

So, now you have found the present value of your operating and maintenance cost, you have to find it is equivalent value, so go for the uniform series capital recovery factor. So, that means you are going to find A for the given P, i, n, what is a known P? P is nothing but your the present value is 98,438.72, interest rate is 0.15, n is 1. So, now we are going to find the A, equivalent A for this P, so how to do that?

$$\textbf{USCRF} = \frac{A}{(98438.72,0.15,1)} = \frac{i(1+i)^n}{(1+i)^n-1} = \frac{0.15(1+0.15)^1}{(1+0.15)^1-1} = 1.15$$

So, this factor you multiply it by the operating and the maintenance cost present value that is 98,438.72.

**EAC of O&M cost = 1.15 × 98,438.72 = 1,13,204.53 rupees**

So, this is an equivalent annual cost of the present worth of operating and maintenance cost for the year 1, this is for the year 1. Let us calculate for one more year.

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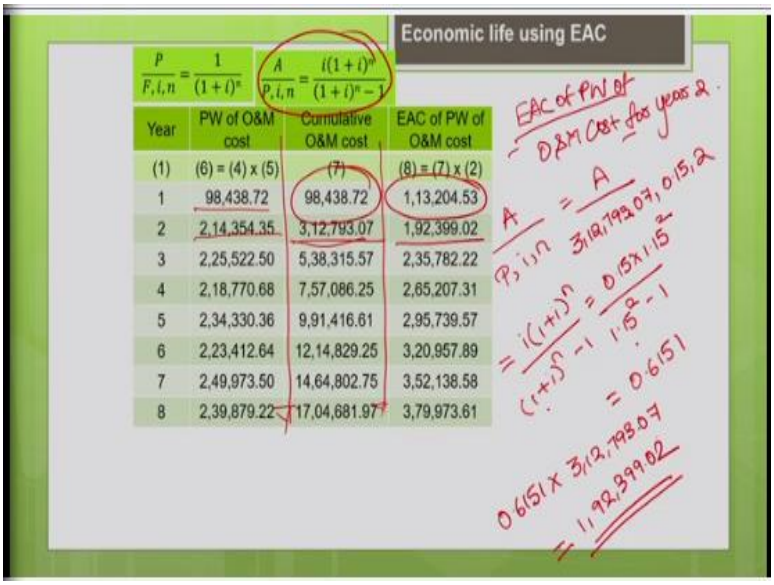


So now we are going to calculate the equivalent annual cost of the present worth of operating and maintenance cost for year 2. So, it is nothing but your you know the present worth of the operating and maintenance cost, you are going to find the A for the known P, i, n.

$$\text{USCRF} = \frac{A}{(312793.07, 0.15, 2)} = \frac{i(1+i)^n}{(1+i)^n - 1} = \frac{0.15(1+0.15)^2}{(1+0.15)^2 - 1} = 0.6151$$

**EAC of O&M cost for year 2 = 0.6151 × 3,12,793.07 = 1,92,399.02 rupees**

This is my equivalent annual cost of the present worth of the operating and maintenance cost. Similarly, you can calculate it for the third year, third year you know, already we have estimated the capital recovery factors for different years.

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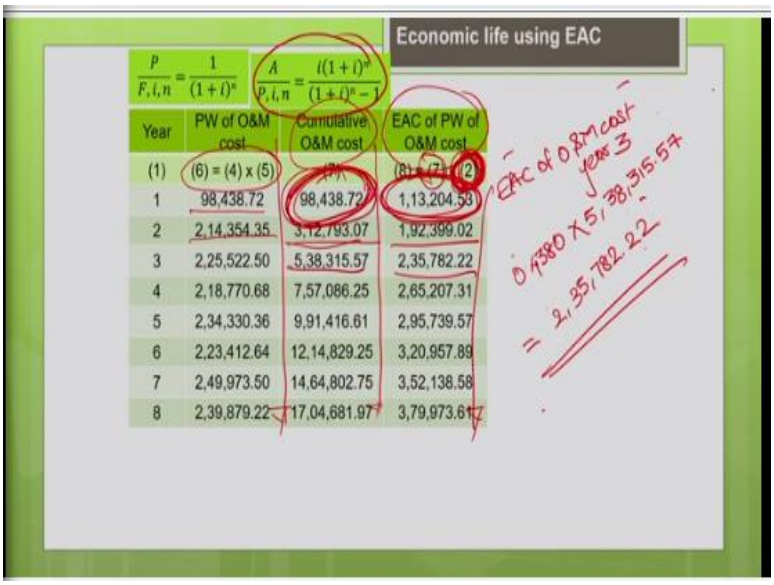


So, now let us calculate the equivalent annual cost of operating and maintenance cost for the third year, year 3. So, already you know the capital recovery factor we have the value, it is 0.4380

**EAC of O&M cost for year 3 = 0.4380 × 5,38,315.57 = 2,35,782.22 rupees**

So, like this you are going to calculate the equivalent annual cost for all for the entire useful life of the machine.

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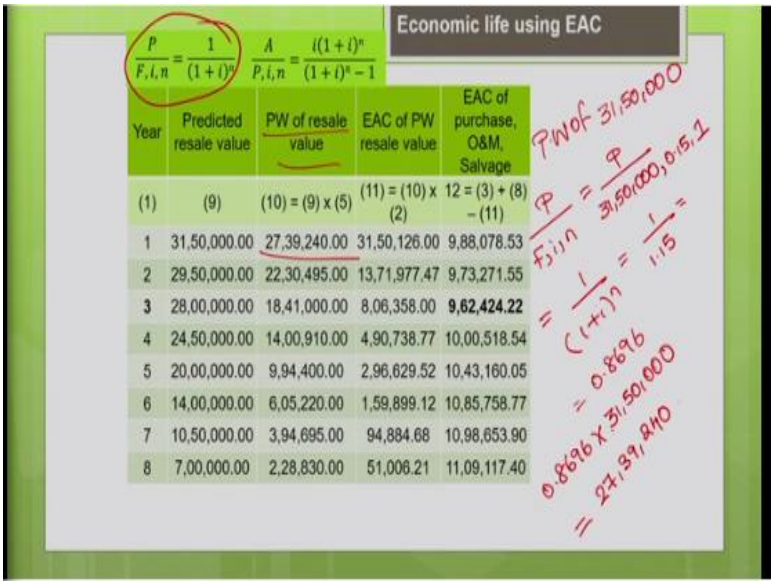


Now let us find the equivalent annual cost of the resale value, that is your salvage value. So, let us go back to the cash flow diagram. So, now what you are going to do is, this is the salvage value which is occurring at the end of year 1. So, you can directly convert into a equivalent annual cost

using uniform series sinking fund factor or the another method is you find it is present value, you convert this future cash flow into t = 0, convert it into t = 0 using present worth factor.

Then again, we have distributed or converted into equivalent annual cost using capital recovery factor, so either of these approaches you can use. So, now we are going to follow the second approach whatever I discussed just now. So, what we are going to do here is, first calculate the present value of the resale value. So, how to find the present value of the present value? Present value of your resale value 31,50,000, so use the present worth factor.

$$\textbf{P.W} = \frac{P}{3150000,0.15,1} = \frac{1}{(1+0.15)^1} = \textbf{0.8696}$$

**Present worth value = 0.8696 × 31,50,000 = 27,39,240 rupees**

So, similarly you calculate the present worth for the year 2.

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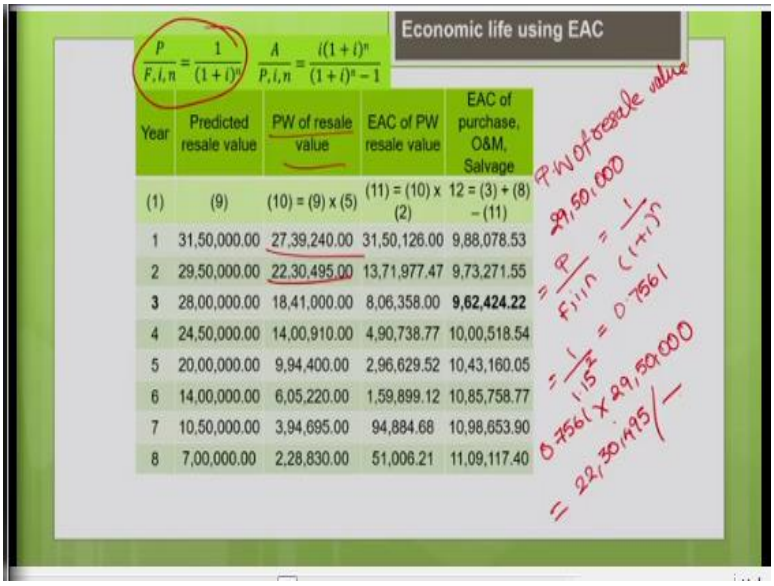


$$\textbf{P.W} = \frac{P}{2950000,0.15,2} = \frac{1}{(1+0.15)^2} = \textbf{0.7561}$$

**Present worth value = 0.7561 × 29,50,000 = 22,30,495 rupees**

So, this is how you have to calculate the present worth of the resale values which are occurring at different time period. Let us calculate for one more year, so that you will have a better understanding.

