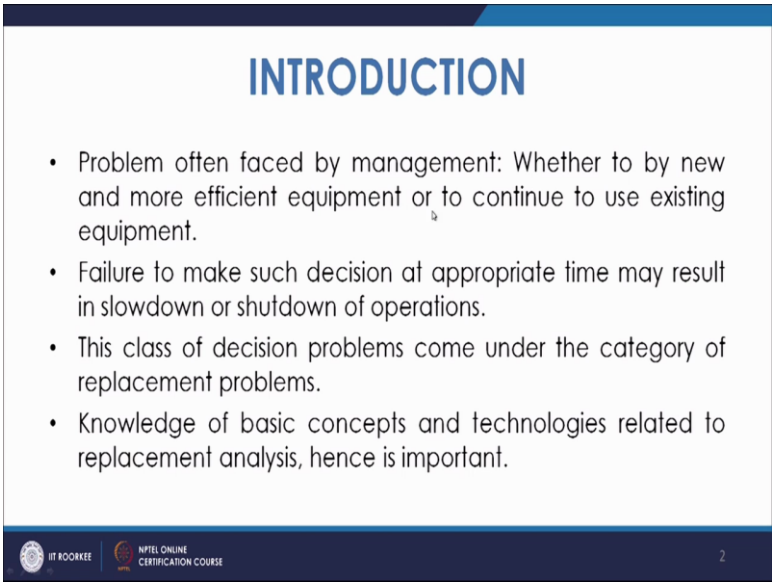
Engineering Economic Analysis
ProfessorDr. Pradeep K Jha
Department of Mechanical and Industrial Engineering
Indian Institute of TechnologyRoorkee
Lecture 16
Replacement Analysis: Reason, Concept of Defender and Challenger

Welcome to the lecture on replacement analysis. So we have come across many principles like equivalence, alternatives, basis of the comparison of alternatives. Now in normal times, you have many alternatives and the organisation has to decide whether they want to go with the present alternative or they want to switch over to the new alternative. These can be in terms of a service on an equipment.

(Refer Slide Time: 01:20)



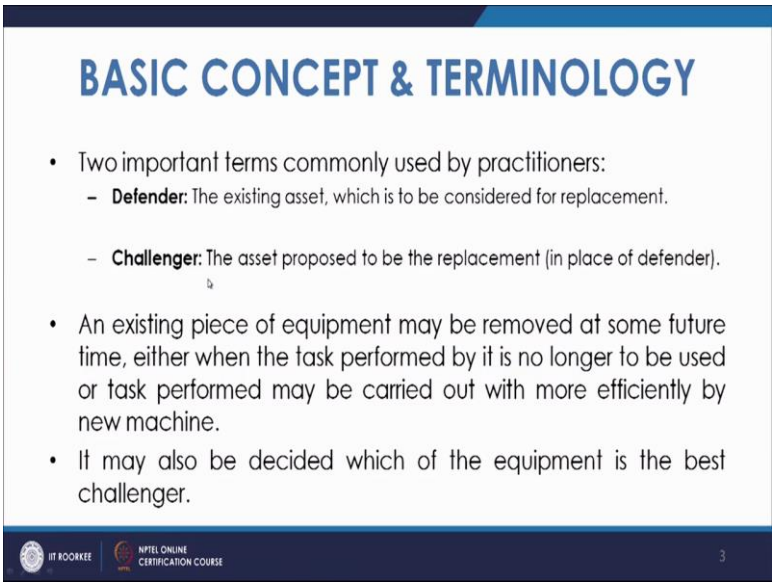
So the problem often faced by the management is whether to buy a new equipment which is supposed to be more efficient or you should continue to use the existing equipment. So basically in economic terms you will have to evaluate whether you want to continue with the existing equipment which was purchased maybe few years back and it has still some life or, sometimes the salesman offers you to purchase new equipment certainly add some added cost.

But maybe that will be offset by the lower operating costs and also the life which is ahead. Now decisions of this type is very important in economic analysis because if the decision is not right, that may lead to loss or failure of certain investment. So failure to make such decision at appropriate time may result in slow down or shut down of operations.

Now these class of decision problems where you have certain alternatives and you have to decide whether you should go with the existing alternative or you should switch over to a new alternative which is suggested to you, they these type of problems are coming under the category of replacement problems. Now for that you need knowledge of basic concepts and terminologies which is for replacement analysis because they are important.

