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

**Lecture-06**
**Equipment Life and Replacement Analysis (Part-1)**

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

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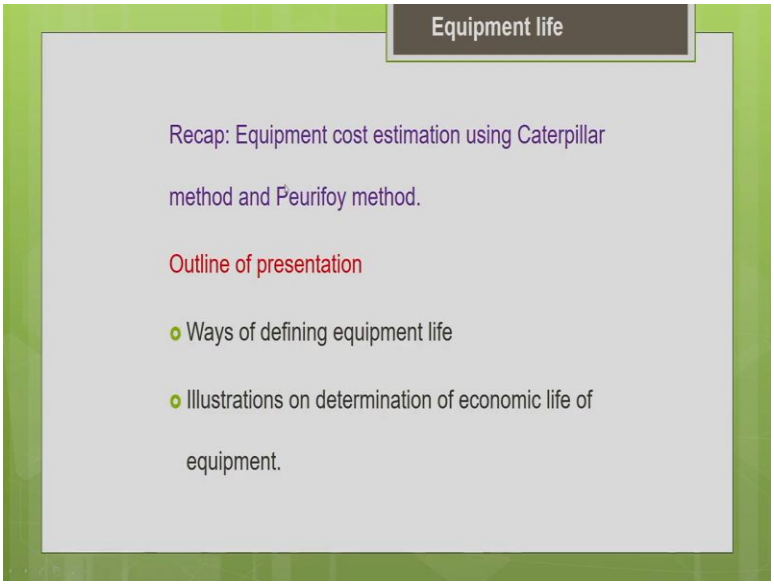


Now, this is outline of the present lecture. So, in this lecture I will be discussing with you what are all the different ways of defining the equipment life and I will also highlight on how to estimate the economical useful life of the equipment. We will be working on some illustrations on how to estimate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

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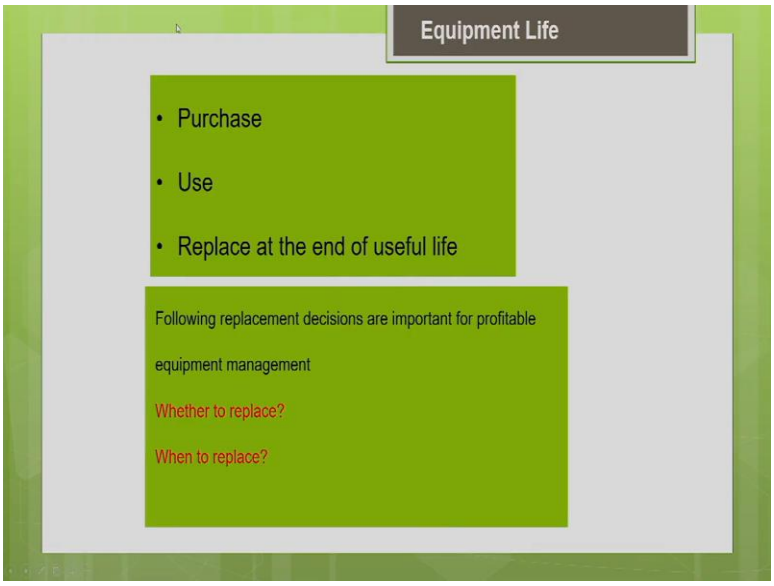


So, equipment life: So, basically there are different phases in the equipment life as everyone knows. So, it starts with the purchase of the machine. We purchase the machine first, then we start using it. As we use it, with age, of the machine ages, you can say that the machine will be subjected to more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