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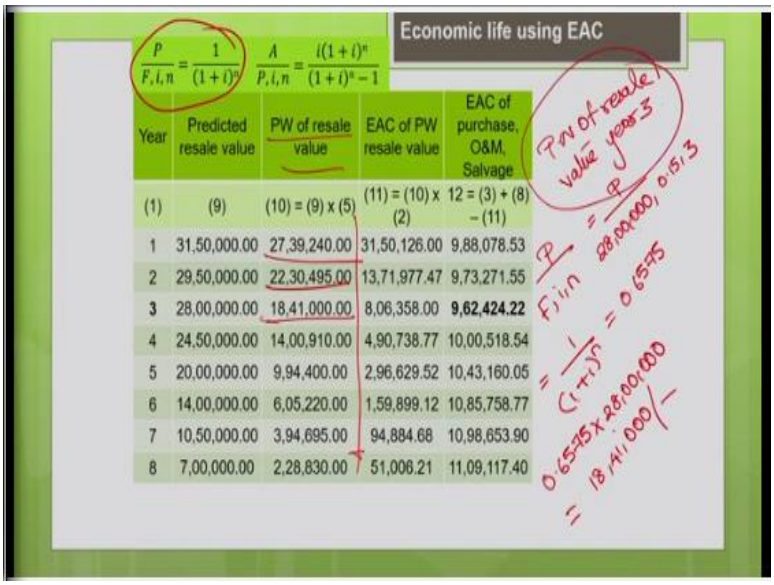


So, the present worth of resale value for year 3 is nothing but,

$$\textbf{P.W} = \frac{P}{2800000,0.15,3} = \frac{1}{(1+0.15)^3} = 0.6575$$

**Present worth value = 0.6575 × 28,00,000 = 18,41,000 rupees**

So, this is how you have to calculate for all the years. So this is how you have to calculate for all the years. So, you have supposed to find the equivalent annual cost of the present value, you have converted the future resale values or the salvage value to time = 0 by using the present worth factor. Now you are going to convert into equivalent annual cost using uniform series capital recovery factor.

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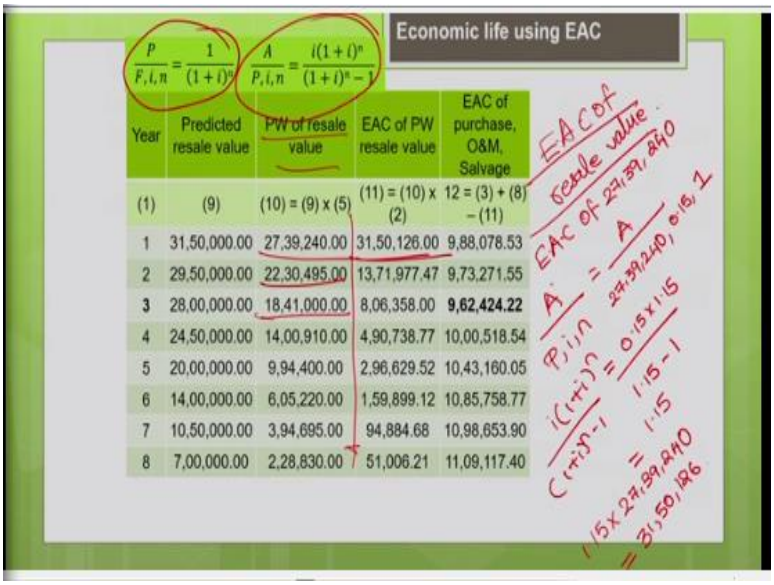

So, that means, so we are going to find the equivalent annual cost of the resale value, so how find that? So, equivalent annual cost of your present worth of the resale value is 27,39,240 for this we have to find the equivalent annual cost, so we need to find A for the given P, i, n.

$$\text{USCRF} = \frac{A}{(2739240, 0.15, 1)} = \frac{i(1+i)^n}{(1+i)^n - 1} = \frac{0.15(1+0.15)^1}{(1+0.15)^1 - 1} = 1.15$$

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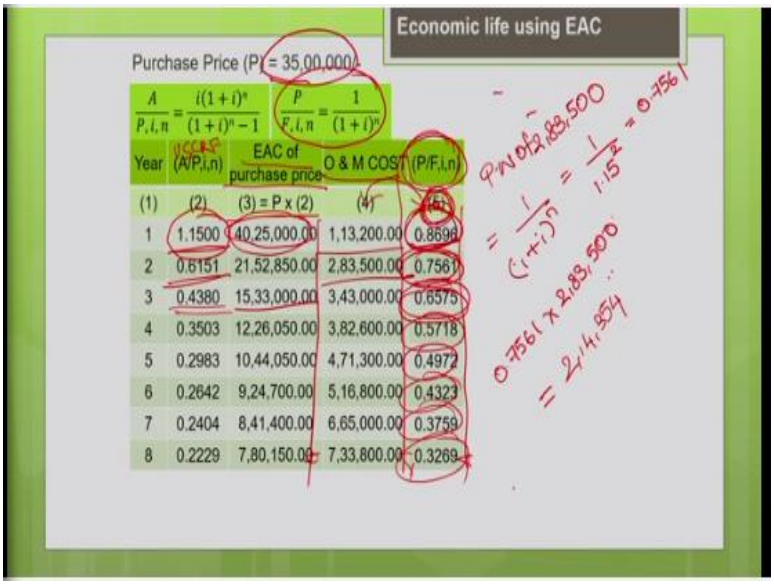


**EAC of resale value for year 1 = 1.15 × 27,39,240 = 31,50,126 rupees**

So, this is how you have to find equivalent annual cost for the resale value at the end of year 1. So, one more year we will work out for the resale value.

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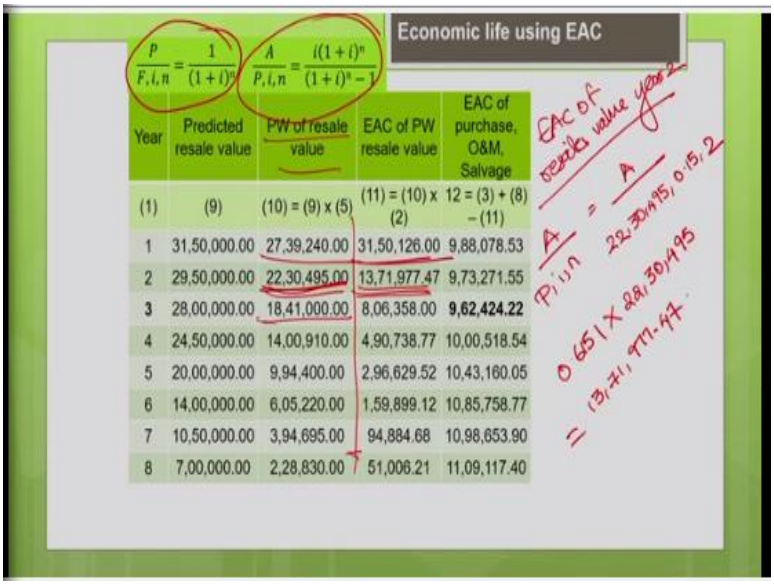

So, a equivalent annual cost of resale value at the end of year 2, so how to find that? So, we are going to find A for the given P, i, n, what is P? P is nothing but your present worth of the resale value 22,30,495,

$$\text{USCRF} = \frac{A}{(2739240, 0.15, 1)} = \frac{i(1+i)^n}{(1+i)^n - 1} = \frac{0.15(1+0.15)^1}{(1+0.15)^1 - 1} = 1.15$$

**EAC of resale value for year 1 = 1.15 × 27,39,240 = 31,50,126 rupees**

interest rate is 0.15, year is 2. So, now we find the factor, already we have determined the factor, factor is nothing but 0.6151.

**EAC of resale value for year 2 = 0.6151 × 22,30,495 = 13,71,977.47 rupees**

So, 0.6151 is a factor multiply by 22,30,495. So, this gives me the equivalent annual cost of the resale value as 13,71,977.47. Similarly, for the year 3 you can find the year 3.