You must be conversant with all the principles which are to be used for economic analysis for both the alternatives. Now there are certain basic concepts and terminologies in replacement analysis.

(Refer Slide Time: 03:48)

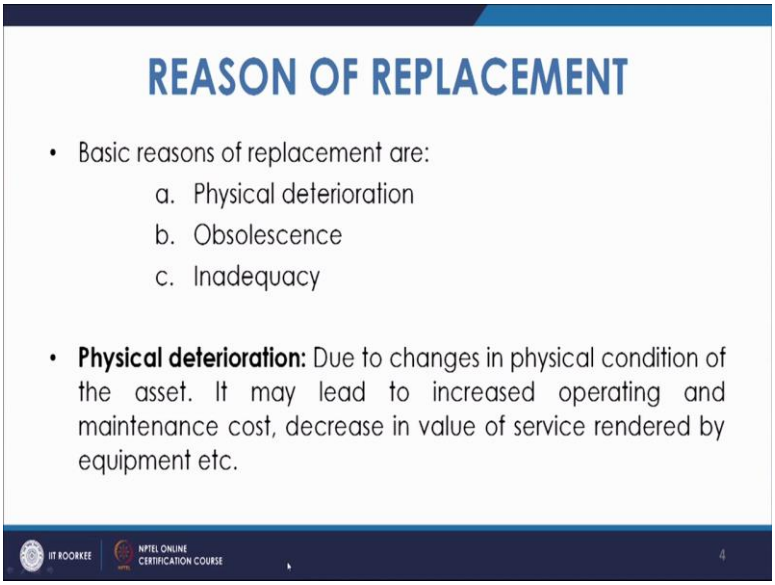


The two important terms which we come across is defender and a challenger. So basically you have an old machine and you have a new machine. The old machine which is supposed to be the replacement, which is supposed to replace basically, the old machine is known as defender because it is existing and it has to defend its value. So it is considered for replacement.

Then you have Challenger, challenger is the new machine which is going to replace the old machine. So the challenger is the asset proposed to be the replacement in place of defender. So we will use these terms while we solve the cases based on replacement analysis. An existing piece of equipment may be removed at some future time, either when the task performed is no longer to be used or task performed may be carried out with more efficiently by new machine.

So we have already discussed that if you have an old machine, if its work which it performs is no longer for the use of the organization, it has to be replaced or sometimes the new machine which is the challenger one, if it performs more efficiently, then also we think of replacing it. So in the analysis, finally we are to come on the conclusion that which of the option is the best and which challenger is the best if you have more than two options.

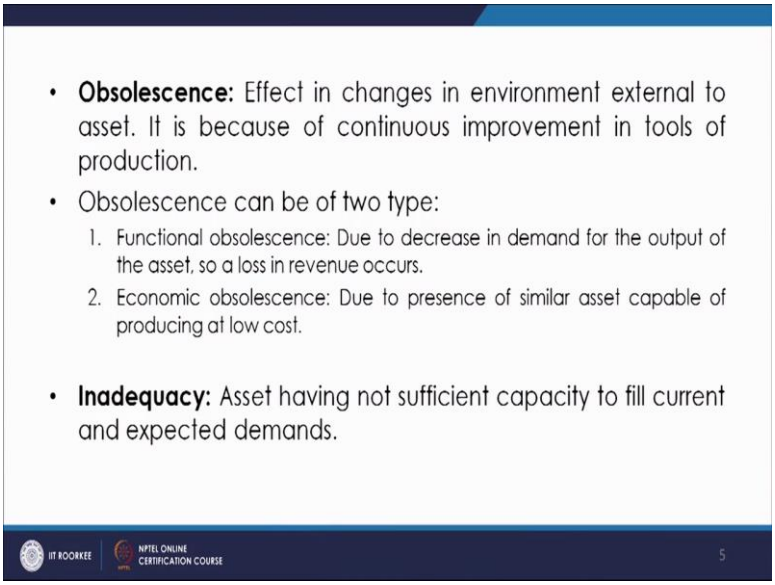
(Refer Slide Time: 05:10)



Now we will talk about the reasons of replacement, why we need to replace. Now the reason are basically physical deterioration, obsolescence and inadequacy. So physical deterioration is because of the changes in physical condition of the asset. So basically some of the moving parts of the equipment, they are rubbing against each other continuously, so slowly their efficiency is decreased.

