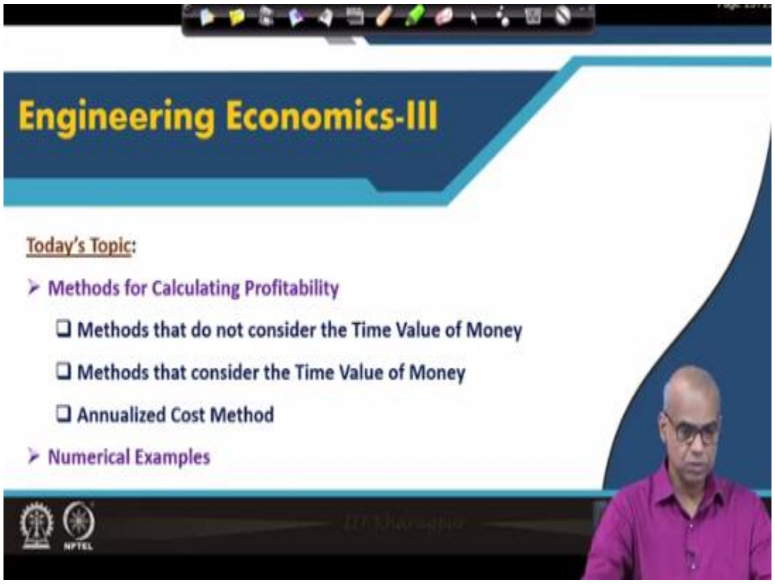
Plant Design and Economics
Prof. Debasis Sarkar
Department of Chemical Engineering
Indian Institute of Technology, Kharagpur

Lecture No -22
Profitability Analysis

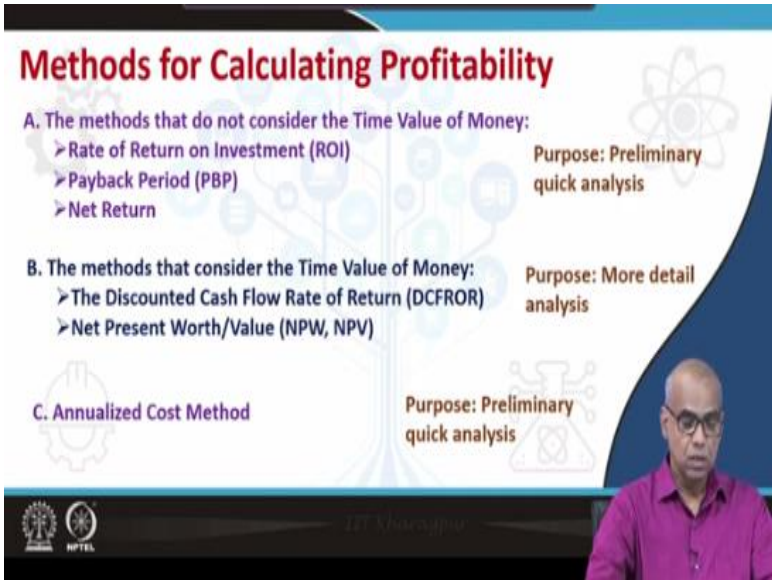
Welcome to lecture 22 on plant design and economics, In this week, we are talking about engineering economics part 3 and today we will talk about various methods for performing profitability analysis.

(Refer Slide Time: 00:30)



Now, there are various methods for calculating profitability. There are methods that do not consider the time value of money, there are methods that consider the time value of money, we will consider these methods, and will also consider annualized cost methods. We will also see numerical examples.