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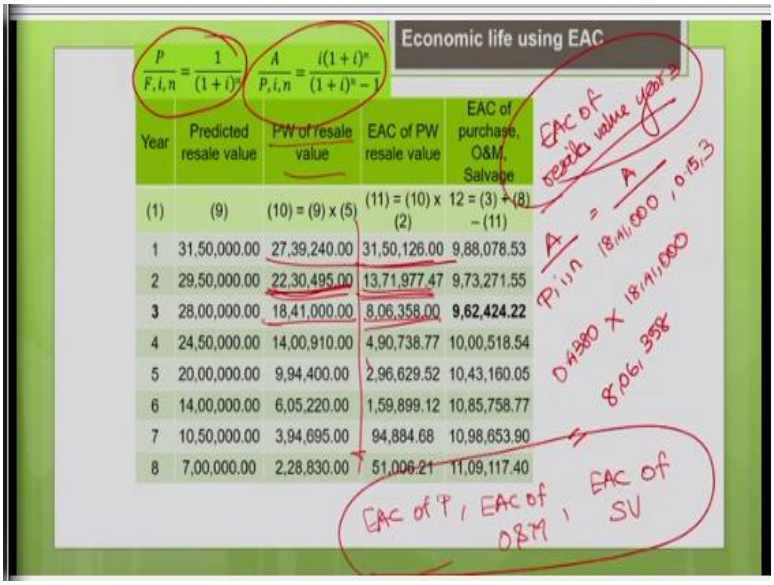


| Year | Predicted resale value | PW of resale value | EAC of PW resale value | EAC of purchase, O&M, Salvage |
|---|---|---|---|---|
| (1) | (9) | (10) = (9) x (5) | (11) = (10) x (2) | 12 = (3) + (8) – (11) |
| 1 | 31,50,000.00 | 27,39,240.00 | 31,50,126.00 | 9,88,078.53 |
| 2 | 29,50,000.00 | 22,30,495.00 | 13,71,977.47 | 9,73,271.55 |
| 3 | 28,00,000.00 | 18,41,000.00 | 8,06,358.00 | **9,62,424.22** |
| 4 | 24,50,000.00 | 14,00,910.00 | 4,90,738.77 | 10,00,518.54 |
| 5 | 20,00,000.00 | 9,94,400.00 | 2,96,629.52 | 10,43,160.05 |
| 6 | 14,00,000.00 | 6,05,220.00 | 1,59,899.12 | 10,85,758.77 |
| 7 | 10,50,000.00 | 3,94,695.00 | 94,884.68 | 10,98,653.90 |
| 8 | 7,00,000.00 | 2,28,830.00 | 51,006.21 | 11,09,117.40 |

Year 3, it is going to be 3. So, here the factor will be different, what is the factor? 0.4380,

**EAC of resale value for year 3 = 0.4380 × 18,41,000 = 8,060358 rupees**

So, this is how you have to estimate the equivalent annual cost of resale value for the different years. So, first convert the resale value into the present worth using the present worth factor, then multiply it by the uniform series capital recovery factor.

So, that you can get the equivalent annual cost the resale value for different time periods. So, now we have estimated the equivalent annual cost of the purchase price, you have estimated the equivalent annual cost of the operating and maintenance cost and you have estimated the

equivalent annual cost of the salvage value. So, now you can find the total cost. So, how to find the total cost?

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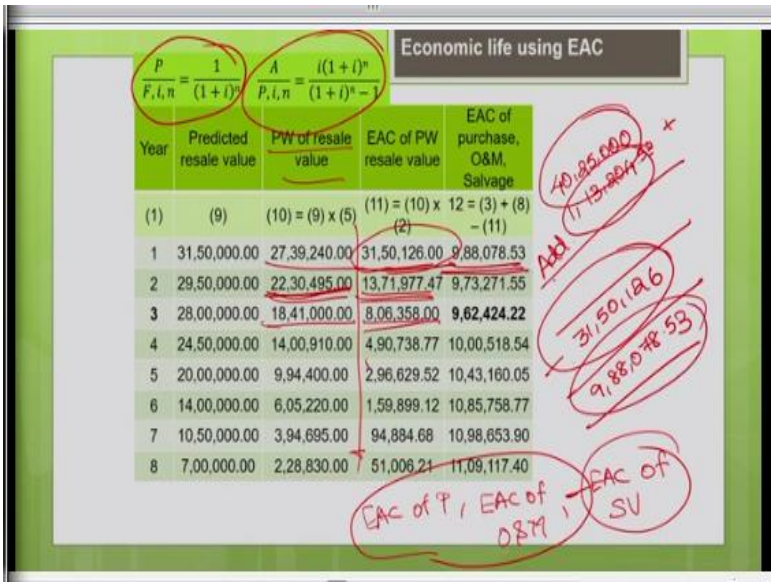


So, you are supposed to add the purchase price and the operating and maintenance cost, your salvage value is in flow cash inflow, so you subtract it. So, what is your equivalent annual cost of the purchase price for the year 1? Equivalent annual cost of the purchase price is 40,25,000 you add it with the equivalent annual cost of the operating and maintenance cost.

**EAC of purchase price, O&M, salvage value=40,25,000+1,13,204.53–31,50,126 = 9,88,078.53**

So, what are we doing actually here? You are adding the purchase price equivalent annual cost of the purchase price and the operating and maintenance cost.

And you are deducting the cash in-flow, that is your salvage value and you will get the total cost 9,88,078.53. So, like this you are going to find the equivalent annual cost for all the years. So, let me summarize how we have done this table. So, first I have tabulated the uniform series capital recovery factor in the second column you can see. Now I am calculating the equivalent annual cost of the purchase price.

How to calculate the equivalent cost of the purchase price? You know the capital recovery factor multiplied by the purchase price. The capital recovery factor is column number 2 multiplied by the purchase price 35,00000 that gives the column number 3. Now you find the equivalent annual cost

of the operating and maintenance cost. So, the operating and maintenance cost are occurring at different time periods converted into time t = 0.

So, for that I need to find the present worth, how to find the present worth? Use the present worth factor, these are the present worth factors calculated for different years. So, multiply this present worth factor with the operating and the maintenance cost, you multiply both, column 4 multiplied by column 5 will give you the present worth of the operating and maintenance cost that is column 6.

So, now you find the cumulative operating and maintenance cost, add everything. Now your column 8 will be equivalent annual cost of the present worth of the operating and maintenance cost, how to find that? You know the present value of your operating and maintenance cost, you multiply this column by the uniform series capital recovery factor, that is column number 2. So, multiply this present value with the uniform series capital recovery factor column number 2. So, column 7 multiplied by column 2 gives you the equivalent annual cost of the operating and maintenance cost.

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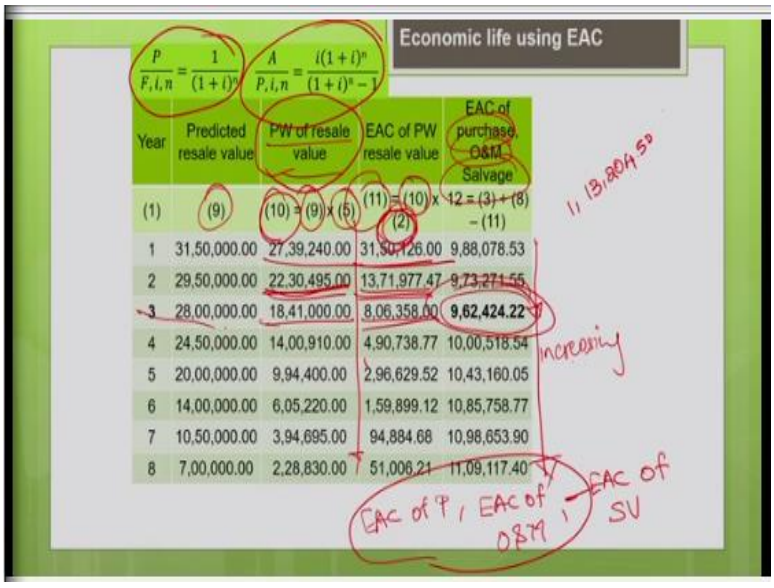


Now your resale value. So, resale value is a column 9, now if converted into time t = 0 by using the present worth factor. So, which is the present worth factor column? Present worth factor column is column number 5. So, this column number 5, you multiply with column number 9, that

is resale- value, you will get the present worth of the resale value. Now find the equivalent annual cost, so how will you do that?

You multiply the present worth the column number 10 multiplied by the uniform series capital recovery factor which you have calculated for in column number 2. That will give you column number 11 equivalent annual cost of the resale value. Now the total equivalent annual cost, you add the purchase price, your cash outflow, operating and maintenance is a cash outflow, add it, and subtract the cash in-flow, that is a salvage value.

That gives you a total equivalent cost. So, now you can see that your cost is high in the initial stage then it reduces, reaches the minimum value then again starts increasing. After year 3, you can see that it is the reaching by minimum at the year 3 and after that it is increasing, why it is increasing significantly? Because of increase in maintenance and the repair cost. So, the economic life of this machine is third year, the optimum replacement time of this machine is third year.

