Construction Methods and Equipment Management
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Lecture-7
Equipment Life and Replacement Analysis (Part-2)

Hello everyone, I welcome you all to the lecture 7 of this course construction methods and equipment management. So, in this lecture, we are going to discuss about the equipment life and replacement analysis in continuation with the earlier lecture. So, let us have a recap of what we learnt in the previous lecture.

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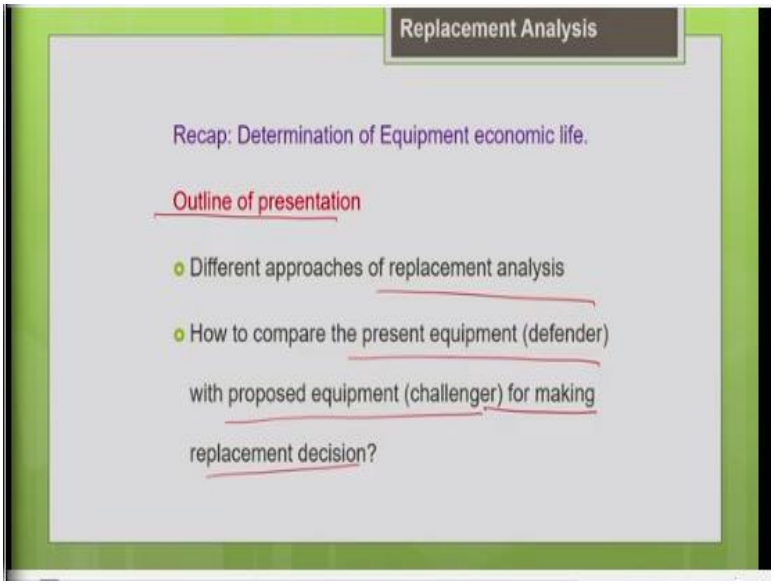

So, in the previous lecture, we discussed about how to define the equipment life in different ways, what is economic life of the equipment. So, how to find out the optimum replacement time of the machine using the economic life and how to determine the economic life for a particular machine? So, we have even worked out an illustration on that, so this will be the outline of the today's presentation.

In today's presentation that we will be discussing about what are the other different approaches which are available for the replacement analysis. So, particularly we are going to compare, like how to compare the present equipment that is a defender, with the proposed equipment that is a

challenger for making the replacement decision. So, that is what we are going to do in the present lecture.

So, in the previous lecture, we found out what is the optimum replacement time for a particular machine by determining the economic life of the machine. Now in this present lecture, we will learn how to compare the present equipment, that is a defender and with the proposed equipment that is a challenger. So, we can make a comparison and we can make addition whether the challenger is suitable for replacement or not, and also, we can find the optimum replacement time by comparing it. So, that is what we are going to discuss in the upcoming slides.

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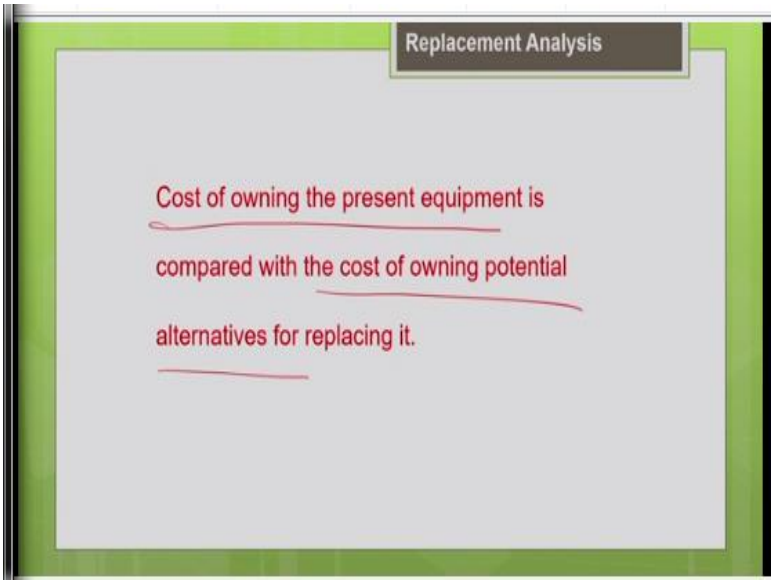

So, basically, we are going to compare the cost of owning the present equipment with the cost of owning the other potential alternatives. So, what are the potential alternatives which are available for replacement, we are going to look into that. See, we will work out the cost of different alternatives and we know the cost of the present equipment, we can make the comparison of the defender with the challengers.

And to make the right decision whether to replace this defender with this particular challenger if at all if we decide to replace, when is the optimum replacement time also you can determine. So, we will be discussing that in detail in the upcoming slides. So, Dr. James Douglas was given different theoretical approaches with respect to replacement analysis.

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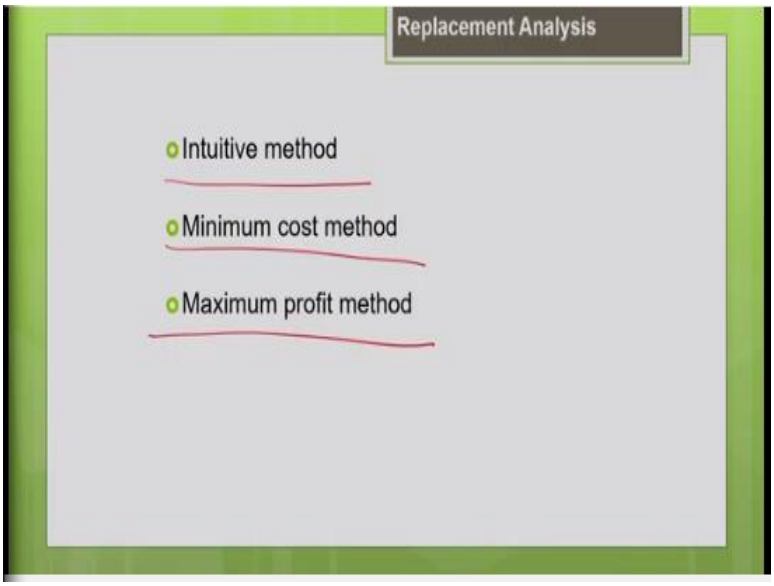

Some of his approaches are the intuitive method, minimum cost method and maximum profit method. So, we are going to discuss about the guidelines given by Dr. James Douglas with respect to replacement analysis. And we will work on some examples, how to apply all these approaches for the replacement analysis to compare the defender with the challenger and to decide the optimum replacement time.

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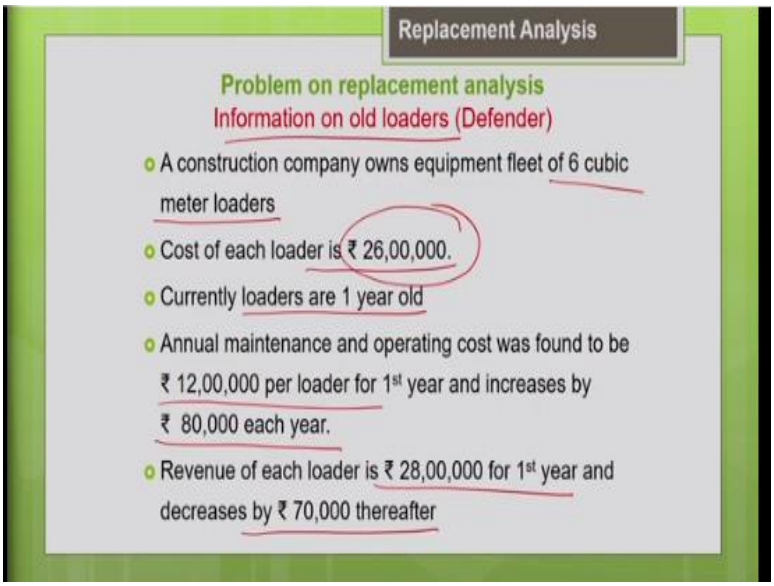

So, first let us work out a problem on the replacement analysis. So, in this problem, as I told you, we are going to compare the present equipment with the proposed equipment, that is a defender with a challenger**.** So, the equipment which we are going to discuss today is about the loader. So,

this is the information on the current loaders or the old loaders or the defender whatever way you call. So, firstly, let us look into the information of the presently owned equipment.

So, a construction company is owning equipment fleet of 6 cubic meter loader. So, the cost of each loader is given us 26 lakh, currently the loaders are 1 year old, so the age of the loader is 1 year. So, the annual maintenance and the operating cost was found to be 12 lakh per loader for the first year. And after that it increases by rupees 80,000 thereafter, so every year it is going to increase by 80,000.

So, as you know as a machine ages, you can see that the maintenance and the repair costs and operating costs will increase. So, that is what is given here, it is initial maintenance and operating costs is 12 lakh for the first year but after that it increases by rupees 80,000 for every year. The revenue of the loader is rupees 28 lakh for the first year, so after that the revenue starts decreasing by 70,000 rupees thereafter.

So, as you know as the machine becomes older, so it is revenue also starts reducing because increase in the operating costs of the machine. Now let us look into the information of the new loaders we call it as challengers.

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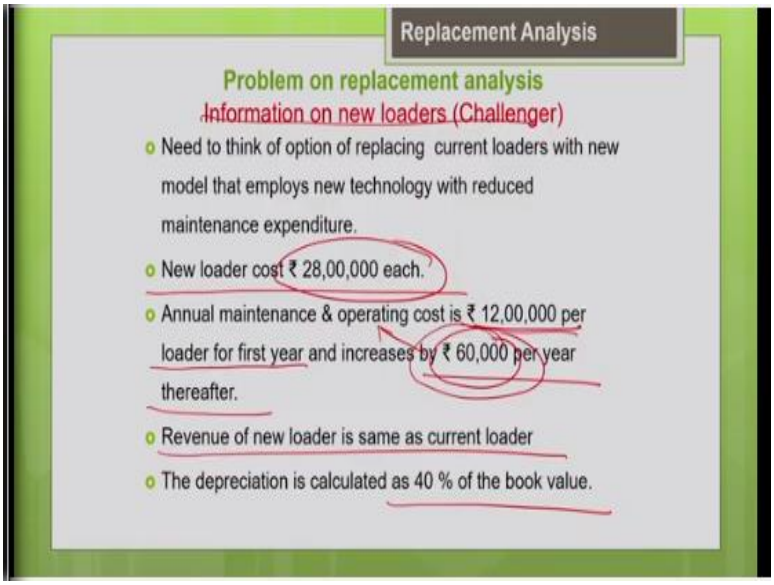

So, we are thinking of option of replacing the current loader with a new model that employs new technology with reduced maintenance expenditure. So, this new loader is having a new technology which can reduce the maintenance expenditure, your operating costs will get reduced. So, we are thinking of replacing our old loader with this new loader, the cost of the new loader is given as 28 lakh**.**

The annual maintenance of the operating costs is same as the old loader you can see 12 lakh per loader for the first year. But the difference is the increase is only 60,000 per year thereafter. So, let us compare the information of the present loader and the proposed loader. So, the cost of the old loader hope you remember it was 26 lakh**,** the cost of old loader was 26 lakh, the cost of the proposed new loader is 28 lakh.