So because of its use, it may lead to operating and maintenance cost, decrease in value of service rendered by the equipment. So this is known as physical deterioration because it is because of the physical impairment of certain parts of the equipment and then because of that, the service you are getting from this equipment, basically its value decreases with time.

(Refer Slide Time: 06:10)



So then next you have obsolescence. So obsolescence is effect in changes environment external to the asset. So obsolescence is not because the equipment is not able to perform to its level but it is because of the changes in environment external to the asset. So the reasons may be because of the continuous improvement in tools of production.

So because this is an era of continuous improvement, so with time new and new machines based on your technologies are coming up and these machines are better in terms of efficiency and are having low maintenance and operating costs. So this basically decreases the value of the old asset and the old asset seems to be obsolete at certain time.

So obsolescence basically can be divided into types, one is functional obsolescence which is because of the decrease in demand of the output of the asset. So basically it is because of the functional inability of the asset because it is not able to perform to a level what the manufacturer now desires off the machine. So this is because of the decrease in demand for the output.

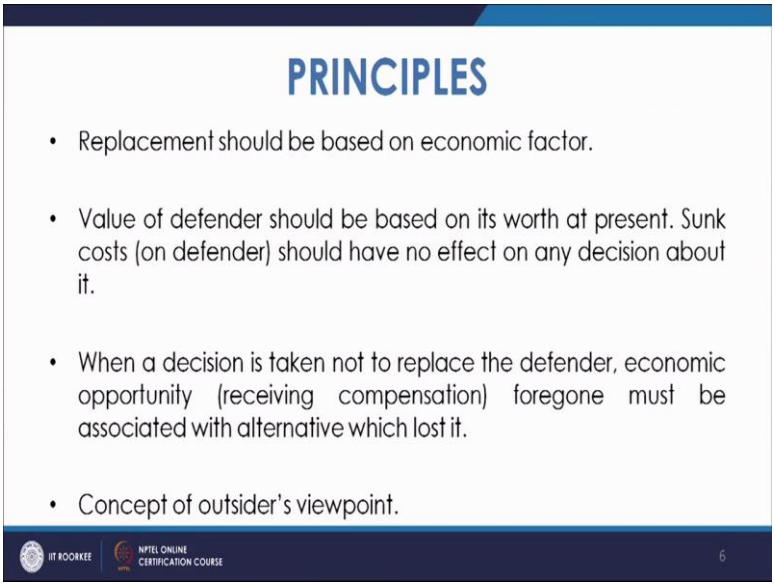
Now next is economic obsolescence, so it is because of the presence of similar asset capable of producing at low cost. So basically this is a condition when in the market because of new technology a machine has come which can produce at lower cost. So the new machine may makes the old machine obsolete, so that is known as economic obsolescence.

Then inadequacy, it can be said to be an extension of the obsolescence and it is that asset is not having sufficient capacity to fill current and expected demands. So basically the asset, the demand has increased and asset is not able to fulfill this demand and that is why the asset can

no longer be kept with the organisation and it is to be replaced with a new machine which can meet the demand of the organization.

So these are the different reasons basically because of which replacement may be considered necessary.

(Refer Slide Time: 08:48)



There are certain principles of replacement, replacement should be based on economic factor. So replacement should be judged purely on economical merit, if you find the terminologies and the values of certain parameters and in economic terms if you see that the challenger is better one, you will have to go for replacement. There are certain extensions to it, we will come across it.

Value of defender should be based on its worth at present. Sunk cost should have no effect on any decision about it. So this is a very important point that we have to live in present, we have to forget the past. Sunk costs are those costs which have been incurred on the object in the past and they have nothing to do with the decision making in present or in future.

So basically the defenders value should be based on its value at present and this evaluation will be done by the person who is supplying the new machine normally or any person who is outside. So basically whatever we have incurred on the existing machine in the past, they have nothing to do with the decision you are going to take in future.