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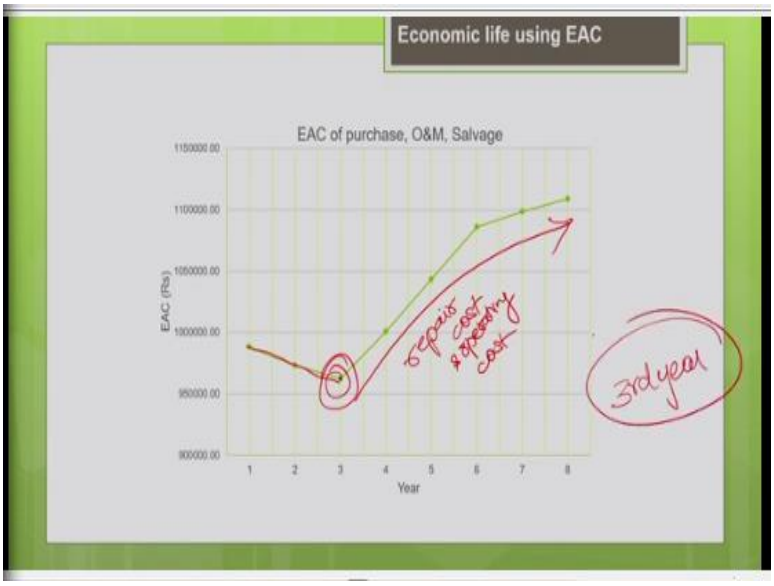


So, you can see the pictorial representation of the cost plotted. You can see it is reducing reaches a minimum at the time 3 and after that there is a significant increase in the cost. This increase will be due to the increase in the repair cost and the operating cost associated with the machine. Due to increase the age of the machine, that is way before the repair cost and operating cost increases

significantly you are supposed to replace the machine. So, the optimum replacement time of this machine or the economic life of the machine is 3rd year.

So, in this problem we have determined the economic life of the machine using the equivalent annual cost approach. Like we have converted all the cash flows which are occurring at different time period into a particular time period = 0.

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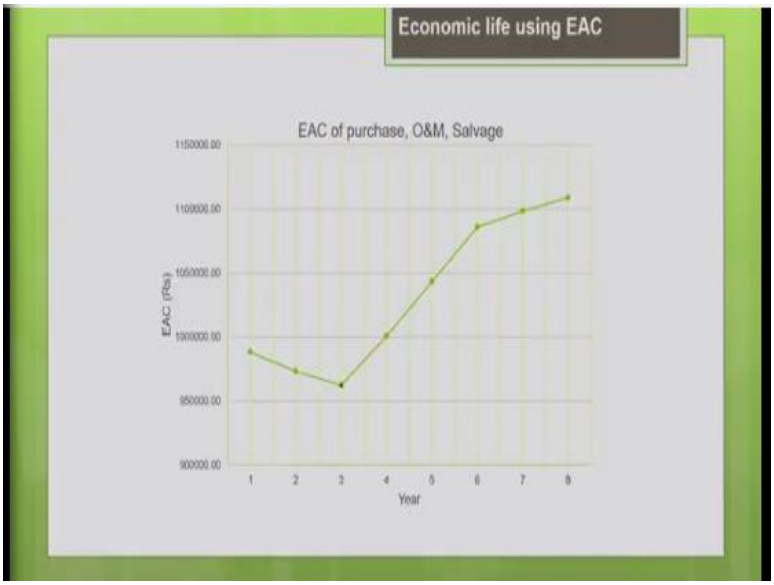


Then we converted into equivalent annual cost using the component factors. So, then we found out the time period during which the equivalent annual cost associated with the machine is minimum, that is the optimum time for the replacement of the machine. So, this is how we determine the economic life of the machine using equivalent annual cost approach.

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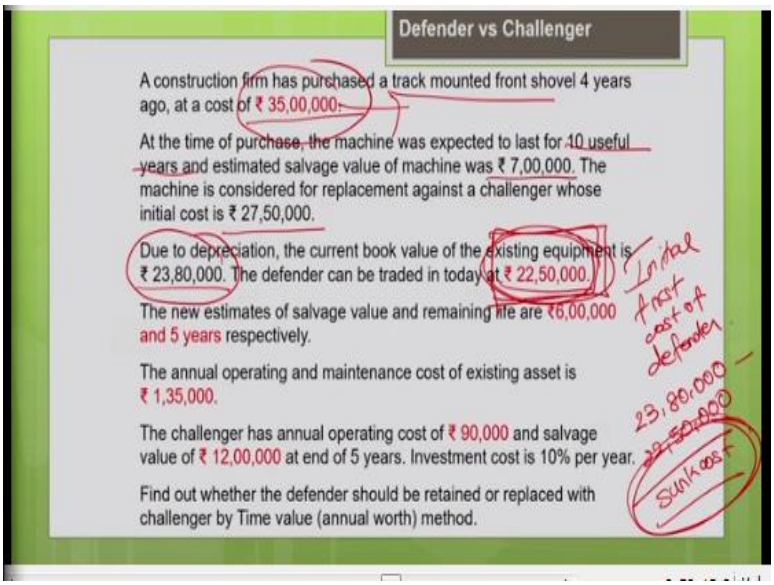


Now let us discuss about another replacement analysis problem in which we are going to compare the defender and the challenger. So, as you know defender is the current equipment and challenger is the proposed equipment. So, we are going to estimate the equivalent annual cost associated with the defender and we are going to compare it with the equivalent annual cost associated with the challenger. And then make a decision whether to replace the defender with the challenger or not.

So, that is what we are going to discuss in this upcoming problem. So, let us now workout this problem and try to understand. So, a construction firm has purchased a track mounted front shovel. So, the purchase price is 35,00,000, 4 years ago, so the construction firm has purchase this machine 4 years ago at the cost of 35,00,000, that time the purchase price was 35,00,000. So, at the time of purchase, the machine was expected to last for 10 useful years.

That means the useful life was estimated at the time of purchase to be 10 years, and the salvage value was estimated to be 7,00,000 after 10 years. The machine is now considered for replacement against the challenger whose initial cost is 27,50,000. Another important thing to be noted is due to depreciation, the current book value of the existing equipment is 23,80,000.

So, we have adopted some depreciation accounting method and we have estimated the current book value of the existing machine as 23,80,000 in your accounting records. But now, the actual trading value of the machine of the defender is 22,50,000. So, as I told you earlier in the

replacement analysis, we have to always look from third party perspective. So, like an outsider we have to look at the process and then make the decision.

So, the replacement analysis has to be done through outsider perspective as a third-party perspective. For an outsider, he is not bothered about your initial purchase price of the machine, this is totally irrelevant to him, this 35,00,000 is your initial purchase price, it is not important for an outsider. What he is concerned about is only the current trading value of the machine, the current trading value is 22,50,000.

So, when you sell in the market, what is the current market value or the trading value is 22,50,000, this is only your initial cost of the defender or you can say the first cost of the defender. The first cost of defender from third party or the outsider perspective. So, you have estimated book value of the machine using your depreciation accounting method in your accounting record as 23,80,000 but your current trading value is only 22,50,000.

So, the difference is your sunk cost, so this 23,80,000 minus 22,50,000, so this is your sunk cost. So, this is a cost which you are invested earlier but it cannot be recovered. Sunk cost is the cost which cannot be recovered in the future recovered in the past. So, basically the sunk cost is also irrelevant, it should be ignored or neglect this sunk cost in the replacement analysis. What we are concerned is only about this value, it is nothing but your market value or the current trading value of your existing machine.

Now, so let us look into what are all the other information available. Now the new estimates of the salvage value is 6,00,000.

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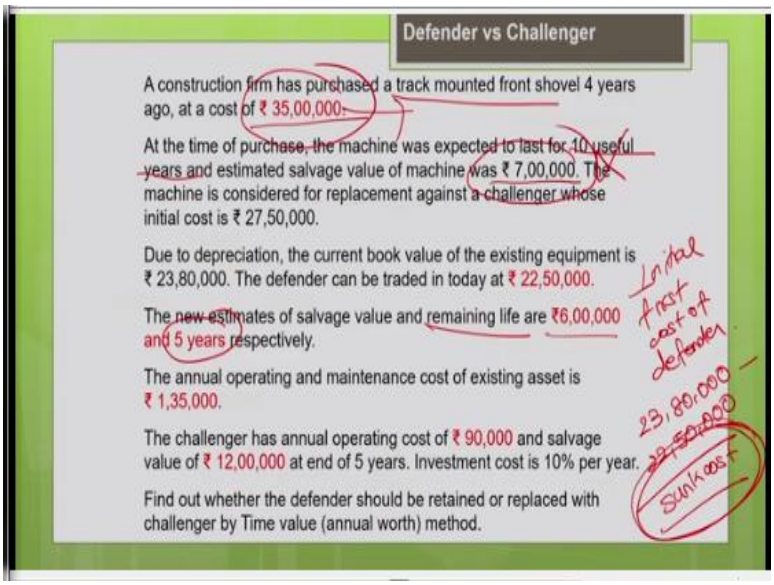


The new estimate is 6,00,000, but the old estimate was 7,00,000 that has to be ignored, you have to consider what is the new estimate. And the current estimate of the remaining life of the machine is 5 years. See based upon your earlier estimate, if we estimate the remaining life, see the total life of the machine was estimated to be 10 years.