And similarly, for the old loader you can see the operating and maintenance cost is 12 lakh but the increase was 80,000 each year. Now for new loader, the initial cost is same that is a 12 lakh per loader first year, but after that the increase is only 60,000. So, there is a saving in the operating and maintenance costs with the new loader. But one thing to be noted is revenue is same, revenue of the proposed loader is same as the current loader. And we are going to calculate the depreciation here as 40% of the book value, just for simplicity I am taking it as 40% of the book value for this problem.

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Now let us see what are all the different approaches possible for the replacement analysis? The first one is the intuitive method as discussed by Dr. James Douglas. So, this intuitive method is basically just application of a common sense based upon our own professional experience, we can make adjustment, so whether to replace the old machine or with a new machine**.** So, in this case, we are not going to work in depth the detail economics associated with the replacement analysis just by looking into the information based on our own experience without using any analytical models or anything, we have just making some judgment.

So, that is what is intuitive method. So, this is most commonly used because it is very simple to apply. So, and it just depends upon your professional judgment based on a experience and there is no sound economic basis for this approach. So, we cannot call this as a very rational approach.

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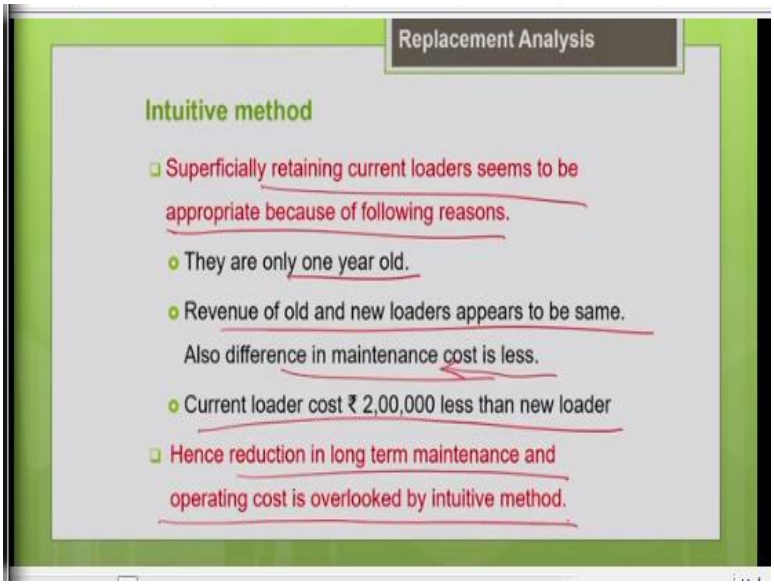

So, now, let us apply this approach to the problem which we have discussed. So, based on this approach, mostly we feel like superficially we feel retaining the current loader seems to be the best option, why? Because of the following reasons they are just 1 year old, the current loaders are just 1 year old, and the revenue of the old and the proposed loaders same as given in the problem.

Also you can say that difference in maintenance cost is less, here we are making some error because we are not looking into the long run. There is a saving of 20,000 per year in the maintenance and the operating cost when you go for the new loader, since we did not go workout

the in-depth economics. So, we may feel that holding the current loader is the best option because there is not much difference in the maintenance costs, but it is not so.

If you work it out, you can easily find it that there is a saving because of this maintenance costs in the long run. So, another important thing to be noted is a current loader cost is 2 lakh less than the new loader, that is a proposed one. So, we can see that when we go by the intuitive method, we can say that the reduction in the long-term maintenance of the operating cost is overlooked.

So, as I told you, every year we are able to save an amount of at least 20,000 in the maintenance and operating costs if you go for the new loader**.** So, that we are overlooking here in the intuitive method, so hence a reduction in the long-term maintenance and operating cost is overlooked by intuitive method. And we may make a decision that retaining the current loader itself is a best option**,** so this is the output of the intuitive method. Now let us look into the other approaches which are available as discussed by Dr. James Douglas.

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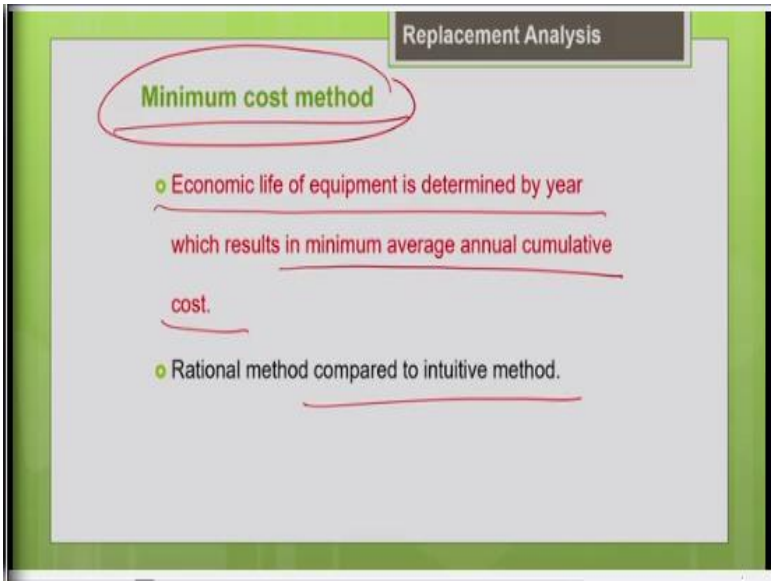

Next approach is minimum cost method, so the minimum cost method you can say whatever we have discussed in the earlier lecture the same way we are going to determine the economic life of the machine in this approach also. So, the economic life of the equipment is determined by the year which results in minimum average annual cumulative cost. So, here we are going to optimize the production with respect to minimum cost.

So, we have choosing the year in which the total cost associated with the machine is minimum. So, that is a optimum replacement time of the machine, so we know that already. So, let us see how to apply this minimum cost method and compare the defender and the challenger. So, that we have not discussed in the earlier lecture**.** In this lecture, we are going to see how to use this method cost method to compare the defender and the challenger. So, when compared to the earlier intuitive method, this should be more rational, so let us see how it is more rational.

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End of Year (1)	Annual O&M Cost ₹ (2)	Book Value $BV_n = BV_{n-1} - D_n$	Annual Depreciation Expense (3)	Annual Cost ₹ (4)=(2)+(3)	Cumulative Cost ₹ (5)	Average Annual Cumulative Cost ₹ (6)=(5)/(1)
Current loaders (Defender)						
Annual O & M cost is ₹ 12,00,000 and increase by ₹ 80,000 per year			40% BV_{n-1}	Cost of loader = ₹ 26,00,000		
1	12,00,000.00	15,60,000.00	10,40,000.00	22,40,000.00	22,40,000.00	22,40,000.00
2	12,80,000.00	9,36,000.00	6,24,000.00	19,04,000.00	41,44,000.00	20,72,000.00
3	13,60,000.00	5,61,600.00	3,74,400.00	17,34,400.00	58,78,400.00	19,59,466.67
4	14,40,000.00	3,36,960.00	2,24,640.00	16,64,640.00	75,43,040.00	18,85,760.00
5	15,20,000.00	2,02,176.00	1,34,784.00	16,54,784.00	91,97,824.00	18,39,564.80
6	16,00,000.00	1,21,305.60	80,870.40	16,80,870.40	108,78,694.40	18,13,115.73
7	16,80,000.00	72,783.36	48,522.24	17,28,522.24	126,07,216.64	18,01,030.95
8	17,60,000.00	43,670.02	29,113.34	17,89,113.34	143,96,329.98	17,99,541.25
9	18,40,000.00	26,202.01	17,468.01	18,57,468.01	162,53,797.99	18,05,977.55
10	19,20,000.00	15,721.21	10,480.80	19,30,480.80	181,84,278.79	18,18,427.88
11	20,00,000.00	9,432.72	6,288.48	20,06,288.48	201,90,567.28	18,35,506.12
12	20,80,000.00	5,659.63	3,773.09	20,83,773.09	222,74,340.37	18,56,195.03

So, now let us estimate the cost associated with the defender and the challenger. So, firstly we are going to work out the cost associated with the current loaders of the defender. So, the annual operating in the maintenance cost is given it is 12 lakh, for the first year it is 12 lakh and thereafter it increases by 80,000 every year. So, let us workout the annual operating and maintenance costs for the current loaders.

So, the first year is 12 lakh, so you have seen the first year it is 12 lakh after that it increases by 80,000. So, the for the second year it should be 12,80,000. So, for the third year again you add 80,000, so it keeps increasing. So, now it is going to be 13,60,000 for the third year, so like that you keep on adding 80,000 every year for this current loader, you will get to operating and the maintenance costs for the number of years we are going to estimate the cost.

Now let us calculate the depreciation associated with the machine. So, in this program we are going to estimate based upon the guideline 40% of book value, so it is 40% of the book value. So, now it is estimate the depreciation for the first year, so depreciation for the first year is nothing but so 0.4 into the book value. So, beginning of the first year what will be the book value it is a nothing but,

$$D_1 = 0.4 \times 26,00,000 = 10,40,000 \text{ rupees}$$

So, that gives you the depreciation as 10,40,000 for the first year, now let us calculate the book value at the end of first year. Book value at the end of first year is nothing but the book value at the beginning of the particular year minus the depreciation of that year. So, what is the book value at the beginning it is nothing but 26 lakh minus the depreciation for the first year is 10,40,000, so that gives me book value as 15,60,000. Similarly calculate for the second year the depreciation. So, depreciation is nothing but 0.4 into book value of the previous year or beginning of the current year for which you are considering.

$$D_2 = 0.4 \times 15,60,000 = 6,24,000 \text{ rupees}$$

Now calculate the book value at the end of second year is nothing but book value at the end of first year minus the depreciation for the second year, book value at the first year is nothing but 15,60,000 minus the depreciation for the second year is 6,24,000. So, that gives you the book value at the end of second year as 9,36,000. So, this is how we have to calculate the depreciation for every year and the corresponding book value.