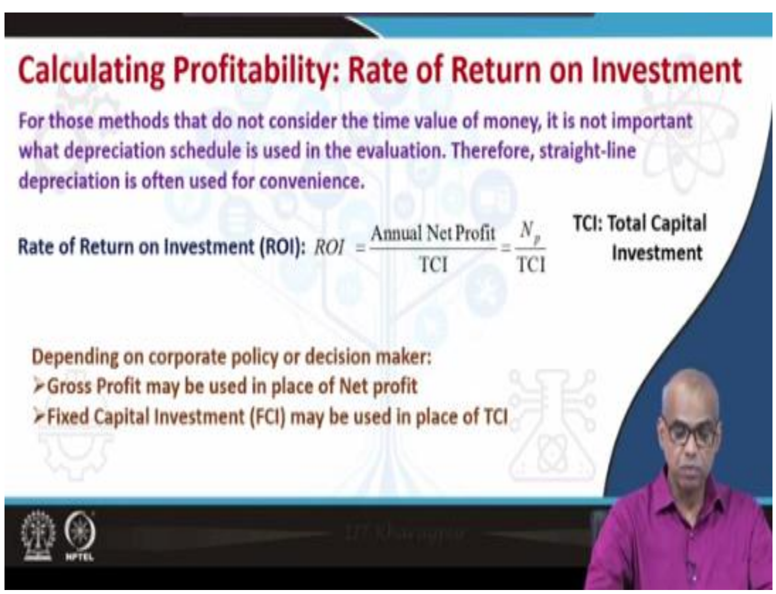
(Refer Slide Time: 00:55)



Now the methods that do not consider the time value of money are relatively simple methods and they are generally used to perform preliminary quick analysis. For example, rate of return on investment, payback period and net return. These methods do not consider the time value of money but they are easy and a preliminary analysis can be obtained quickly. The methods that consider the time value of money are the net present worth or net present value and the discounted cash flow rate of return.

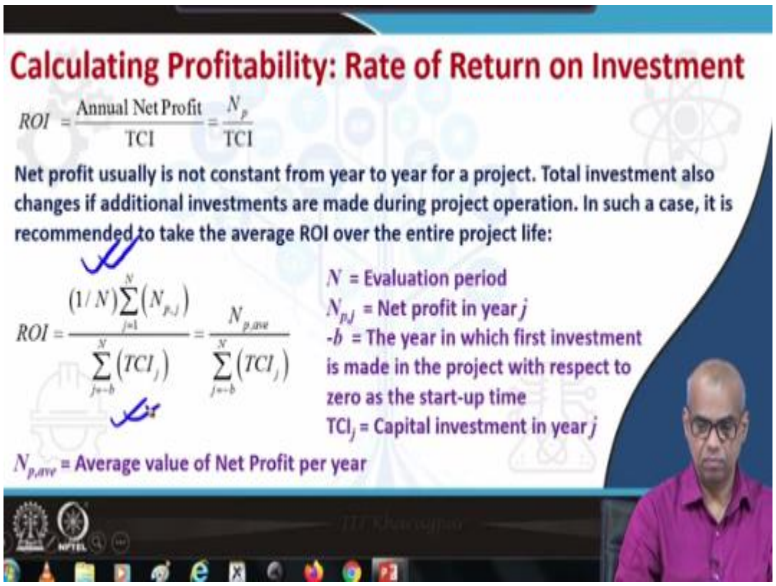
So here the purpose is to perform more detailed analysis. We will also look at the annualized cost method which is again a quick method for preliminary analysis.

(Refer Slide Time: 02:14)



Let us start with the rate of return on investment. For those methods that do not consider the time value of money, it is not important what depreciation schedule is used in the evaluation. Therefore, straight-line depreciation is often used for the purpose of convenience. Rate of return on investment is defined as annual net profit divided by total capital investment. Depending on corporate policy or decision makers gross profit may be used in place of net profit or fixed capital investment may be used in place of total capital investment.

(Refer Slide Time: 03:05)