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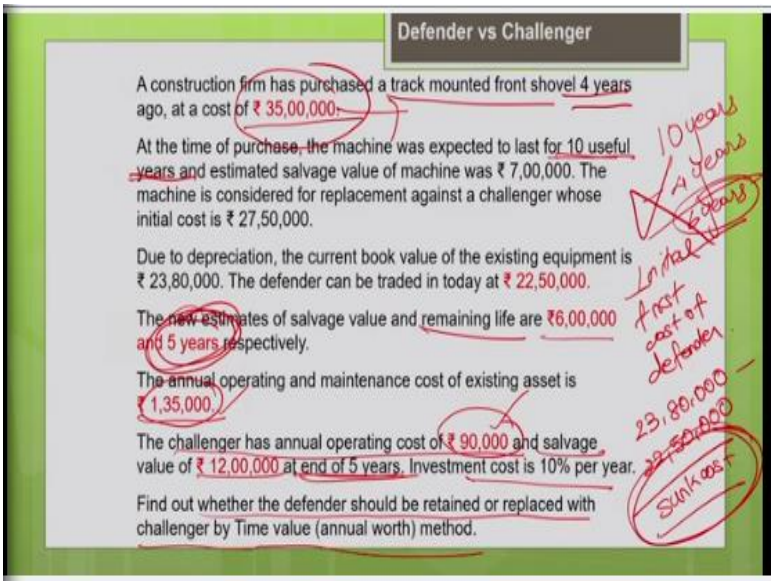


At the time of purchase, we have estimated the useful life of the machine was 10 years. So, now the remaining life is supposed to be 10 years minus 4 years is nothing but 6 years is the remaining life but it is not so. According to the new estimate the remaining life is only 5 years, you have to consider only this new estimate, you have to ignore this old estimate. So, the annual operating and the maintenance cost of the existing assert is 1,35,000.

So, this is all about your defender that is the current equipment. Now let us discuss about the challenger, that is a proposed equipment. The challenger's annual operating and maintenance cost is 90,000. So, you can see that it is lesser than your old equipment, so lesser than your defender. So, the defender operating and maintenance cost is 1,35,000 but your challenger operating cost is 90,000, so it is lesser.

And the salvage value for the challenger is 12,00,000 after 5 years. So, the life of the challenger we are considering is for 5 years, investment cost is 10% per year. Now we are supposed to compare the challenger and the defender, find out whether the defender should be retained or replaced with the challenger using time value or annual worth method. So, that is what we are going to do.

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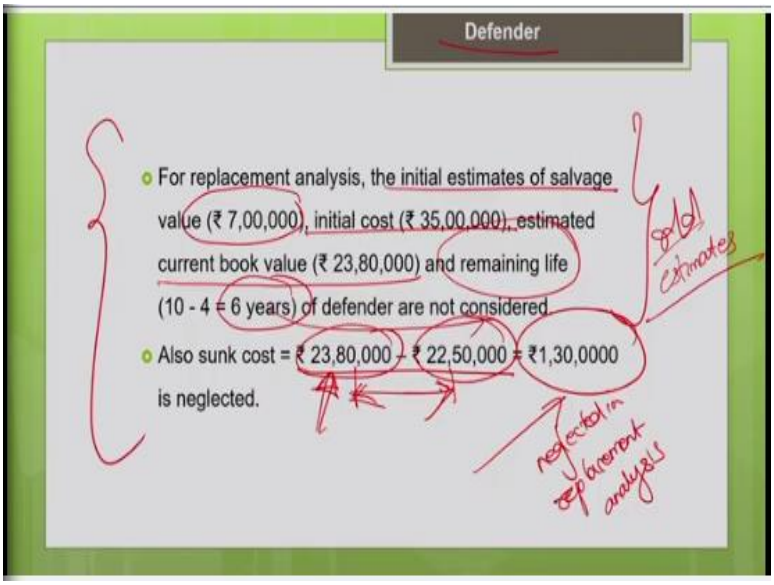


Now let us look into the information about the defender. So, for the replacement analysis, as I told you your initial estimates should be ignored or neglected, they are not relevant. Your initial purchase price 35,00,000 it should not be considered in the replacement analysis. And similarly your initial estimate of salvage value 7,00,000 is should not be considered. And the estimated current book value using your depreciation accounting method 23,80,000, it is also not relevant in the analysis.

And the estimated life initial estimate based upon the remaining life was found to be 6 years, this 6 years is also not considered. All these are old estimates, old estimates should be neglected in the replacement analysis. And also, as I told you your sunk cost, so what is the sunk cost? So, it is a estimated book value of the machine, this is the estimated book value of the machine using depreciation accounting method it is currently 3,80,000.

But your current trading value is only 22,50,000 this difference cannot be recovered, this difference is called as the sunk cost, this is a cost which is spent and it is lost, it cannot be recovered. So, this difference is a sunk cost and this also should be neglected in the replacement analysis. So, all the old estimates, initial cost, initial estimate of salvage value, initial estimate of useful life **so** and the sunk cost are not consider the replacement analysis. So, these are not imparted from the outsider perspective or the third-party perspective.

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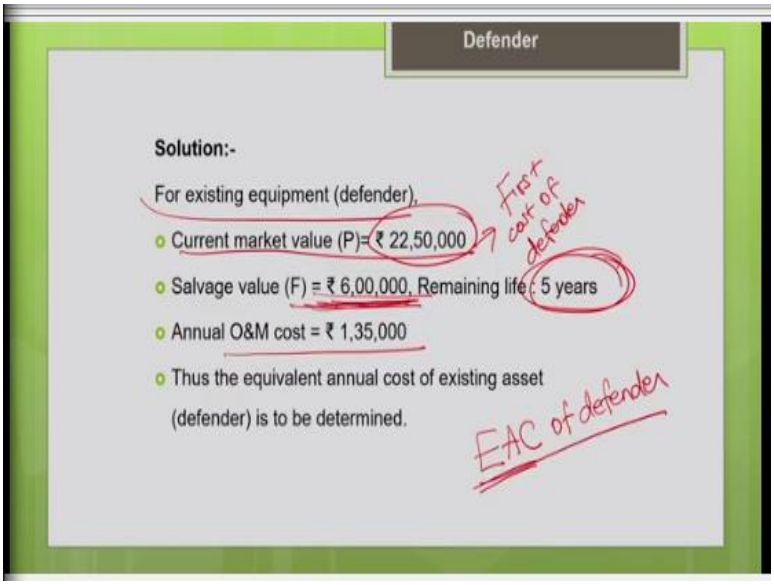


Now for the existing equipment that is defender what are all relevant in the replacement analysis or what are all to be considered in the replacement analysis, let us see that. Current market value is 22,50,000, this is your initial cost of your the first cost of your defender, this is what we are going to consider, what is your current trading value of the machine in the market. Now the salvage value, the final estimate of salvage value the recent estimate is 6,00,000, that you have to consider.

At after 5 years, after the remaining life of 5 years, the salvage value is going to be 6,00,000, the remaining life is 5 years according to the recent estimate. The annual operating and maintenance cost is 1,35,000. Based upon this you are supposed to calculate the equivalent annual cost of the defender. We are going to estimate the equivalent annual cost of the defender. So, for that you need to draw the cash flow diagram. Let us draw the cash flow diagram and do the analysis.

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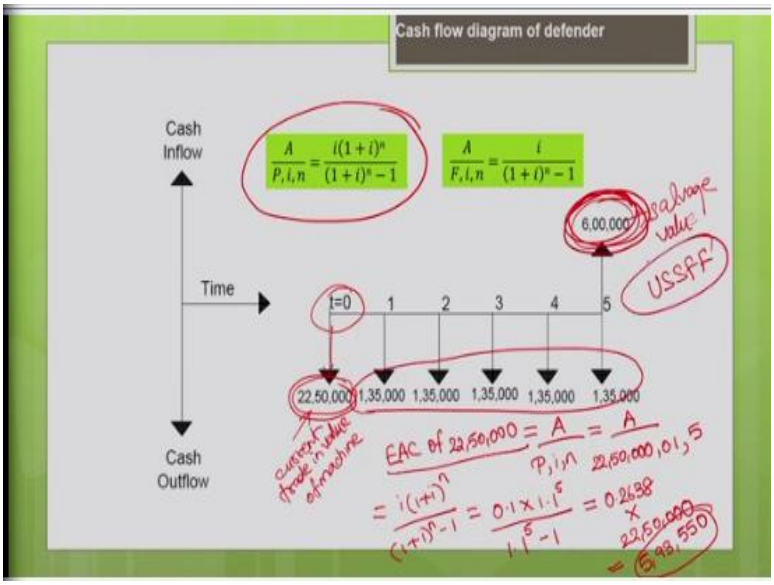


So, now the first cost of the defender is the current, this is nothing but your current trading value of your machine, that is nothing but 22,50,000. Every year the operating cost is going to be same and it is found to be 1,35,000, so the remaining life of the machine estimated is 5 years, you can see 5 years. At the end of 5th year, when you sell it you are going to get a cash inflow of 6,00,000.