When a decision is taken not to replace the defender, economic opportunity forgone must be associated with alternative which lost it. So what happens that, when we are comparing to

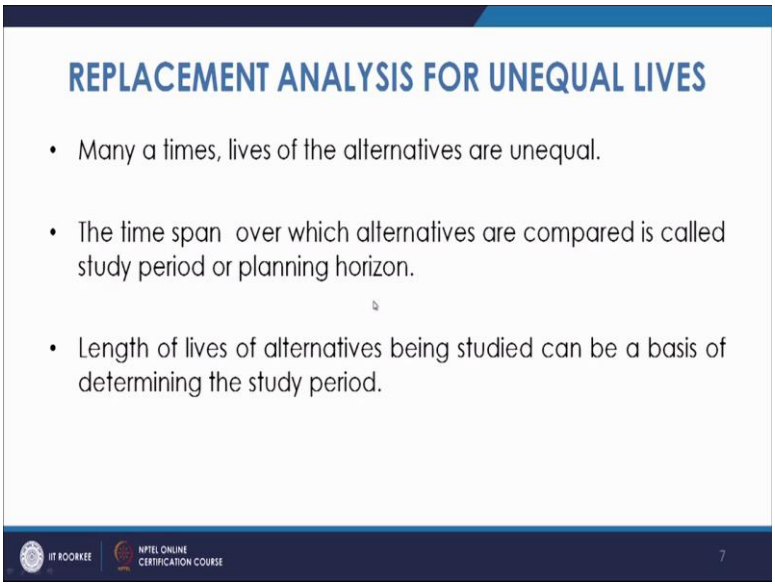
alternative, we are given certain opportunity cost, basically if you are taking the new machine, the old machine can be taken for some price or you are losing if not taking the new machine at certain rate.

So certainly, some opportunity cost is forgone and that has to be taken into account when doing their replacement analysis.

Concept of outsiders view point, this is again important because when we are comparing two assets there are two parties but then the replacement analysis is based on outsiders view point. Means you have to be outside preview of these two and an outsider will only judge whether he should go for the present machine or he should go for the new machine.

So certainly the outsider will have nothing to do with the sunk cost, so he will see the present value of the present machine and the present value of the new machine and its lives as well. So outsiders view point is an important thing in replacement analysis.

(Refer Slide Time: 11:44)

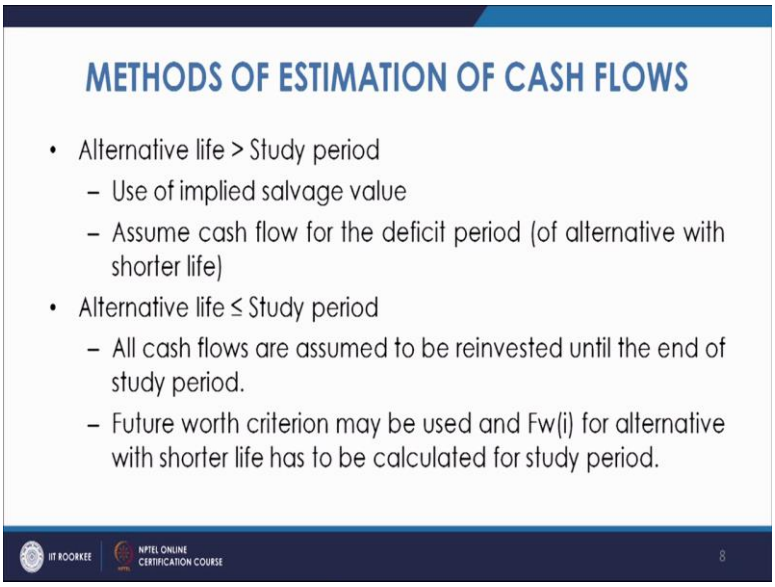


Replacement analysis for unequal lives, so normally when we compare two assets of equal lives, the analysis of the replacement is easy because for the equal life period, you can certainly go for any basis of comparison what we have discussed so far, either be it annual equivalent basis, future worth or present worth basis. But then many times, the life of the existing asset and the life of the new asset they are different.

So the time span over with alternative are compared is called the study period or planning horizon. So basically you will have to have a period over which you have to do the replacement analysis and this time is known as study period or planning horizon.

Length of lives of alternatives being studied can be a basis of determining the study period. So there may be different cases based on which you will have to take the length of the study period and then you have to do the replacement analysis. Now this leads to many cases.

(Refer Slide Time: 13:25)



Alternative life may be more than the study period. So what happens, that if **the** there are two alternatives, one of the alternative has a larger life than the other one and if the study period is lesser than one of the life of alternative, in that case you can use the use of implied salvage value concept which we will see later. Because it is that value, basically the salvage value is the value which is the residual value of the asset at the end of its complete life.