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

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

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

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

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

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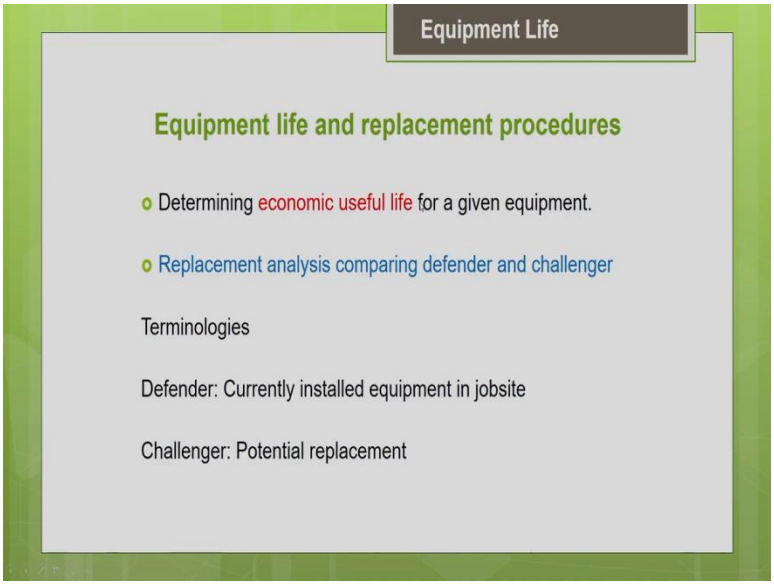


So, what is this economic useful life, I will be discussing more in detail in the upcoming slides. Basically, economic useful life is the time period during which the cost associated with the machine is minimum. The total cost, the cumulative total cost associated with the machine is minimum. If you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

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

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

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

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

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

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

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

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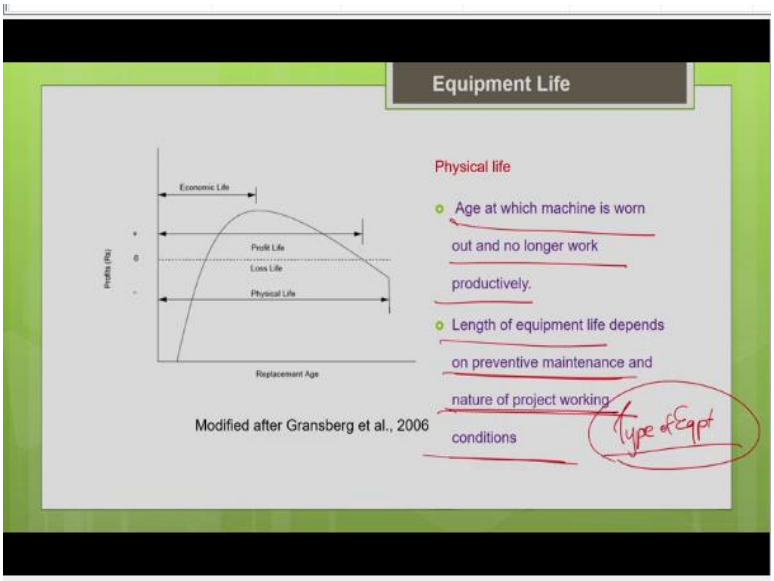


So, now let me define you what is the equipment life? There are different ways to define the equipment life. This graph shows you the pictorial presentation of the equipment life, you can see. So, you have the replacement age in the X axis and you have the profit in the Y axis. So, basically, you can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

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

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

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

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

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

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

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

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

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

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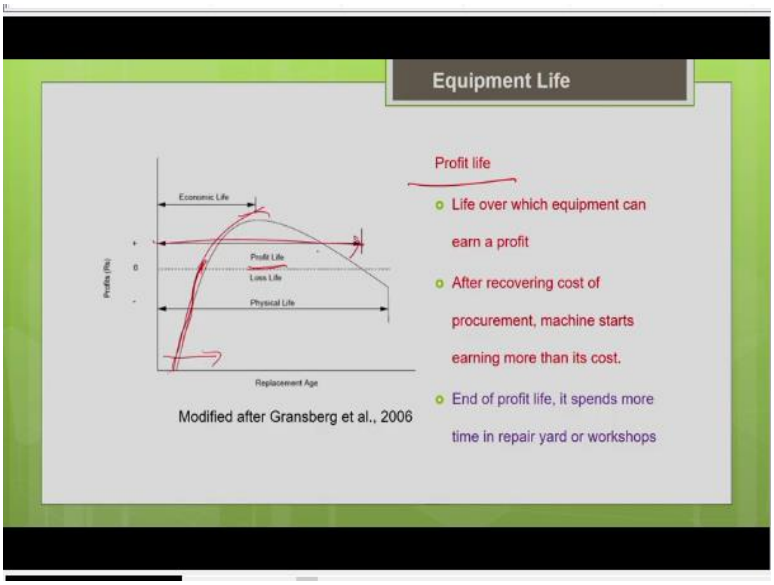