So, this is nothing but your salvage value of your machine. Now, so based upon this you can estimate the equivalent annual cost. So, how to estimate the equivalent annual cost? You are going to convert this values all this values to time period of t = 0. So, now what you do is, your initial cost of the defender, initial cost of the defender is 22,50,000. So, this one you are going to converted into equivalent annual cost, this is already at t = 0 only.

This present value, I am going to convert it into equivalent annual cost, so how to do that? Equivalent annual cost of 22,50,000, so you need to calculate A for know P, i and n. So, what is

P? P here is present value 22,50,000, interest rate is 10% 0.1 and number of years is 5. So, it is nothing but you have to use your uniform series capital recovery factor to find this,

$$\textbf{USCRF} = \frac{A}{(2250000, 0.1, 5)} = \frac{i(1+i)^n}{(1+i)^n - 1} = \frac{0.1(1+0.1)^5}{(1+0.1)^5 - 1} = 0.2638$$

$$\textbf{EAC} = 0.2638 \times 22{,}50{,}000 = 5{,}93{,}550 \text{ rupees}$$

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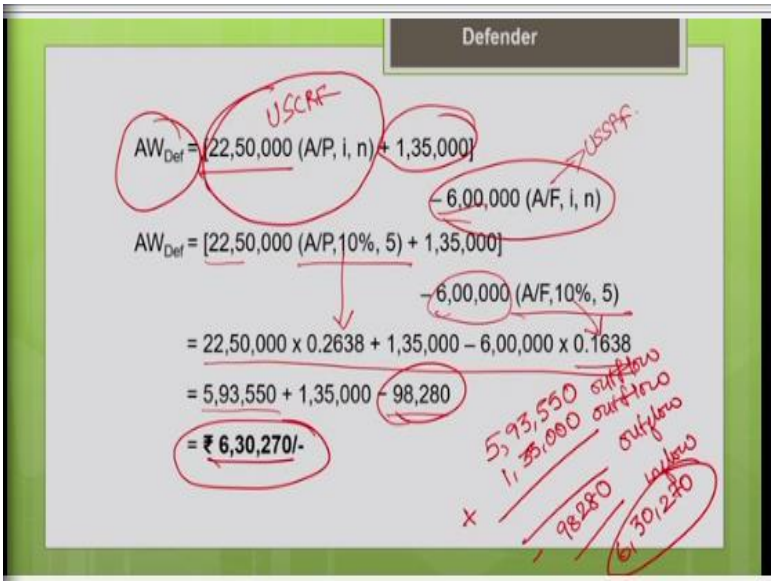


So, this is the equivalent annual cost of your initial cost of defender, so we have estimated it. Already the operating and the maintenance cost already annual cost and they are equal, they are already annualized cost, so you need not convert them.

Now let us go to the salvage value, I need to convert this salvage value into equivalent annual cost. So, you can do it by 2 approaches as I told you can use the uniform series sinking fund factor. You can use uniform series sinking fund factor and convert it into equivalent annual cost or you can find the present worth of this future salvage value using present worth factor and then convert it into a equivalent annual cost using uniform series capital recovery factor.

So, both these approaches you can use any one of these approaches you can use. Now let us calculate using uniform series sinking fund factor approach, so let us see how to do that.

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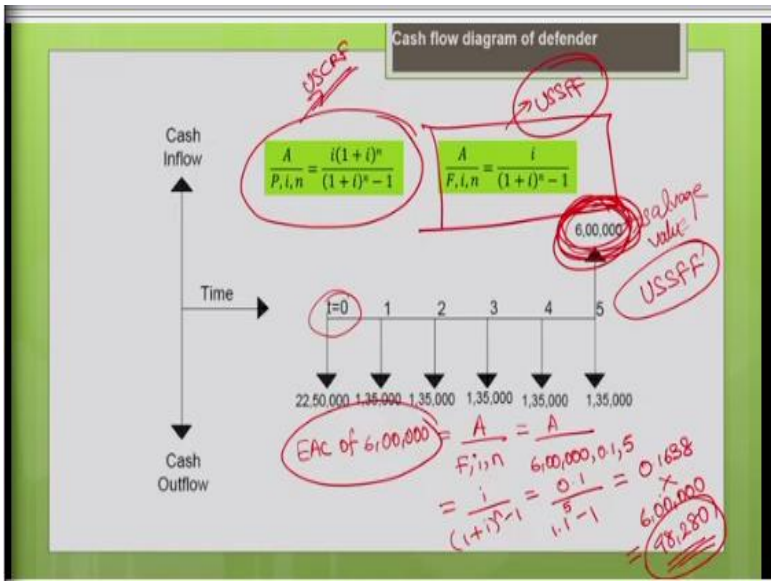


So, now you need to find the equivalent annual cost of 6,00,000, that is your salvage value. So, you need to find A for the known F, i and n, F is nothing but your future value, the future salvage value. So, what is the salvage value, F is nothing but 6,00,000 and the interest rate is 0.1 number of years is 5, you are going to use this formula, this is nothing but your uniform series sinking fund factor. So, using this we are going to calculate this, this is uniform series capital recovery factor, hope you remember. So, now we are going to use this uniform series sinking fund factor to find the equivalent annual cost,

$$\textbf{USSFF} = \frac{A}{(600000, 0.1, 5)} = \frac{i}{(1+i)^n - 1} = \frac{0.1}{(1+0.1)^5 - 1} = 0.1638$$

$$\textbf{EAC} = 0.1638 \times 6{,}00{,}000 = 98{,}280 \text{ rupees}$$

So, this is the equivalent annual cost of your salvage value 98,280. So, now let us see how it is done? Let me summarize whatever I have discussed so far. So, you are finding the annual worth or the equivalent annual cost of your defender. So, first you are converting the initial cost of the defender, it is 22,50,000 into equivalent annual cost using uniform series capital recovery factor.

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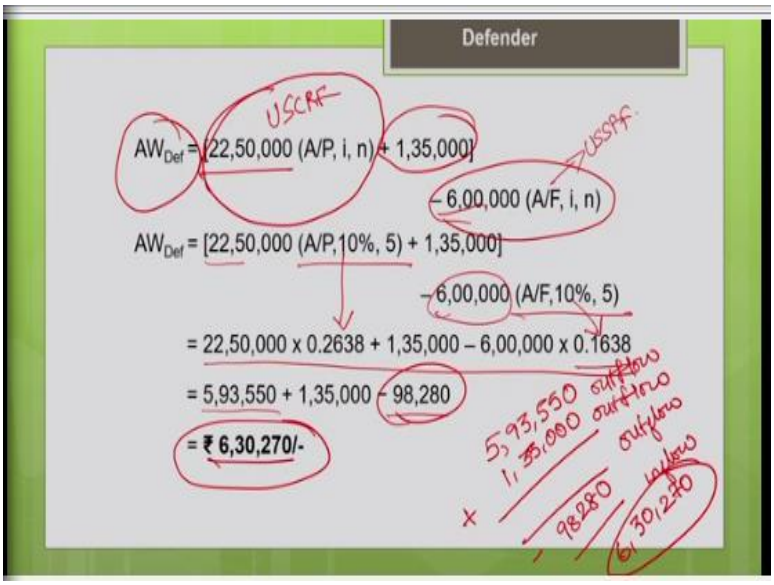


Your operating cost is already in the annualize form, no need to convert. Then you convert your salvage value 6,00,000 into equivalent annual cost using uniform series sinking fund factor. That is what is done here 22,50,000 to the factory is A, for known P, i and n, + 1,35,000 - salvage value you have to multiply with the uniform series sinking fund factor which is nothing but you are going to find A for the given F, interest rate 10% and n = 5.

So, now you substituted we will get it, the factor is corresponding to 0.2638, here the factor is corresponding to 0.1638, so when you simplify you will get this value. So, the annualize initial cost of the defender is 5,93,550, this is your outflow. Your operating cost is your cash outflow 1,35,000 add both the cash outflows, you will get the total outflow, then what is your inflow? Your inflow is nothing but your salvage value 98,280 you subtract it from the added value.

You will get the final equivalent annual cost of the defender or the annual worth of the defender as 6,30,270. So, this is the cost liability of holding the defender with you, so this is the cost implication or the equivalent annual cost associated with the defender. If you are going to hold this machine for 5 years. So, what is the equivalent annual cost associated is 6,30,270. A similar manner you are going to find the equivalent annual cost for your challenger machine, that is a proposed equipment.