So since the asset is not being used for full of its life, so it has still more salvage value left that is known as implied salvage value. Then you can also assume the cash flow for the deficit period because either you can go for calculating the implied salvage value or you can also assume certain cash flow for the deficit period.

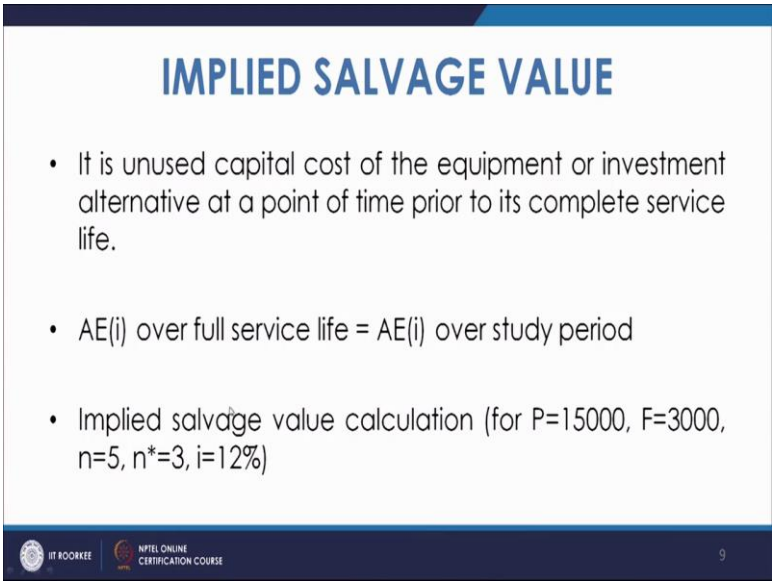
Because suppose in one case you have 5 years of life, in another case you have 3 years of life, if you take the study period of 3 years, either you can calculate the implied salvage value and this being mentioned. Or sometimes for the deficit of two periods, you can assume certain costs and based on that you can to the replacement analysis taking whole period as the study period.

There are cases when alternative life is less than study period or study period is more than or equal to the alternative life. So in that case all cash flows are assumed to be reinvested until the end of study period. So basically you feel that because study period is larger so and certain alternatives life is smaller, so basically you assume that they are reinvested till we go for the study period, so that may be another case.

Then in those cases what happens, if you are going for future worth criterion, so what happens in certain cases, you have the study period and then you have the alternative life. Now in that cases, when one of the period is small at that point of time, you will have certain future worth and that is to be again mapped to the larger life period.

So that is what it means, that you can go for FW criterion and you have to calculate this Fwi, future worth till the end of the period. Now we will discuss about implied salvage value. So what we will be discussing that how this implied salvage value is calculated.

(Refer Slide Time: 16:03)

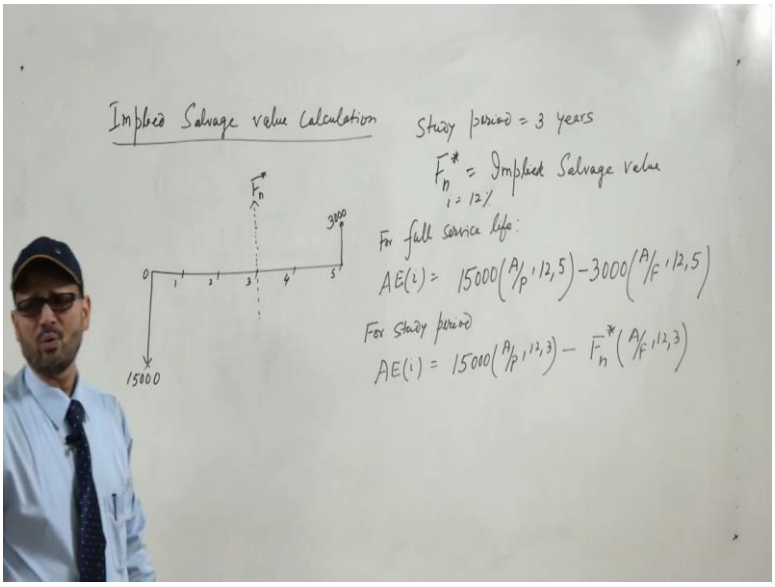


It is unused capital cost of the equipment or investment alternative at the point of time prior to its complete service life. So basically, what we see, we can solve this problem which is given as an asset which has the first cost of 15,000 and in its salvage value is given as 3000 at the end of 5 years. Now in another case if the alternatives life is only 3 years, in that case suppose you have to dispose this asset after 3 years, what should be its salvage value?