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So, basically if you want a book value for the second year, so you are detecting the book value of the first year and the depreciation for the second year, that will give you the book value of the second year. Similarly, when you calculate the book value for the third year, you have to subtract the depreciation for the third year from the book value of the second year, that will give you the book value of third year, so, this is how you have to calculate.

Now, let us estimate the annual cost. So, in this problem to make it more simpler, I have reduced the components of the equipment cost, I have not considered all the components of the equipment cost. We are considered the operating in the maintenance cost and we are considering the depreciation. So, all the other costs which are discussed for the earlier problem like downtime, the effect of inflation, the obsolescence cost.

So, all those things need to be considered but for simplicity for this problem I have not considered. But to make a accurate estimation you are supposed to consider all the components of the equipment cost. Now let us calculate the total annual cost is nothing but your column 2 + column 3, that is nothing but your operating and the maintenance costs plus the depreciation. Add the operating and the maintenance cost and the depreciation we will get the total annual cost.

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Current loaders (Defender)

Annual O & M cost is ₹ 12,00,000 and increase by ₹ 80,000 per year

40% BV_{n-1}

Cost of loader = ₹ 26,00,000

End of Year (1)	Annual O&M Cost ₹ (2)	Book Value $BV_n = BV_{n-1} - D_n$	Annual Depreciation Expense (3)	Annual Cost ₹ (4)=(2)+(3)	Cumulative Cost ₹ (5)	Average Annual Cumulative Cost ₹ (6)=(5)/(1)
1	12,00,000.00	15,60,000.00	10,40,000.00	22,40,000.00	22,40,000.00	22,40,000.00
2	12,80,000.00	9,36,000.00	6,24,000.00	19,04,000.00	41,44,000.00	20,72,000.00
3	13,60,000.00	5,61,600.00	3,74,400.00	17,34,400.00	58,78,400.00	19,59,466.67
4	14,40,000.00	3,36,960.00	2,24,640.00	16,64,640.00	75,43,040.00	18,85,760.00
5	15,20,000.00	2,02,176.00	1,34,784.00	16,54,784.00	91,97,824.00	18,39,564.80
6	16,00,000.00	1,21,305.60	80,870.40	16,80,870.40	108,78,694.40	18,13,115.73
7	16,80,000.00	72,783.36	48,522.24	17,28,522.24	126,07,216.64	18,01,030.95
8	17,60,000.00	43,670.02	29,113.34	17,89,113.34	143,96,329.98	17,99,541.25
9	18,40,000.00	26,202.01	17,468.01	18,57,468.01	162,53,797.99	18,05,977.55
10	19,20,000.00	15,721.21	10,480.80	19,30,480.80	181,84,278.79	18,18,427.88
11	20,00,000.00	9,432.72	6,288.48	20,06,288.48	201,90,567.28	18,35,506.12
12	20,80,000.00	5,659.63	3,773.09	20,83,773.09	222,74,340.37	18,56,195.03

Say for the first year your operating and maintenance costs is 12 lakh you added with the depreciation at the end of first year that is 10,40,000**,**

Annual cost of first year = 10,40,000+12,00,000 = 22,40,000 rupees

Now for the second year it is nothing but 12,80,000 is your operating and maintenance cost. Now, you are going to add the depreciation with that, it is nothing but your 6,24,000 if you add it,

Annual cost of second year = 6,24,000+12,80,000 = 19,04,000 rupees

So, this is how you have to add the column 2 and column 3, you will get the total annual cost. Now find the cumulative cost, you can find the cumulative cost by adding the cost of first year with the second year second with the third year like that you keep on adding you will get the cumulative cost for all the years. So, once you get the cumulative costs, we are going to calculate the average annual cumulative cost.

That means, you are going to divide the cumulative cost by the cumulative usage of the machine. So, in this problem we are not taking the hourly basis, we are taking a yearly basis. Say for the first year you know that the cumulative cost for the first year is 22,40,000.

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End of Year (1)	Annual O&M Cost ₹ (2)	Book Value $BV_n = BV_{n-1} - D_n$	Annual Depreciation Expense (3)	Annual Cost ₹ (4)=(2)+(3)	Cumulative Cost ₹ (5)	Average Annual Cumulative Cost ₹ (6)=(5)/(1)
Current loaders (Defender)						
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3	13,60,000.00	5,61,600.00	3,74,400.00	17,34,400.00	58,78,400.00	19,59,466.67
4	14,40,000.00	3,36,960.00	2,24,640.00	16,64,640.00	75,43,040.00	18,85,760.00
5	15,20,000.00	2,02,176.00	1,34,784.00	16,54,784.00	91,97,824.00	18,39,564.80
6	16,00,000.00	1,21,305.60	80,870.40	16,80,870.40	108,78,694.40	18,13,115.73
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9	18,40,000.00	26,202.01	17,468.01	18,57,468.01	162,53,797.99	18,05,977.55
10	19,20,000.00	15,721.21	10,480.80	19,30,480.80	181,84,278.79	18,18,427.88
11	20,00,000.00	9,432.72	6,288.48	20,06,288.48	201,90,567.28	18,35,506.43
12	20,80,000.00	5,659.63	3,773.09	20,83,773.09	222,74,340.37	18,56,195.03

Average annual cumulative cost, first year = $\frac{22,40,000}{1}$ = 22,40,000 rupees

Average annual cumulative cost, second year = $\frac{41,44,000}{2}$ = 20,72,000 rupees

Average annual cumulative cost, third year = $\frac{58,78,400}{3}$ = 19,59,466.67 rupees

So, like that you keep calculating. So, basically, so as I told you, we are doing it on cumulative basis. So, it means if you are holding the equipment that you for 3 years, if you are holding this

defender machine with you for 3 years, the average annual cumulative costs which you are going to incur for the past 3 years is 19,59,466.67.

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End of Year (1)	Annual O&M Cost ₹ (2)	Book Value $BV_n = BV_{n-1} - D_n$	Annual Depreciation Expense (3)	Annual Cost ₹ (4)=(2)+(3)	Cumulative Cost ₹ (5)	Average Annual Cumulative Cost ₹ (6)=(5)/(1)
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So, that is why we have calculating the cumulative basis, so that we can get a cumulative picture. So, now, you can see that initially the cost is high but after that it keeps reducing, it reaches the minimum point after that it starts increasing. So, you can see that it starts increasing after that, so it forms the trend of a parabola. So, the minimum the duration at which the cost is minimum, that is a economic life of the machine. That is what we discussed in the last class. So, for this current loader, so what is the economic life of the machine?

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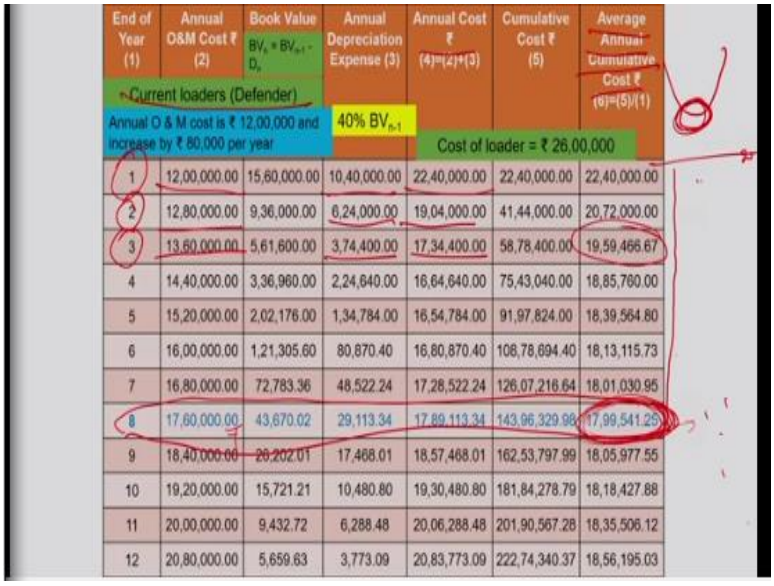

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3	13,60,000.00	5,61,600.00	3,74,400.00	17,34,400.00	58,78,400.00	19,59,466.67
4	14,40,000.00	3,36,960.00	2,24,640.00	16,64,640.00	75,43,040.00	18,85,760.00
5	15,20,000.00	2,02,176.00	1,34,784.00	16,54,784.00	91,97,824.00	18,39,564.80
6	16,00,000.00	1,21,305.60	80,870.40	16,80,870.40	108,78,694.40	18,13,115.73
7	16,80,000.00	72,783.36	48,522.24	17,28,522.24	126,07,216.64	18,01,030.95
8	17,60,000.00	43,670.02	29,113.34	17,89,113.34	143,96,329.98	17,99,541.25
9	18,40,000.00	26,202.01	17,468.01	18,57,468.01	162,53,797.99	18,05,977.55
10	19,20,000.00	15,721.21	10,480.80	19,30,480.80	181,84,278.79	18,18,427.88
11	20,00,000.00	9,432.72	6,288.48	20,06,288.48	201,90,567.28	18,35,506.12
12	20,80,000.00	5,659.63	3,773.09	20,83,773.09	222,74,340.37	18,56,195.03

You can see, so the economic life is the 8th year. So, the 8th year, the total cost associated with the machines minimum 17,99,541.25. So, this is optimum replacement type for this machine when you consider only the defender. So, if you are going to hold this machine with you for 8 years, for the past 8 years the average annual cumulative cost will be 17,99,541.25, so this is the economic life of this particular loader. Now let us work it out for the challenger**.**

(Refer Slide Time: 19:00)