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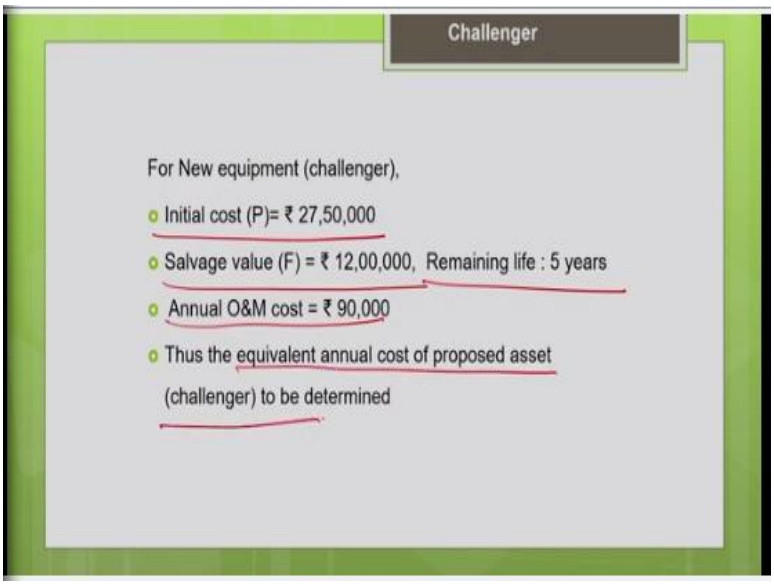


So, for the new equipment challenger, the initial cost is given as 27,50,000. So, this is a cost for the acquisition of the machine to your project site. Then the salvage value is given as 12,00,000, after 5 years, so after 5 years it is going to be 12,00,000. So, here the life of the machine we are considering is 5 years. So, the annual operating and maintenance cost is 90,000, now you are going to find the equivalent annual cost of the proposed asset, that is a challenger, in the same manner, you can find it.

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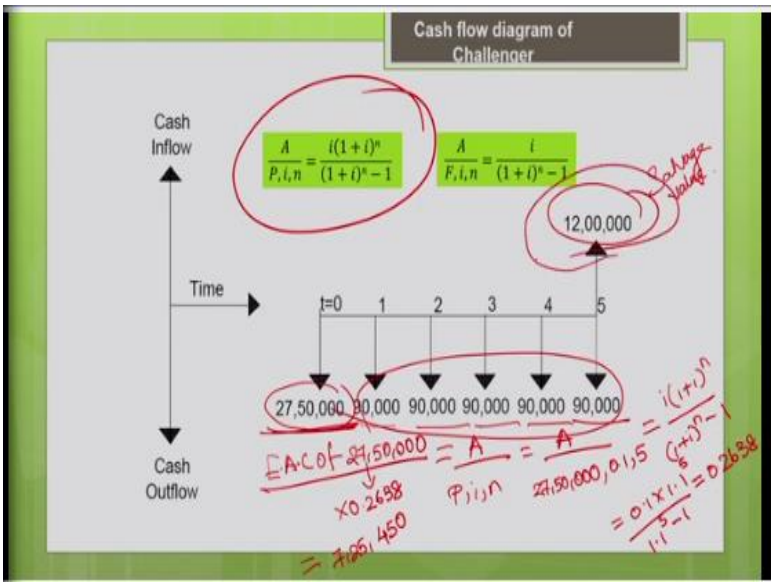


Let us draw the cash flow diagram first. Now the initial cost of the challenger is 27,50,000, the operating cost is same for every year. For the 5 years it is found to be 90,000, at the end of the 5th year if you are going to sell it your salvage value is 12,00,000. Now, find the equivalent annual

cost of your initial cost of a challenger that is 27,50,000, so how to find this? So, you need to find the A for the known P, i, n what is P here?

$$\textbf{USCRF} = \frac{A}{(2750000, 0.1, 5)} = \frac{i(1+i)^n}{(1+i)^n - 1} = \frac{0.1(1+0.1)^5}{(1+0.1)^5 - 1} = \textbf{0.2638}$$

$$\textbf{EAC} = 0.2638 \times 27{,}50{,}000 = \textbf{7,25,450 rupees}$$

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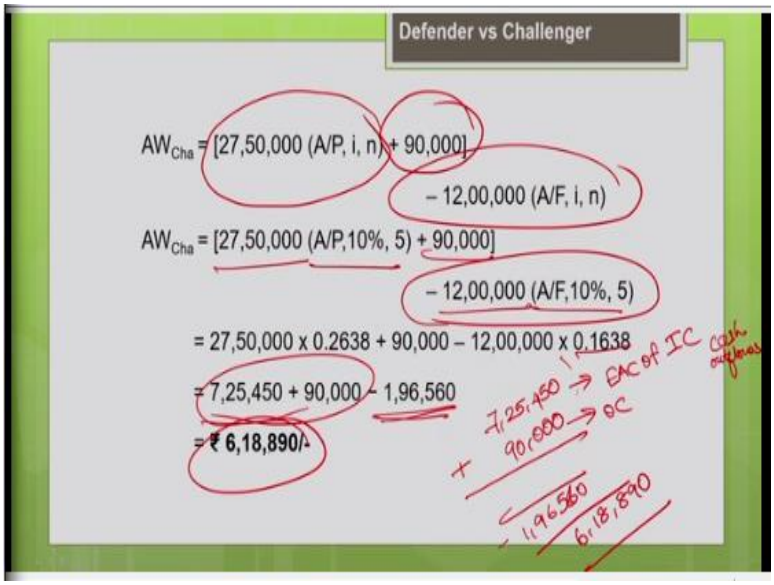


You can see, so this is what their estimated. Now already the operating cost is annualized, you need to convert that, into equivalent annual cost, it is already equivalent annual cost. Now we are going to calculate the equivalent annual cost associated with the salvage value of the machine. So, let me now estimate the equivalent annual cost of the salvage value 1200000.

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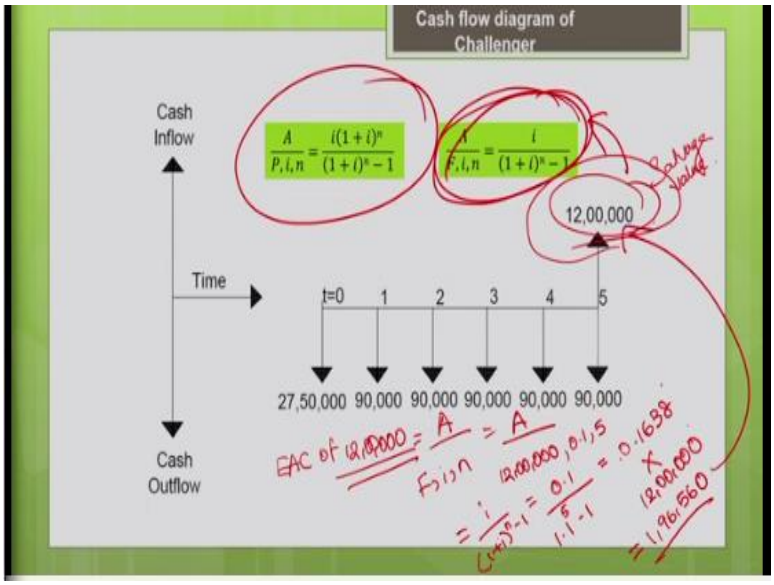


So, you are going to use the uniform series sinking fund factor, using this you can convert it. You need to find the A for the known future value i and n, the future value is nothing but your salvage value 12,00,000, interest rate is 0.1, number of years is 5.

$$\textbf{USSFF} = \frac{A}{(1200000, 0.1, 5)} = \frac{i}{(1+i)^n - 1} = \frac{0.1}{(1+0.1)^5 - 1} = 0.1638$$

$$\textbf{EAC} = 0.1638 \times 12{,}00{,}000 = 1{,}96{,}560 \text{ rupees}$$

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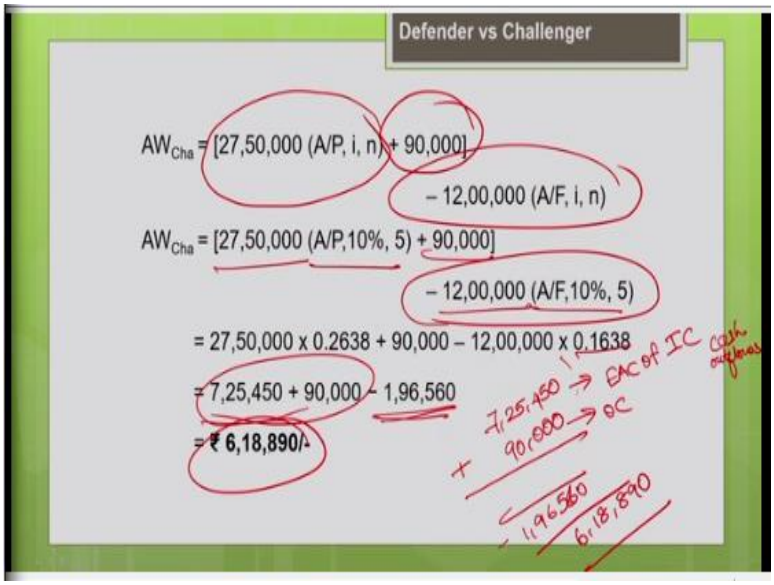

So, let me know summarize, we are finding the annual worth of the challenger. So, here we are finding the equivalent annual cost of the initial cost of a challenger plus the operating cost minus your salvage value, equivalent annual cost of the salvage value.