So, the next what you are going to see is your profit life. So, basically, we know that we have spent a lot of money for purchasing the machine. So, we have invested huge amount of money for purchasing the machine. So, during the initial periods, you can see that your machine will be just recovering,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

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

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

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

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

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

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

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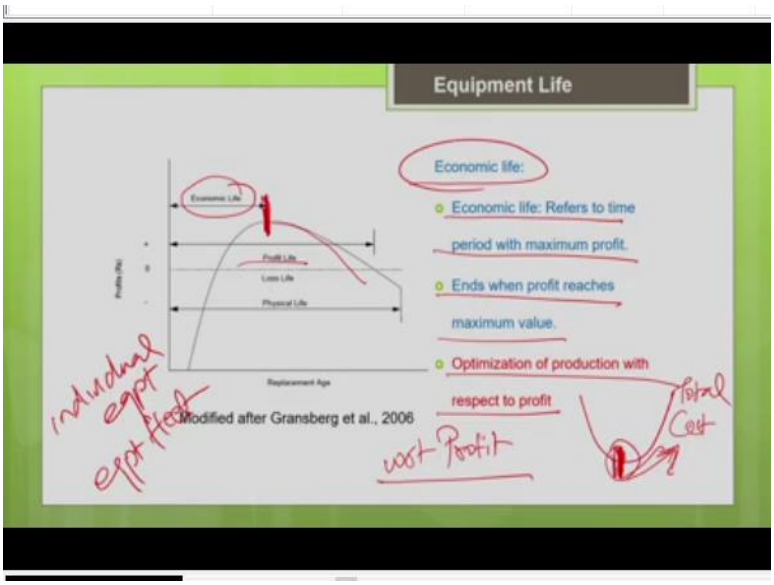


So, the next important thing, what we are interested in is economic life, which I discussed in the initial part of this lecture also. Economic life, here I am going to discuss with respect to profit. So, here I am talking about optimization of production with respect to profit. So, economic life is a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

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

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

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

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

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

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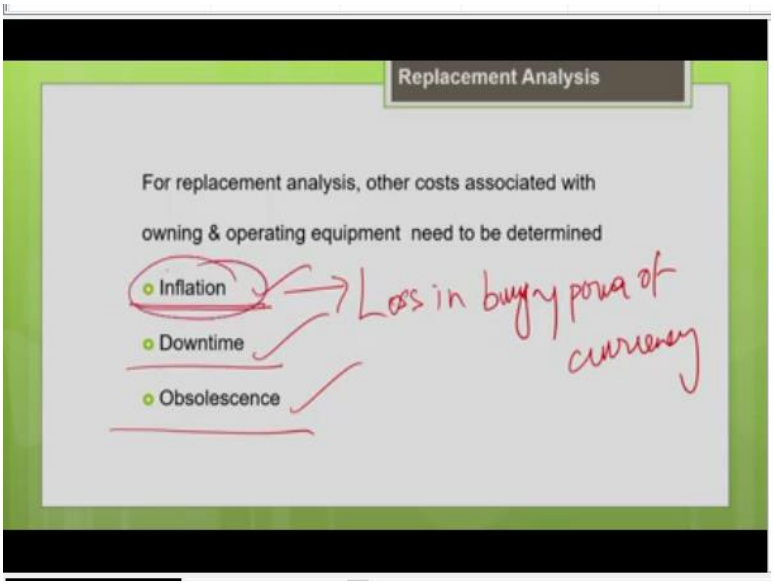