And that value is its implied salvage value. So for that the criteria is that AEi of the first asset or the asset of for full service life, it should be equal to the AEI over the study period that is a

smaller period of 3 years and then if once you equate, you can get the value of implied salvage value. So let us see how we calculate the implied salvage value.

(Refer Slide Time: 22:00)



Now what happens that, you have the asset, for which you have the first cost of 15,000 and it had a life of 5 years and after the 5 years of its life, it had the salvage value of 3000. Now depending upon the study period, the equipment may be used only for 3 years, so if the equipment is used for only 3 years, basically there must be certain salvage value for the equipment and this salvage value at the end of 3 years is known as implied salvage value.

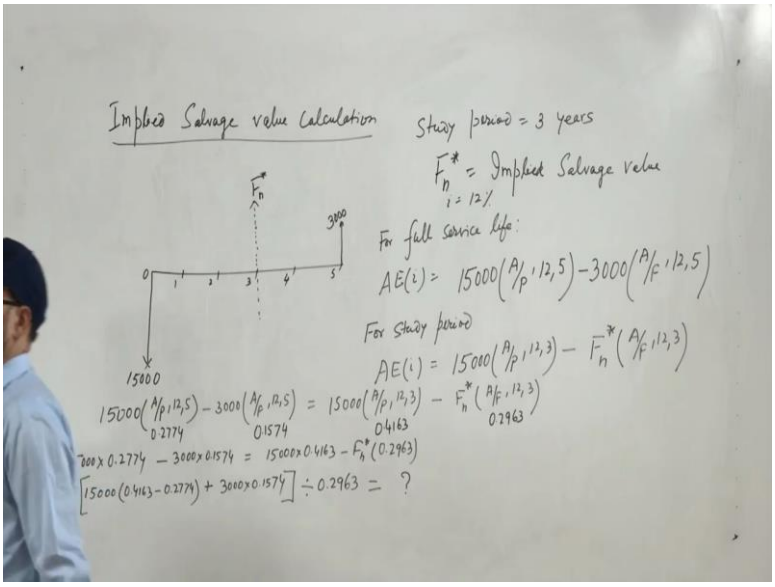
So Fn star is implied salvage value. Now what we see that, you will have to equate the annual equivalent value for the full service life to annual equivalent value for the study period and study period is here 3 years. Because the study period was taken as 3 years, so it is nothing but we are going to calculate the capital recovery with return cost and that is the annual equivalent value.

So once we get for the full life fall for full service life, if we find the capital recovery with return cost that is annual equivalent i, it will be 15,000 into A by P and you have interest rate and interest rate is given as 12%, so 12 5. Then you have - 3000, A by F 12 5. This is the annual equivalent value or the capital recovery with return value for the period of 5 years because 5 year is the life of the asset.

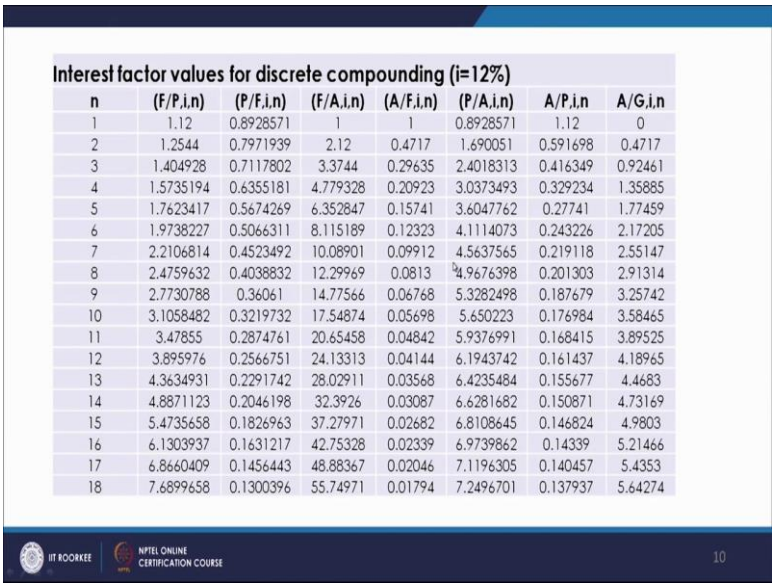
So now if you are taking for service for study period, it will be basically the first cost is same but now n your n becomes 3, so it should be 15,000 A by P 12 3 - Fn star A by F 12 3. So basically Fn star is the salvage value which is supposed to be for the equipment when it is

assumed to be disposed at the end of 3 years because we are doing the replacement analysis calculations for 3 years.