End of Year (1)	Annual O&M Cost ₹ (2)	Book Value $BV_n = BV_{n-1} - D_n$	Annual Depreciation Expense ₹ (3)	Annual Cost ₹ (4)=(2)+(3)	Cumulative Cost ₹ (5)	Average Annual Cumulative Cost ₹ (6)=(5)/(1)
Proposed loaders (Challenger)			40% of BV_{n-1}	Cost of loader = ₹ 28,00,000		
Annual O & M cost = ₹ 12,60,000 and increase by ₹ 60,000 per year						
1	12,00,000.00	16,80,000.00	11,20,000.00	23,20,000.00	23,20,000.00	23,20,000.00
2	12,60,000.00	10,08,000.00	6,72,000.00	19,32,000.00	42,52,000.00	21,26,000.00
3	13,20,000.00	6,04,800.00	4,03,200.00	17,23,200.00	59,75,200.00	19,91,733.33
4	13,80,000.00	3,62,880.00	2,41,920.00	16,21,920.00	75,97,120.00	18,99,280.00
5	14,40,000.00	2,17,728.00	1,45,152.00	15,85,152.00	91,82,272.00	18,36,454.40
6	15,00,000.00	1,30,636.80	87,091.20	15,87,091.20	107,69,363.20	17,94,893.87
7	15,60,000.00	78,382.08	52,254.72	16,12,254.72	123,81,617.92	17,68,802.56
8	16,20,000.00	47,029.25	31,352.83	16,51,352.83	140,32,970.75	17,54,121.34
9	16,80,000.00	28,217.55	18,811.70	16,98,811.70	157,31,782.45	17,47,975.83
10	17,40,000.00	16,930.53	11,287.02	17,51,287.02	174,83,069.47	17,48,306.95
11	18,00,000.00	10,158.32	6,772.21	18,06,772.21	192,89,841.68	17,53,621.97
12	18,60,000.00	6,094.99	4,063.33	18,64,063.33	211,53,905.01	17,62,825.42

So, we are comparing with the new loader whose cost is 28 lakh. And as we discussed in the question of this problem, here the annual operating and maintenance costs is same, but it increases by 60,000 per year. So, in the earlier problem, we saw that it increases by 80,000 per year. Here we are using some new technology because of that we have able to have some reduction in the operating and the maintenance cost.

Because of that you can have a saving of 20,000 per year when compared to the old loader. So, the same way you calculate the operating and maintenance cost. Here for the first year it is 12 lakh now at 60,000, every year the operating and maintenance costs is increasing, so it is 12,60,000. For the second year, so again for the third year add 60,000 you will get 13,20,000, so we keep adding 60,000 every year**.** You can see the operating cost is increasing with the duration, now the same way estimate the depreciation so you are going to estimate the depreciation now.

(Refer Slide Time: 20:13)

End of Year (1)	Annual O&M Cost ₹ (2)	Book Value $BV_n = BV_{n-1} - D_n$	Annual Depreciation Expense ₹ (3)	Annual Cost ₹ (4)=(2)+(3)	Cumulative Cost ₹ (5)	Average Annual Cumulative Cost ₹ (6)=[5]/(1)
Proposed loaders (Challenger)			40% of BV_{n-1}		Cost of loader = ₹ 28,00,000	
Annual O & M cost is ₹ 12,00,000 and increase by ₹ 60,000 per year						
1	12,00,000.00	16,80,000.00	11,20,000.00	23,20,000.00	23,20,000.00	23,20,000.00
2	12,60,000.00	10,08,000.00	6,72,000.00	19,32,000.00	42,52,000.00	21,26,000.00
3	13,20,000.00	6,04,800.00	4,03,200.00	17,23,200.00	59,75,200.00	19,91,733.33
4	13,80,000.00	3,62,880.00	2,41,920.00	16,21,920.00	75,97,120.00	18,99,280.00
5	14,40,000.00	2,17,728.00	1,45,152.00	15,85,152.00	91,82,272.00	18,36,454.40
6	15,00,000.00	1,30,636.80	87,091.20	15,87,091.20	107,69,363.20	17,94,893.87
7	15,60,000.00	78,382.08	52,254.72	16,12,254.72	123,81,617.92	17,68,802.56
8	16,20,000.00	47,029.25	31,352.83	16,51,352.83	140,32,970.75	17,54,121.34
9	16,80,000.00	28,217.55	18,811.70	16,98,811.70	157,31,782.45	17,47,975.83
10	17,40,000.00	16,930.53	11,287.02	17,51,287.02	174,83,069.47	17,48,306.95
11	18,00,000.00	10,158.32	6,772.21	18,06,772.21	192,89,841.68	17,53,621.97
12	18,60,000.00	6,094.99	4,063.33	18,64,063.33	211,53,905.01	17,62,825.42

So, depreciation for the first year is nothing but 0.4 into book value.

$$D_1 = 0.4 \times 28,00,000 = 11,20,000 \text{ rupees}$$

So, now you calculate the book value at the end of first year, so what is the book value at the beginning of year that is nothing but your purchase price of the machine 28 lakh minus the depreciation for the first year. That is nothing but 11,20,000, that gives you the book value at the end of the first year as 16,80,000 so hope you can understand. So, let us work it for the second year.

(Refer Slide Time: 21:08)

End of Year (1)	Annual O&M Cost ₹ (2)	Book Value $BV_n = BV_{n-1} - D_n$	Annual Depreciation Expense ₹ (3)	Annual Cost ₹ (4)=(2)+(3)	Cumulative Cost ₹ (5)	Average Annual Cumulative Cost ₹ (6)=[5]/(1)
Proposed loaders (Challenger)			40% of BV_{n-1}		Cost of loader = ₹ 28,00,000	
Annual O & M cost is ₹ 12,00,000 and increase by ₹ 60,000 per year						
1	12,00,000.00	16,80,000.00	11,20,000.00	23,20,000.00	23,20,000.00	23,20,000.00
2	12,60,000.00	10,08,000.00	6,72,000.00	19,32,000.00	42,52,000.00	21,26,000.00
3	13,20,000.00	6,04,800.00	4,03,200.00	17,23,200.00	59,75,200.00	19,91,733.33
4	13,80,000.00	3,62,880.00	2,41,920.00	16,21,920.00	75,97,120.00	18,99,280.00
5	14,40,000.00	2,17,728.00	1,45,152.00	15,85,152.00	91,82,272.00	18,36,454.40
6	15,00,000.00	1,30,636.80	87,091.20	15,87,091.20	107,69,363.20	17,94,893.87
7	15,60,000.00	78,382.08	52,254.72	16,12,254.72	123,81,617.92	17,68,802.56
8	16,20,000.00	47,029.25	31,352.83	16,51,352.83	140,32,970.75	17,54,121.34
9	16,80,000.00	28,217.55	18,811.70	16,98,811.70	157,31,782.45	17,47,975.83
10	17,40,000.00	16,930.53	11,287.02	17,51,287.02	174,83,069.47	17,48,306.95
11	18,00,000.00	10,158.32	6,772.21	18,06,772.21	192,89,841.68	17,53,621.97
12	18,60,000.00	6,094.99	4,063.33	18,64,063.33	211,53,905.01	17,62,825.42

So, for the second year the depreciation is nothing but D2 is 0.4 into book value the end of first year,

$$D_2 = 0.4 \times 16,80,000 = 6,72,000 \text{ rupees}$$

Now calculate the book value at the end of second year, it is nothing but book value at the end of the first year minus the depreciation for the second year.

So, what is the book value at the end of first year? It is nothing but 16,80,000 minus your depreciation for the second year is 6,72,000 that gives me the book value at the end of second year as 10,8000. So, like this you calculate the depreciation for all the years and the corresponding book values also you have to estimate. Now you can estimate the annual cost by adding the operating and the maintenance cost as the depreciation. When you add column 2 and the column 3 you will get the annual costs for every year. So, what is the annual cost for the first year?

(Refer Slide Time: 22:27)

End of Year (1)	Annual O&M Cost ₹ (2)	Book Value $BV_n = BV_{n-1} - D_n$	Annual Depreciation Expense ₹ (3)	Annual Cost ₹ (4)=(2)+(3)	Cumulative Cost ₹ (5)	Average Annual Cumulative Cost ₹ (6)=[5]/(1)
Proposed loaders (Challenger)			40% of BV_{n-1}			
Annual O & M cost is ₹ 12,00,000 and increase by ₹ 60,000 per year				Cost of loader = ₹ 28,00,000		
1	12,00,000.00	16,80,000.00	11,20,000.00	23,20,000.00	23,20,000.00	23,20,000.00
2	12,60,000.00	10,08,000.00	6,72,000.00	19,32,000.00	42,52,000.00	21,26,000.00
3	13,20,000.00	6,04,800.00	4,03,200.00	17,23,200.00	59,75,200.00	19,91,733.33
4	13,80,000.00	3,62,880.00	2,41,920.00	16,21,920.00	75,97,120.00	18,99,280.00
5	14,40,000.00	2,17,728.00	1,45,152.00	15,85,152.00	91,82,272.00	18,36,454.40
6	15,00,000.00	1,30,636.80	87,091.20	15,87,091.20	107,69,363.20	17,94,893.87
7	15,60,000.00	78,382.08	52,254.72	16,12,254.72	123,81,617.92	17,68,802.56
8	16,20,000.00	47,029.25	31,352.83	16,51,352.83	140,32,970.75	17,54,121.34
9	16,80,000.00	28,217.55	18,811.70	16,98,811.70	157,31,782.45	17,47,975.83
10	17,40,000.00	16,930.53	11,287.02	17,51,287.02	174,83,069.47	17,48,306.95
11	18,00,000.00	10,158.32	6,772.21	18,06,772.21	192,89,841.68	17,53,621.97
12	18,60,000.00	6,094.99	4,063.33	18,64,063.33	211,53,905.01	17,62,825.42

Your operating in the maintenance cost for the first year is 12 lakh and your depreciation for the first year is 11,20,000, so your annual cost will be

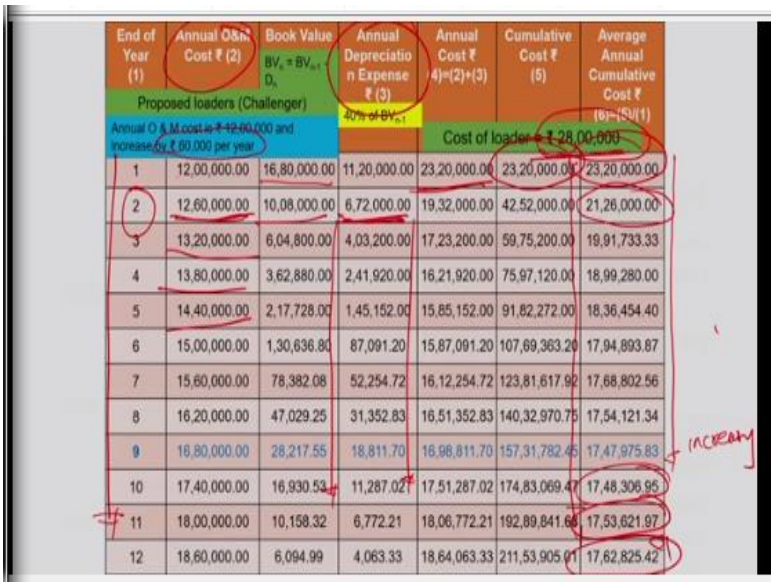
Annual cost of first year = 11,20,000+12,00,000 = 23,20,000 rupees

Annual cost of second year = 6,72,000+12,60,000 = 19,32,000 rupees

So, like this you keep calculating for all the years with every year you can calculate the annual cost.