So, coming to the replacement analysis. So, now we are going to estimate the economic life of the machine, we will be working on some illustration on how to estimate the economical life of a particular machine. So, as I told you, to make an accurate estimation of the economic life. To do

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

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

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

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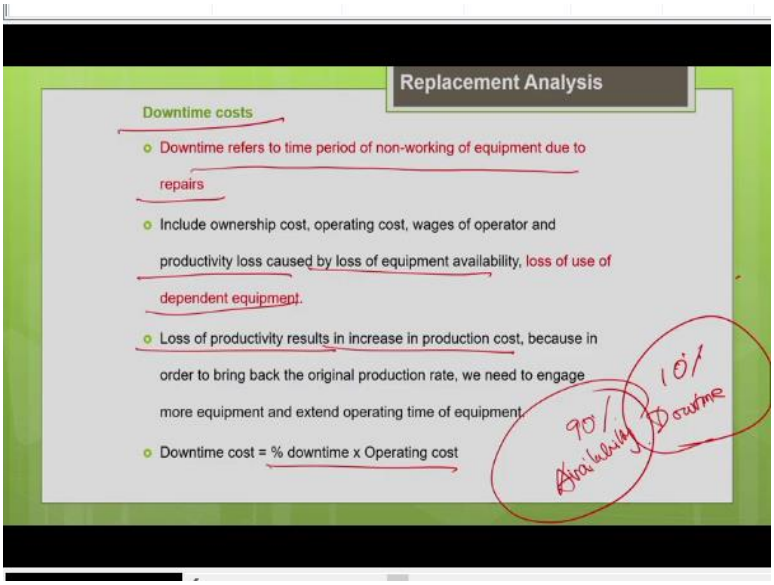


Downtime is nothing but your machine is not available for working productively. Either it is broken down it has been sent to the repair yard for the repair. So, this generally refers to the time period of non-working of the equipment due to repairs. Basically, as the age of the machine increases, it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

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

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

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

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

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

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

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

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

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

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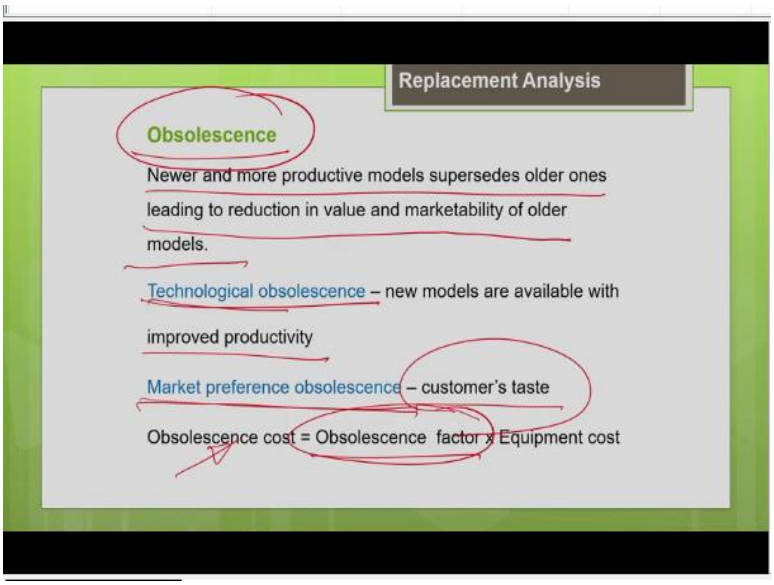


So, the next important cost, which we should consider when we do the replacement analysis, is the obsolescence cost. So, this we discussed earlier also as a machine gets older, it becomes obsolete, why it becomes obsolete? Because it is worn out already, its productivity would have been reduced; its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

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

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

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

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

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

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

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