(Refer Slide Time: 25:20)



(Refer Slide Time: 22:56)



Interest factor values for discrete compounding (i=12%)

n	(F/P,i,n)	(P/F,i,n)	(F/A,i,n)	(A/F,i,n)	(P/A,i,n)	A/P,i,n	A/G,i,n
1	1.12	0.8928571	1	1	0.8928571	1.12	0
2	1.2544	0.7971939	2.12	0.4717	1.690051	0.591698	0.4717
3	1.404928	0.7117802	3.3744	0.29635	2.4018313	0.416349	0.92461
4	1.5735194	0.6355181	4.779328	0.20923	3.0373493	0.329234	1.35885
5	1.7623417	0.5674269	6.352847	0.15741	3.6047762	0.27741	1.77459
6	1.9738227	0.5066311	8.115189	0.12323	4.1114073	0.243226	2.17205
7	2.2106814	0.4523492	10.08901	0.09912	4.5637565	0.219118	2.55147
8	2.4759632	0.4038832	12.29969	0.0813	4.9676398	0.201303	2.91314
9	2.7730788	0.36061	14.77566	0.06768	5.3282498	0.187679	3.25742
10	3.1058482	0.3219732	17.54874	0.05698	5.650223	0.176984	3.58465
11	3.47855	0.2874761	20.65458	0.04842	5.9376991	0.168415	3.89525
12	3.895976	0.2566751	24.13313	0.04144	6.1943742	0.161437	4.18965
13	4.3634931	0.2291742	28.02911	0.03568	6.4235484	0.155677	4.4683
14	4.8871123	0.2046198	32.3926	0.03087	6.6281682	0.150871	4.73169
15	5.4735658	0.1826963	37.27971	0.02682	6.8108645	0.146824	4.9803
16	6.1303937	0.1631217	42.75328	0.02339	6.9739862	0.14339	5.21466
17	6.8660409	0.1456443	48.88367	0.02046	7.1196305	0.140457	5.4353
18	7.6899658	0.1300396	55.74971	0.01794	7.2496701	0.137937	5.64274

So in that case this one and this one should be equal. So what we see if we equate them 15,000 A by P 12 5 - 3,000 A by F 12 5 should be equal to 15,000 A by P 12 3 - Fn star A by F 12 3. Now these values of the interest factors we can refer to the table. A by P 12 5, this is the 12% table and A by P 12 5, so in the five we are coming to A by P series here. So it will be .2774, A by P 12 5 is .2774.

And A by F 12 5, A by F 12 5 is coming out to be .1574. Similarly A by P 12 3, A by P 12 3 is .4163 and then A by F 12 3, A by F 12 3 is .2963. So you can do the calculation here now, 15,000 multiplied by .2774 - 3000 multiplied by .1574 should be equal to 15,000 multiplied by .4163 - Fn star multiplied by .2963. So you can have the Fn star as 15,000 into .4163 - .2774 + 3000 into .1574 and this will be divided by .2963.

So this gives you the value of implied salvage value. So this is how the implied salvage value calculation is carried out and once you get it this value say, Q, this Q value can be considered as the value of implied salvage value. So when we finally arrive at the conclusion that which of the option should be selected under these cases, you must specify that if you are going to use this machine for 3 years.

This is the implied salvage value of this particular machine which should be used. Another aspect which is important in the cases of selecting the alternatives is that you may go for different lives when the annual equivalent criterion is to be used. So basically you will come across many situations when the alternatives have different lives.

When the alternatives have different lives annual equivalent base of comparison is considered to be the best comparison method but you should assume that after the end of the life of the short lived asset, it can further be continued at a rate which is supplied by the another equipment. So in the remaining period there is not going to be much difference in the annual equivalent value of the asset.

So there are these are the aspects which are used in case of replacement analysis. Thank you.