Then you can calculate the cumulative cost, then find the average annual cumulative cost. So, like we did for the earlier old loader or the current loader or the defender. So, now, how will you calculate the average annual cumulative cost?

(Refer Slide Time: 23:23)



End of Year (1)	Annual O&M Cost ₹ (2)	Book Value $BV_n = BV_{n-1} - D_n$	Annual Depreciation Expense ₹ (3)	Annual Cost ₹ 4)=(2)+(3)	Cumulative Cost ₹ (5)	Average Annual Cumulative Cost ₹ (6)=(5)/(1)
Proposed loaders (Challenger)			40% of BV_{n-1}			
Annual O & M cost is ₹ 12,00,000 and increase by ₹ 60,000 per year				Cost of loader is ₹ 28,00,000		
1	12,00,000.00	16,80,000.00	11,20,000.00	23,20,000.00	23,20,000.00	23,20,000.00
2	12,60,000.00	10,08,000.00	6,72,000.00	19,32,000.00	42,52,000.00	21,26,000.00
3	13,20,000.00	6,04,800.00	4,03,200.00	17,23,200.00	59,75,200.00	19,91,733.33
4	13,80,000.00	3,62,880.00	2,41,920.00	16,21,920.00	75,97,120.00	18,99,280.00
5	14,40,000.00	2,17,728.00	1,45,152.00	15,85,152.00	91,82,272.00	18,36,454.40
6	15,00,000.00	1,30,636.80	87,091.20	15,87,091.20	107,69,363.20	17,94,893.87
7	15,60,000.00	78,382.08	52,254.72	16,12,254.72	123,81,617.92	17,68,802.56
8	16,20,000.00	47,029.25	31,352.83	16,51,352.83	140,32,970.75	17,54,121.34
9	16,80,000.00	28,217.55	18,811.70	16,98,811.70	157,31,782.45	17,47,975.83
10	17,40,000.00	16,930.53	11,287.021	17,51,287.02	174,83,069.47	17,48,306.95
11	18,00,000.00	10,158.32	6,772.21	18,06,772.21	192,89,841.68	17,53,621.97
12	18,60,000.00	6,094.99	4,063.33	18,64,063.33	211,53,905.01	17,62,825.42

It is nothing but your the cumulative cost divided by the cumulative usage of the machine. So, for the first year,

$$\textbf{Average annual cumulative cost, first year} = \frac{23,20,000}{1} = \textbf{23,20,000 rupees}$$

$$\textbf{Average annual cumulative cost, second year} = \frac{42,52,000}{2} = \textbf{21,26,000 rupees}$$

So, the same way you can see the trend here, here also the initially the cost is high then it starts reducing, it reaches a minimum point here, after that it starts increasing you can see it is increasing. So, basically here the economic life of the machine is 9th year for the proposed loader, because the cost is minimum 9th year. So, the economic life of the proposed loader is 9th year but for the old loader the economic life is 8th year.

Now you can compare the average annual cumulative cost of the proposed loader and the old loader. You can see the average annual cumulative costs minimum is 17,99,541.

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End of Year (1)	Annual O&M Cost ₹ (2)	Book Value $BV_n = BV_{n-1} - D_n$	Annual Depreciation Expense ₹ (3) 40% of BV_{n-1}	Annual Cost ₹ (4)=(2)+(3)	Cumulative Cost ₹ (5)	Average Annual Cumulative Cost ₹ (6)=(5)/(1)
Proposed loaders (Challenger)						
Annual O & M cost is ₹ 12,00,000 and increase by ₹ 60,000 per year				Cost of loader = ₹ 28,00,000		
1	12,00,000.00	16,80,000.00	11,20,000.00	23,20,000.00	23,20,000.00	23,20,000.00
2	12,60,000.00	10,08,000.00	6,72,000.00	19,32,000.00	42,52,000.00	21,26,000.00
3	13,20,000.00	6,04,800.00	4,03,200.00	17,23,200.00	59,75,200.00	19,91,733.33
4	13,80,000.00	3,62,880.00	2,41,920.00	16,21,920.00	75,97,120.00	18,99,280.00
5	14,40,000.00	2,17,728.00	1,45,152.00	15,85,152.00	91,82,272.00	18,36,454.40
6	15,00,000.00	1,30,636.80	87,091.20	15,87,091.20	107,69,363.20	17,94,893.87
7	15,60,000.00	78,382.08	52,254.72	16,12,254.72	123,81,617.92	17,68,802.56
8	16,20,000.00	47,029.25	31,352.83	16,51,352.83	140,32,970.75	17,54,121.34
9	16,80,000.00	28,217.55	18,811.70	16,98,811.70	157,31,782.45	17,47,975.83
10	17,40,000.00	16,930.53	11,287.02	17,51,287.02	174,83,069.47	17,48,306.95
11	18,00,000.00	10,158.32	6,772.21	18,06,772.21	192,89,841.68	17,53,621.97
12	18,60,000.00	6,094.99	4,063.33	18,64,063.33	211,53,905.01	17,62,825.42

So, for here you can see it is 17,47,975, so can you see here? So, you can see, here it is 17,99,000, here it is 17,47,000. So, it justifies the replacement of your proposed loader with the old loader because the minimum average annual cumulative cost for the challenger is lesser when compared to the old loader which is higher. So, this justifies a replacement. Now, let us see when to replace this current loader with the new loader.

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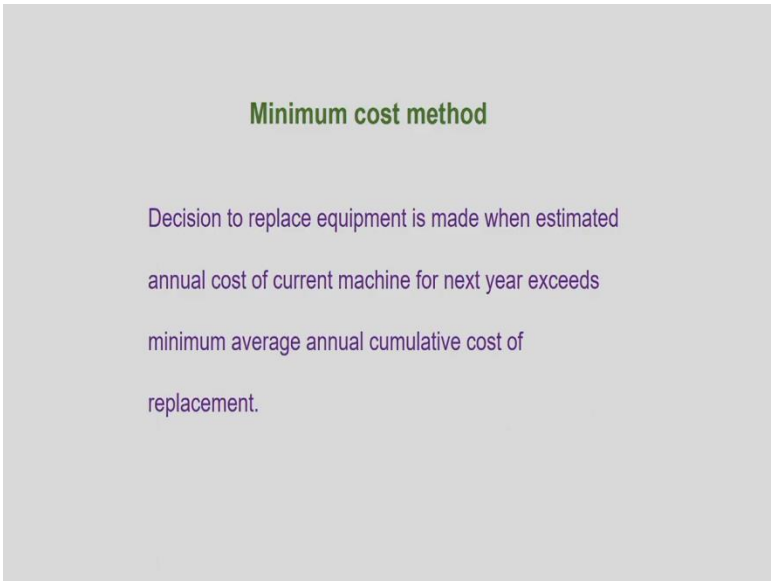

So, Dr. James Douglas has given a guideline for this minimum cost approach to decide when to replace the old machine with the new machine. So, the decision to replace the equipment is made when the estimated annual cost of the current machine for the next year exceeds the minimum average annual cumulative cost of the proposed machine. So, you are going to compare the annual

cost of the current machine for the next year with the minimum average annual cumulative cost of the proposed machine. When the annual costs of the current machine is higher, that is the time you have to plan for the replacement.

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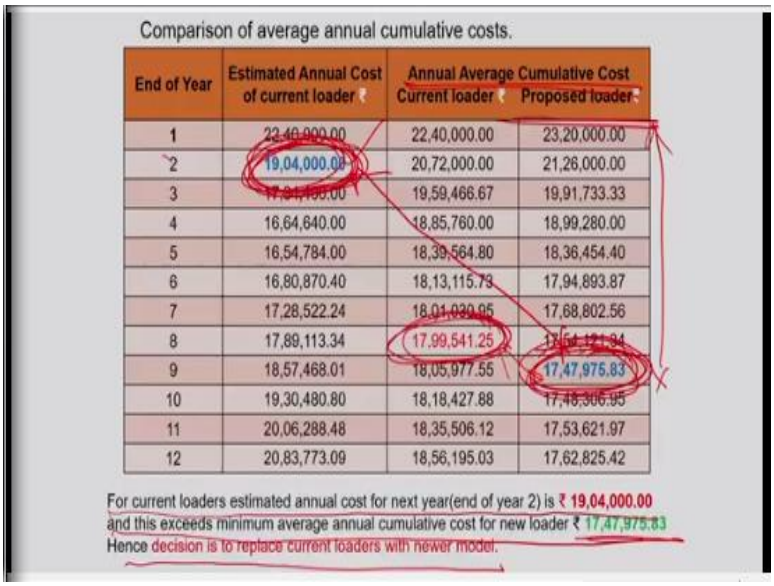

So, now let us compare as per Dr. James Douglas guideline the estimated annual cost of the machine for the next year. So, next year is nothing but because you are the loaders are already 1 year old. The current loader is 1 year old, so we are finding the estimated annual cost for the second year. Second year the value is 19,04,000, you compare it with the minimum average annual cumulative cost of the proposed loader.

For the proposed loader the minimum average annual cumulative costs is 17,47,975, you compare this and this. Since your annual cost the estimated cost for the current loader for the next year is very much higher than the proposed loader. So, it implies that you have to replace immediately. So, you have to replace the current loader with the new loader as per the Dr. Douglas guidelines.

So, and also as I told you when we compare the average annual community cost of the current loader as well as the minimum loader, these 2 minimum values also if you compare, you can see it justifies replacement. Because for the proposed loader value is lesser when compared to the current loader. So, it means that if you are going to hold their proposed loader with you for 9 years, the average annual cumulative cost which you will incur for the 9 yours will be 17,47,975.