To find the equivalent annual cost of the initial cost you have to multiply by uniform series capital recovery factor, then add it with the operating cost. Then you have salvage value, you multiply it with the uniform series sinking fund factor and then subtract it from the cash outflow. This is the cash inflow, so these 2 are cash outflows. So, the 7,25,450 is your equivalent annual cost of your initial cost of machine, 90,000 is your operating cost of the machine.

So, both are cash outflows, you have to add both. Now your cash inflow is the salvage value - 196560, so you will get the final resultant as 6,18,890. So, this is the cost liability of holding the challenger with you. So, the cost implication of holding the challenger for 5 years the equivalent annual cost will be 6,18,890

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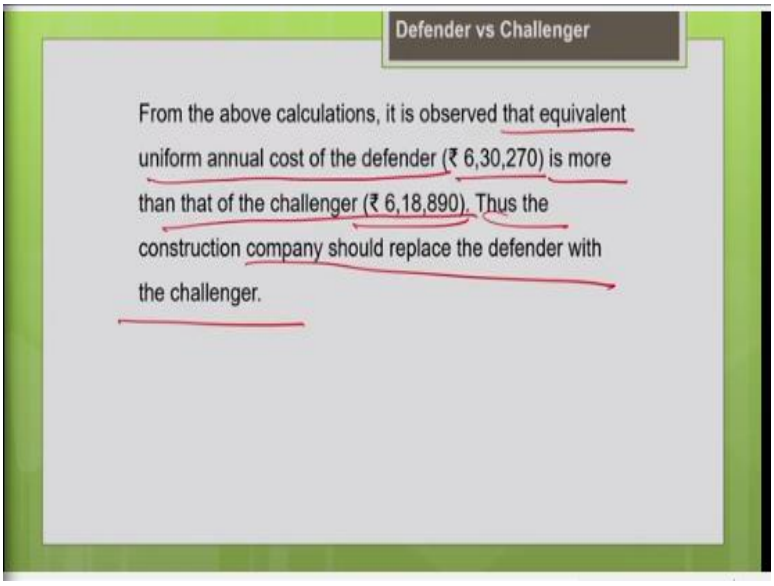


Now let us compare, from the above calculations you confine that the equivalent uniform annual cost of the defender is 630270. So, it is more than that of the equivalent annual cost of challenger which is 6,18,890. Hence it is advisable to replace your defender with a challenger. So, the construction company should replace the defender with the challenger, so this is a decision made.

So, in this approach we are comparing 2 different machines, your current existing machine defender and the proposed machine where estimating the equivalent annual cost for both things, and we are finding for which one the cost liability is minimum. So, whichever equipment the cost liability is minimum we will recommend that. In this case, the challenger cost liability is minimum, so it is preferable to replace a defender with the challenger.

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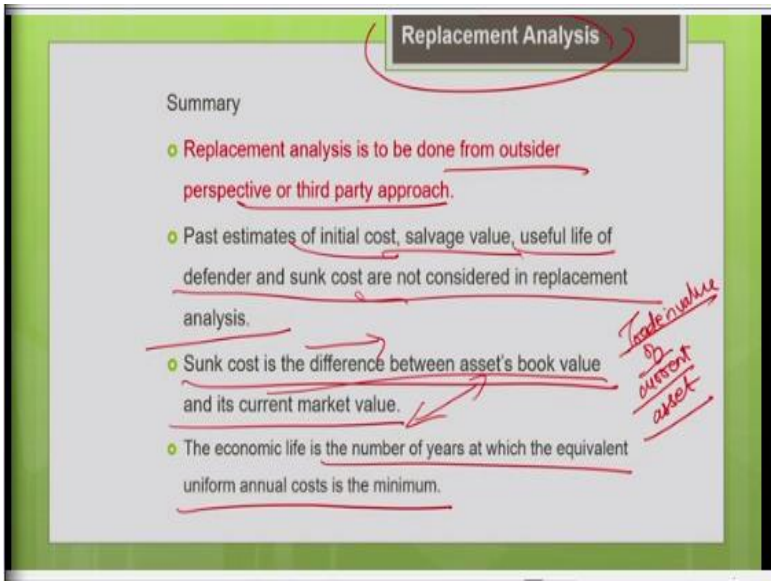


So, we are come to the end of this lecture 8. So, let me summarize whatever we have discussed so far. So, as I told you earlier, the replacement analysis is to be done from outsider perspective or the third-party approach. So, the outsider is not concerned about your initial purchase price. For him for the current equipment, he is concerned only about the current trading value of the machine in the market.

So, all your past estimates of your initial cost, your estimate of your useful life there, yearly estimates, the yearly estimates of salvage value of the defender and the sunk cost all are irrelevant in the replacement analysis. They should not be considered in the replacement analysis. You are supposed to consider only the current trading value of your machine, current trading value of your current asset that is only important for an outsider.

And I explained to you what is the sunk cost, sunk cost is the cost which cannot be recovered. Say for example, your estimated book value of the machine is going to be higher than the current

trading value of the machine, that difference is your sunk cost. The difference between the asset book value and the current market value, this cost cannot be recovered. So, that is a sunk cost, and this cost should not be considered in the replacement analysis.

So, basically the economic life of the machine is a time period at which the equivalent uniform annual cost is a minimum. So, we have discussed 2 different types of problems, in one problem we have estimated the economic life of the machine using the equivalent annual cost of the machine. In another problem we have compared the defender and challenger and we have estimated the equivalent annual cost for both the defender and the challenger.

And compare both the values for whichever equipment the cost liabilities minimum, we recommend that particular equipment. So, we have discussed 2 different types of approaches using this time value method. So, basically we have dedicated 3 different lectures, lecture 6, 7 and 8 for the equipment life and the replacement analysis. So, as I told you when you do the replacement analysis, we have to consider all the components of the equipment cost.

Then only you can get a accurate picture, all the cost including your downtime cost, obsolescence cost, your cost of inflation, everything should be considered in the cost estimation to get the accurate replacement decision. Also, you should consider the timing of the cash flows, time value factor you should consider. So, that you can get an accurate replacement decision. So, with this let me conclude with the lecture 8.

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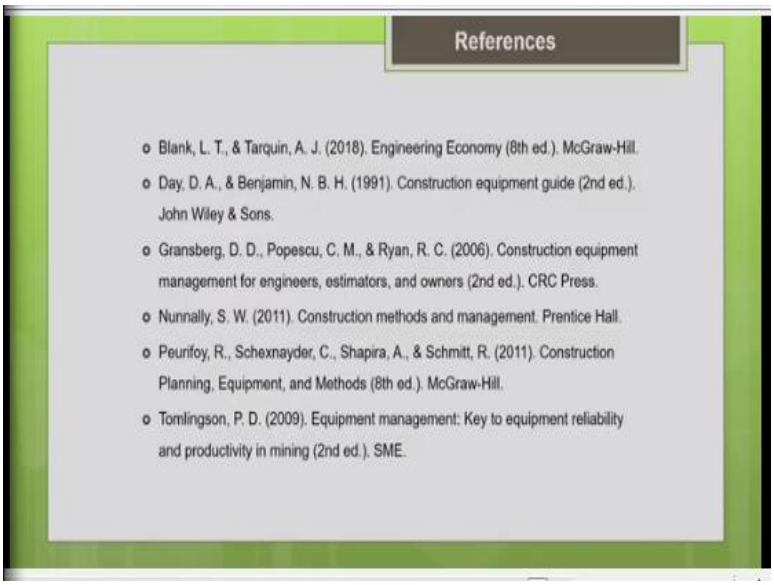


So, these are the reference textbooks which I have used for the preparation of this lecture. I recommend you to procure some of these books for the preparation of topics later. In the next lecture we will be discussing about engineering fundamentals of the earthmoving operation. Like we will be discussing what are all the important fundamental terminologies related to earthmoving operation, I will introduce those terms.

And we will also discuss about different types of machines earth moving machines, their mode of operation, how to estimate the productivity of those machines? All those things will be discussed in the upcoming lectures, thank you.