Which is lesser than the estimated annual cost for the current loader for the next year that is second year, so that is why we are replacing it immediately. So, for the current loader estimated annual cost for the next year is 19,04000 and this exceeds the minimum average cumulative cost for a new loader that is 17,47,975. Hence the decision is to replace the current loader with the newer model. So, this is the finding or the decision based on the minimum cost method.

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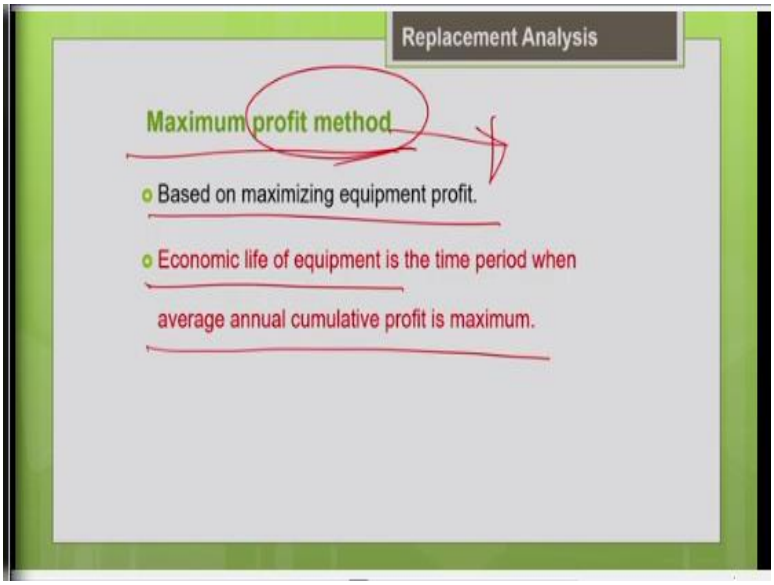

Now let us look into the next approach given by Dr. Douglas, it is nothing but maximum profit method. So, this is based on maximizing the equipment profit, so here we are optimizing the prediction with respect to profit. So, how to defend economic life here, it is a time period when the average annual cumulative profit is maximum. So, actually this is more attractive from business point of view because profit is always a bottom line of any company.

But to implement this method, you should have the data on the profit of the individual equipment**.** You should be able to extract the profit of the individual equipment from the equipment fleet or the entire project. In that case you will be able to use these guidelines, do the replacement analysis.

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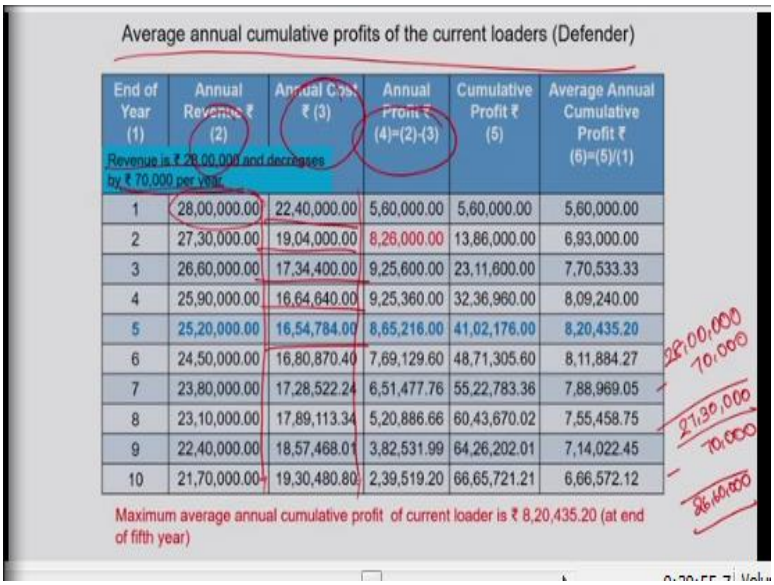

So, now let us workout the same problem using maximum profit method. So, we are going to find the average annual cumulative profit of the current loader as well as the proposed loader. Now as given in the question, the revenue for the current loader is 28 lakh, it decreases by 70,000 every year. So, if you know as a machine age increases, you can see its productivity will be less, it is operating cost will be very high, it keeps increasing.

So, you can see there will be loss in revenue, so the revenue keep decreasing by 70,000 every year**.** To start with for the first year it is 28 lakh then the revenue is decreasing by 70,000 every year. So, subtract 70,000 you will get the revenue for the second year that is 27,30,000. Now again subtract the 70,000 to give the revenue for the third year, it is nothing but 26,60,000.

So, it keep deducting 70,000 for every year you will get the revenue for the annual revenue for every year. So, already we have estimated the annual cost by adding the operating and the maintenance cost and the depreciation in the earlier tables itself**.** You can use those values for the annual cost of the current loader. Now we are going to find the actual profit to determine the profit we have to subtract the cost from the revenue, then only we will get the annual profit. So, you are going to subtract column 2 minus column 3, that will give you the annual profit. So, how are you going to do it for the first year?

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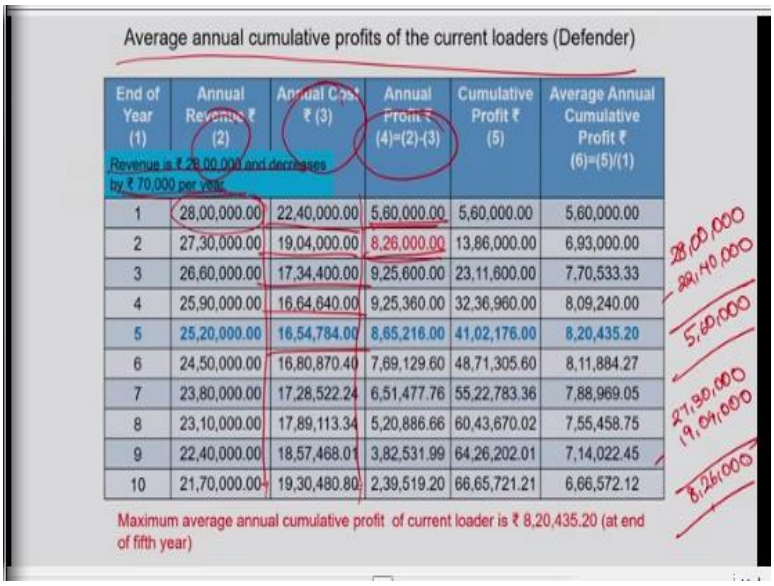

Annual profit of first year = 28,00,000-22,40,000 = 5,60,000 rupees

Annual profit of second year = 27,30,000-19,04,000 = 8,26,000 rupees

So, you keep calculating, it for all the years, you have to subtract column 3 from column 2, so that you can get actual profits alone for every year.

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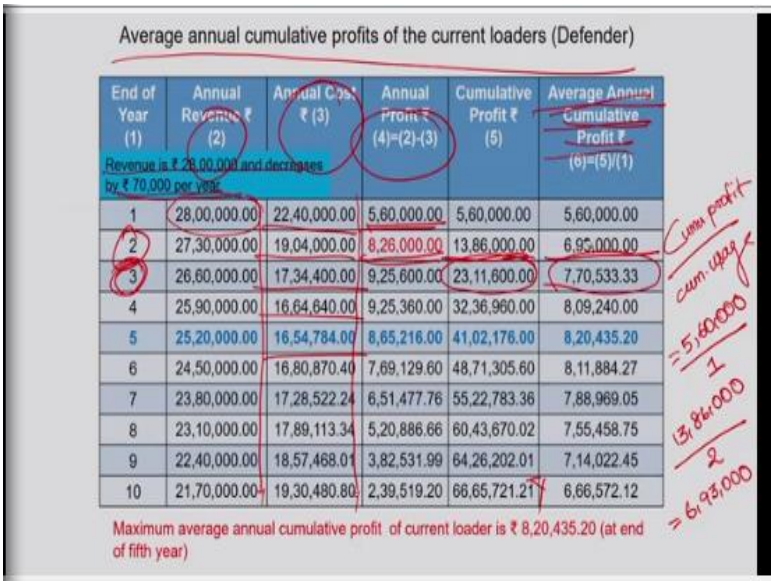

So, similarly, you have to find the cumulative profit by adding the profit of all the years you can get the cumulative profit. Now the average annual cumulative profit, so that is going to be the nothing but your cumulative profit divided by cumulative usage of the machine, that gives you the average annual cumulative profit.

Average annual cumulative profit, first year = $\frac{5,60,000}{1}$ = 5,60,000 rupees

Average annual cumulative profit, second year = $\frac{13,86,000}{2}$ = 6,93,000 rupees

Similarly calculate the profit for the third year, so for the third year, the annual cumulative profit is

Average annual cumulative profit, third year = $\frac{23,11,000}{3}$ = 7,70,533.33 rupees

So, this is how you have to estimate based on the maximum profit method. So, now the same way you can find economic life, so the year is which the profit is maximum that is an economic life. Here also you can see a kind of parabolic trend, so you can see initially the profit is low.

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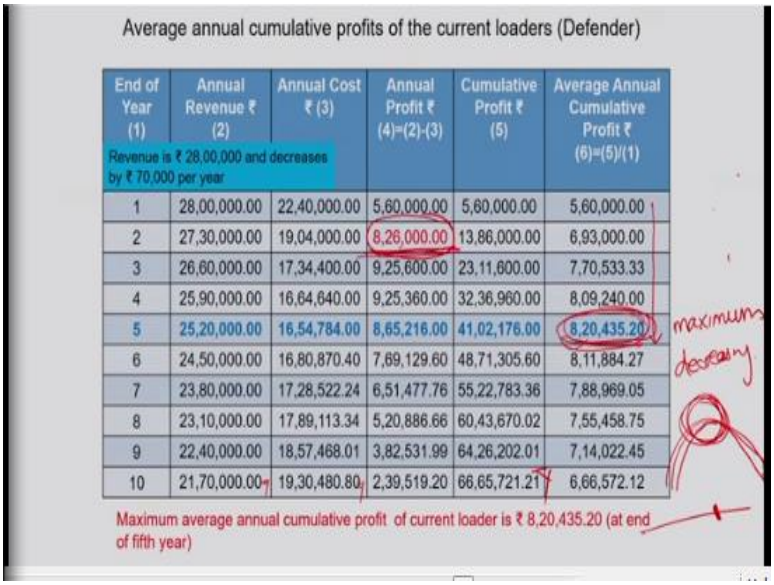

End of Year (1)	Annual Revenue ₹ (2)	Annual Cost ₹ (3)	Annual Profit ₹ (4)=(2)-(3)	Cumulative Profit ₹ (5)	Average Annual Cumulative Profit ₹ (6)=(5)/(1)
1	28,00,000.00	22,40,000.00	5,60,000.00	5,60,000.00	5,60,000.00
2	27,30,000.00	19,04,000.00	8,26,000.00	13,86,000.00	6,93,000.00
3	26,60,000.00	17,34,400.00	9,25,600.00	23,11,600.00	7,70,533.33
4	25,90,000.00	16,64,640.00	9,25,360.00	32,36,960.00	8,09,240.00
5	25,20,000.00	16,54,784.00	8,65,216.00	41,02,176.00	8,20,435.20
6	24,50,000.00	16,80,870.40	7,69,129.60	48,71,305.60	8,11,884.27
7	23,80,000.00	17,28,522.24	6,51,477.76	55,22,783.36	7,88,969.05
8	23,10,000.00	17,89,113.34	5,20,886.66	60,43,670.02	7,55,458.75
9	22,40,000.00	18,57,468.01	3,82,531.99	64,26,202.01	7,14,022.45
10	21,70,000.00	19,30,480.80	2,39,519.20	66,65,721.21	6,66,572.12

Now the profit is increasing, the profit reaches a maximum point here after that it starts decreasing. So, you can say the trend is like this, the profit increases the maximum increases, and reaches a maximum point and then again starts decreasing, so you are getting a trend like this. So, now you can find the time period during which a profit is maximum, that is your economic life, so that is happening in the 5th year for the current loader.

So, the maximum profit we are getting at the 5th year. So, it means that if you are holding this machine for 5 years with you. So, for the first five years, the average annual profit for the past five years will be 8,20,435.2. So, this is the economic life for the current loader based on maximum

profit method. Now we are going to compare it with the challenger. So, we have to estimate all these which are profits again for the challenger.

So, one thing you have to note it here is when you estimate based on the minimum cost method, the economic life was different. For the defender, hope you remember the economic life was 8 year based on minimum cost approach. Based on maximum profit approach, you can see the economic life is 5th year. So, different approaches gives you different view of the time of replacement.

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Now let us calculate the average annual cumulative profit for the proposed loader that is challenger**.** The revenue is same, so the same way you are going to calculate the revenue, every year the revenue is decreasing by 70,000 per year, so you can calculate. The annual cost is already calculated for the proposed loader from the previous table you can take these values**.** Now your profit is nothing but your revenue minus cost column 2 minus column 3 that is going to give you the profit.

The same way you can calculate and then you find the cumulative profit so find the cumulative profit. Now we are going to find the average annual cumulative profit which is nothing but the cumulative profit divided by the usage.

$$\textbf{Average annual cumulative profit, first year} = \frac{4{,}80{,}000}{1} = \textbf{4,80,000 rupees}$$

Average annual cumulative profit, second year = $\frac{12,78,000}{2}$ = 6,39,000 rupees

So, now you can again determine the economic life for your proposed loader. So, proposed loader you can see the profit is increasing with the time. So, you are getting a trend like this.

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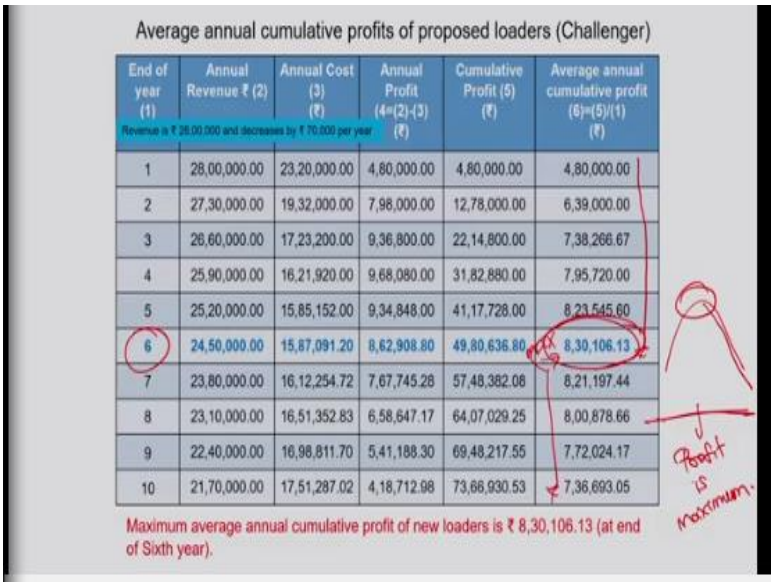

End of year (1)	Annual Revenue ₹ (2)	Annual Cost (3) (₹)	Annual Profit (4=(2)-(3) (₹)	Cumulative Profit (5) (₹)	Average annual cumulative profit (6)=(5)/(1) (₹)
1	28,00,000.00	23,20,000.00	4,80,000.00	4,80,000.00	4,80,000.00
2	27,30,000.00	19,32,000.00	7,98,000.00	12,78,000.00	6,39,000.00
3	26,60,000.00	17,23,200.00	9,36,800.00	22,14,800.00	7,38,266.67
4	25,90,000.00	16,21,920.00	9,68,080.00	31,82,880.00	7,95,720.00
5	25,20,000.00	15,85,152.00	9,34,848.00	41,17,728.00	8,23,545.60
6	24,50,000.00	15,87,091.20	8,62,908.80	49,80,636.80	8,30,106.13
7	23,80,000.00	16,12,254.72	7,67,745.28	57,48,382.08	8,21,197.44
8	23,10,000.00	16,51,352.83	6,58,647.17	64,07,029.25	8,00,878.66
9	22,40,000.00	16,98,811.70	5,41,188.30	69,48,217.55	7,72,024.17
10	21,70,000.00	17,51,287.02	4,18,712.98	73,66,930.53	7,36,693.05

Your profit is increasing and at the particular point it reaches the maximum, then again it starts reducing with the duration with the age of the machine. So, the duration for which your profit is maximum that is your economic life. So, you can see it is increasing reaches the maximum point, this is a maximum point after that it starts again decreasing. So, this is the economic life for your challenger 6th year. So, hope you remember based on minimum cost method, we found the economic life as 9th year based on minimum cost method.

But based on maximum profit method for the proposed loader, that is a challenger the economic life is your 6th year, because the profit is maximum at the 6th year**.** Another thing you have to compare here is what is the maximum profit for the current loader and the propose loader. So, the maximum average annual cumulative profit is 8,20,435, here it is 8,30,106.13, that means the profit is maximum for the challenger.

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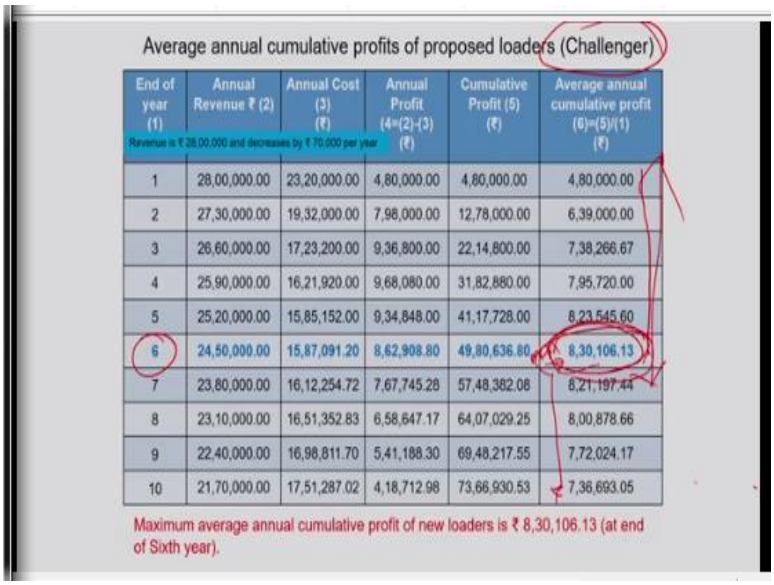

So, when you compare the maximum average annual cumulative profits, it justifies that your challenger is generating more profit. So, if you are going to hold it for 6 years so you are able to realize a maximum profit of 8,30,000 for the past 6 years. So, basically it is preferable to replace your old machine with the new machine, that is what is the decision. When to replace? We will go by the guides by Dr. James Douglas.

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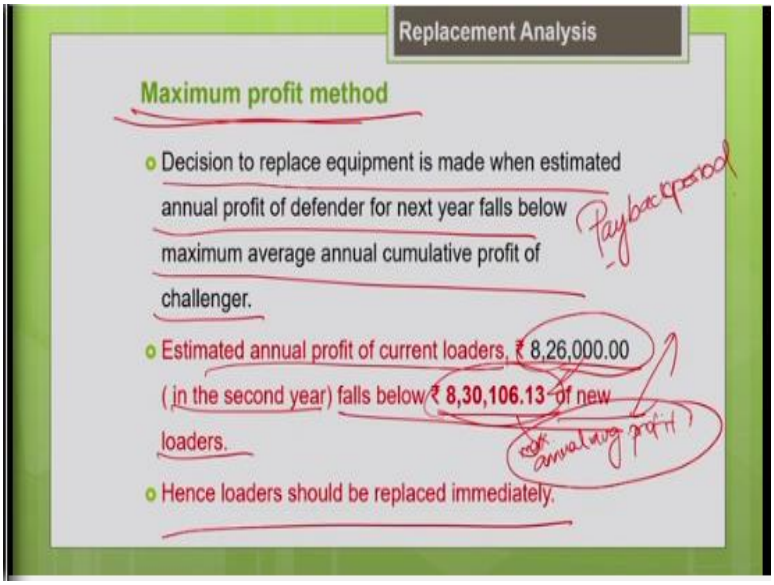

So, the decision to replace the equipment is made, when the estimated annual profit of defender for the next year falls below the maximum average annual cumulative profit of the challenger. So, we are going to calculate the see what is the estimated annual profit of the defender for the next

year. So, basically, your current loader is already 1 year old, so the next year means for the second year what is the estimated annual profit?

Estimated annual profit of your current loader is 8,26,000. Now you compare this value with the maximum profit achieved by a challenger, maximum profit, so 8,30,806. So, the estimated annual profit of the current loader is 8,26,000, in the second year this is very much less when compared to the this is lesser when compared to the new loader that is this value is nothing but your annual average the profit of your proposed loader.

So, you compare the estimated annual profit of the current loader with the average annual that is the maximum average annual profit of your the proposed loader. So, this profit is falling below this, the current loader profit is falling below this, that is why we have to replace the loader immediately, so this is a decision based upon your maximum profit method. So, in the minimum cost method, hope you remember how we made the decision.

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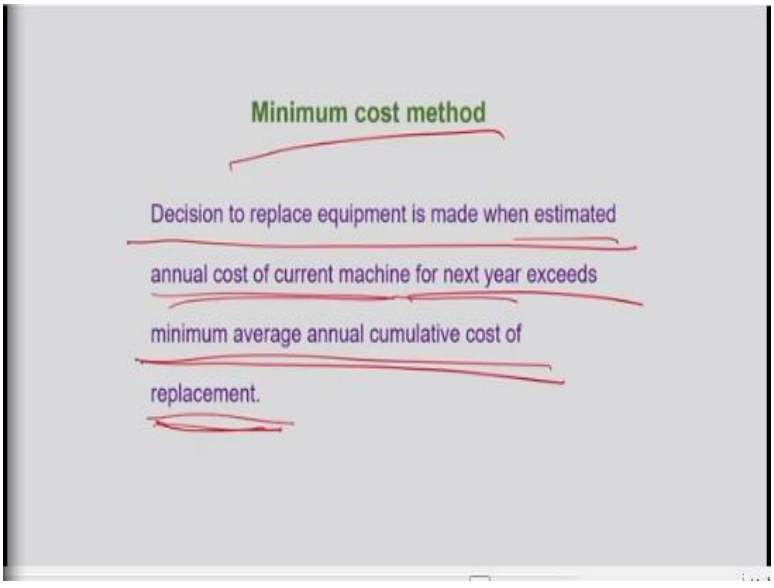

So, we are comparing the annual cost of the current machine of the next year with the minimum average annual cumulative cost of the replacement. So, if the annual cost of the current machine for the next year exceeds the minimum average annual cumulative cost of your proposed machine, then you have to replace.

In a similar perspective here you can see that in the maximum profit method, if the annual profit of the current loader for the next year falls below the maximum average annual the cumulative profit for the new loader, in that case we have to justify the replacement. So, this as per the guidelines of Dr. James Douglas, we have to replace the current loader with the new loader.

So, the challenger is found to be more economical and the replacement has to be done immediately, so that is what is the output of this analysis. But based on intuitive method, we can find that we are not able to work it out in a more rational way. So, hence the intuitive method can be use in addition with the other methods like minimum cost method or maximum profit method to present a different view of the replacement analysis.

So, solely we cannot depend upon the intuitive method, there is one more method which was discussed by Dr. James Douglas, that is payback period method. In this method we are going to find the time, payback time for the defender and the challenger, you are finding the payback time.

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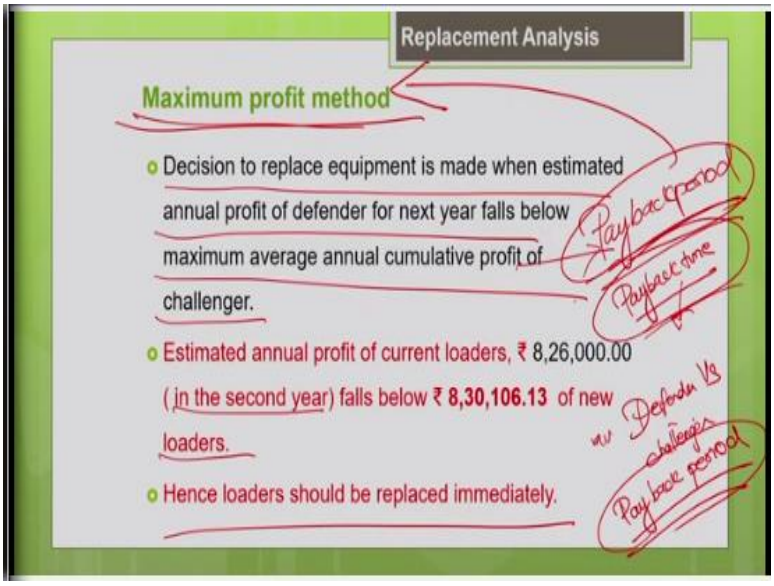

Payback time is nothing but the time duration needed for a machine to recover the initial investment you are putting to the machine**.** So for every machine you know that you have invested some amount of money, there may be some huge investment in the machine that is a the purchase price of the machine. So, how much time it takes for you to recover that initial investment, what you are made in the machine.

That is nothing but your payback period by generating the profit**.** So, how much time is needed for the machine to recover the initial investment made in the machine by generating the profit?**.** So, that is what we are finding in the payback period method and you will compare the payback period value of the defender and the challenger. So, defender versus challenger, you can compare the payback period.

So, whichever the machine has a lower payback period, that means if you are able to recover the initial cost faster, so that machine is suitable. So, that is how we compare based on the payback period method. So, if say for example of the challenger gives you a shorter payback period when compared to the defender then we have to replace the defender with the challenger. Whichever is having shorter payback period, we have to go for that machine.

So, that is how we compare alternatives, this is also not very much rational when compared to the minimum cost method or maximum profit method. Because in this method, we are not looking into what is happening beyond payback time beyond the payback period, what is actually happening, we are not analyzing in detail. So, that is why we cannot solely depend upon this method, payback period method.

We have to do compare the conclusion achieved by this method along with any other method like a maximum profit method or minimum cost method. So, you can use it in combination with the other methods and compare the replacement analysis decision. So, the best approach is your minimum cost method and the maximum profit method. Other methods like intuitive method or the payback period method; you can use it in combination with the other methods to have a comparison of different replacement decisions. Now let me summarize what we have discussed so far in this lecture.

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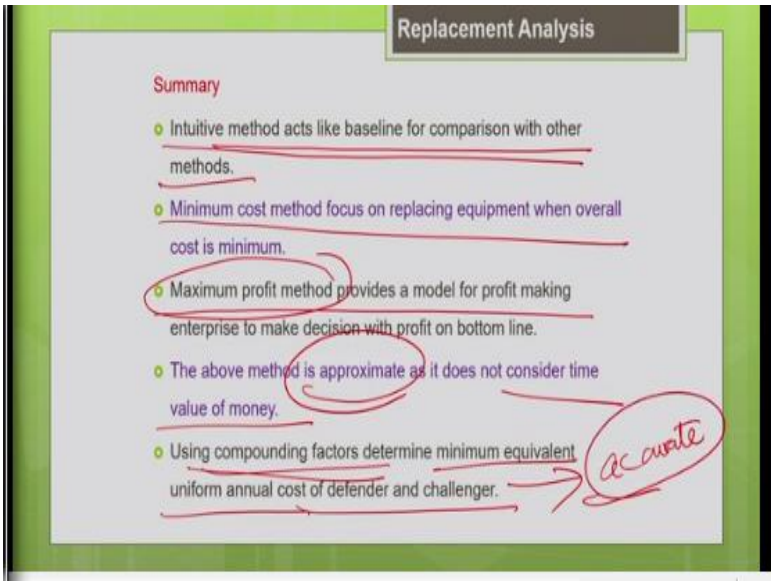

So, the intuitive method is acting like a baseline for comparison with the other methods. As I told you it is just a decision what we make based upon our professional experience or based on the common sense, we can just make a decision without working the economics in detail. So, like we are not using any theoretical model or analytical model to work it out. So, that is why you can use this method in comparison with other approaches.

Then minimum cost method focus on replacing your equipment when the overall cost is minimum. And the maximum profit method provides a model for profit making enterprise particularly for the companies who main objective is only to make profit. So, those companies they can use the maximum profit method. But provided they should be able to extract the profit of the individual equipment from the entire project, then only they can do the analysis.

So, and one thing we have to note it here as I mentioned in the earlier lecture also, here we are not considering the timing of the cash flows. That is why the analysis what we have done so far it is only approximate, because we have not considered the timing of cash flows. So, in the next lecture, what we are going to do is, we will consider the timing of cash flows, we will convert the cash flows which are occurring at different time interval into equivalent cash flows at the particular time period and make the comparison.

So, using the various component factors, what we were discussing earlier lectures. So, using component factors, we will determine minimum equivalent uniform annual cost of defender and challenger and make the comparison and do the replacement analysis. That will give you with the accurate estimate. So, this method is going to be more accurate when compared to the previous methods whatever we have discussed so far. So, the next lecture we are going discuss the replacement analysis using the time value concept.

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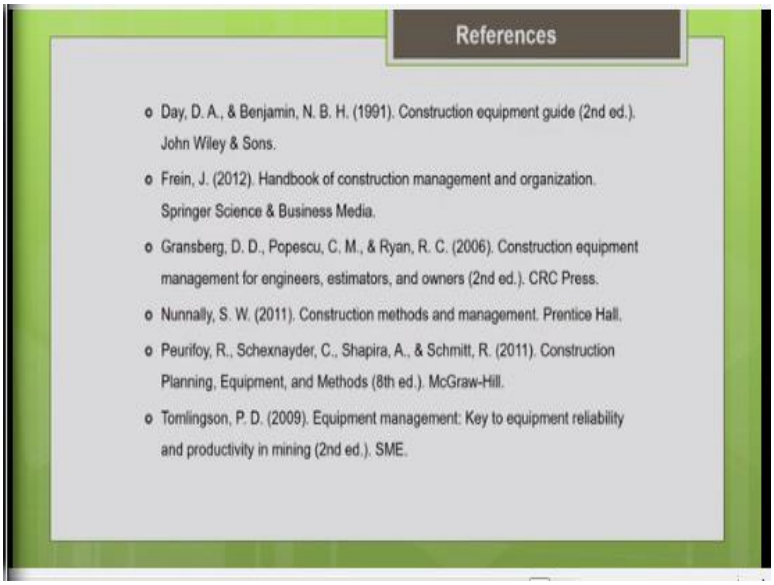

So, these are the references which I have referred for this lecture. So, you can go through this textbooks to prepare the topics related to this lecture, so let us meet in the next lecture, thank you.