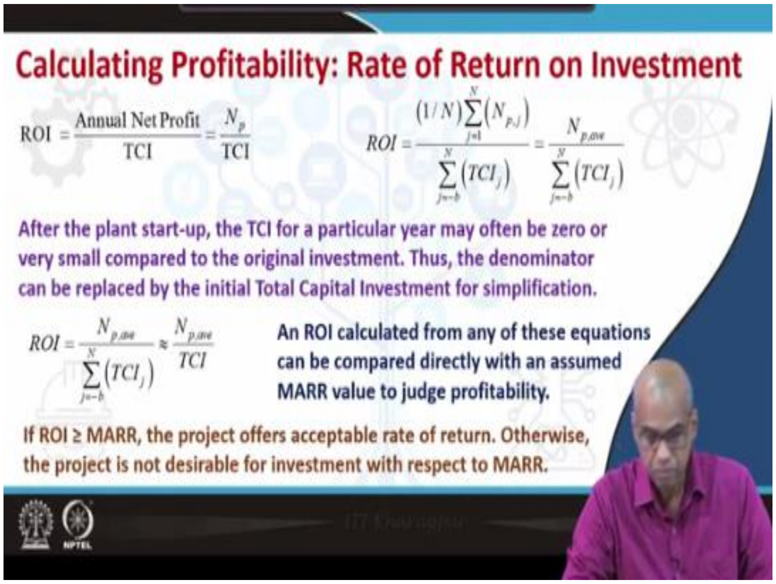


Net profit usually is not constant from year to year for a project, because the profit may vary from one year to another. Similarly, total investment also changes if additional investments are made during the project operation. In such a case, it is recommended to take the average return on investment over the entire project life. So how do I modify my definition now? So rate of return on investment is the average annual net profit.

So what you do is, we sum up the annual net profit from year 1 to year N, N is the evaluation period. And then divide that quantity by N, so what I get is average profit, average value of the net profit per year or average annual net profit. So this is in the numerator and the denominator where taking the total investment over the entire project line. So you sum up the capital investment in all the years starting from the year in which the first investment is made.

Note that, if I say the start-up operation corresponds to the time equal to 0, I say the year in which the business made as - b. So this is 0 which is the start-up operation, it is the beginning of the start-up operation and this is the time where you have started investing, this is - b, this is the time axis and this is the end of the project line N. So the average return on investment is divided by the total capital investment over the entire project life.

(Refer Slide Time: 06:26)



Now the maximum amount of investment you make in the shape of total capital investment is only during the early hours before startup operation. After the plant start-up, the total capital investment for a particular year may often be 0 or very small compared to the original investment. So this denominator may actually be replaced by the initial total capital investment for simplification.

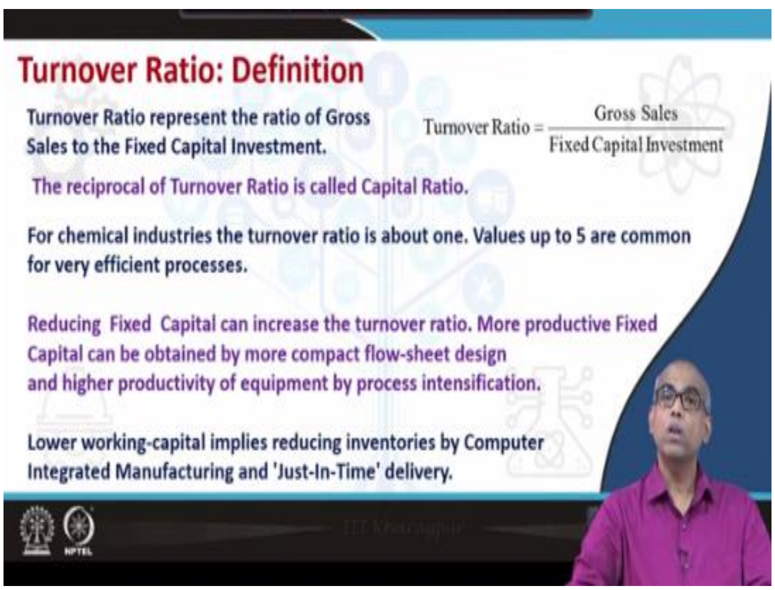
So I can redefine the rate of return on investment as the annual average net profit divided by total capital investment, that is taking place initially, initial total capital investment in the denominator. And return on investment calculated from any of these equations can be compared directly with an assumed minimum acceptable return value to judge profitability. So what we see here is 3 different expressions for calculating rate of return on investment.

Now when you do the economic evaluation of your project, you first assume a minimum acceptable rate of return, it can be assumed judiciously or you can look at the table that we just have seen in our previous lecture and can select some value or from your past experience in the company for a similar project, you can also choose or assume some value for minimum acceptable rate of return.

Now, you can make use of any of these three equations and compute the rate of return on investment, compare this rate of return with the minimum acceptable rate of return value. If the return on investment is greater or equal to the minimum acceptable rate of return, only then the project offers an acceptable rate of return, otherwise the project is not desirable for investment with respect to the selected minimum acceptable rate of return.

Preferably the return on investment should be higher, then the minimum acceptable rate of return, even if the rate of return on investment matches the minimum acceptable rate of return, you can consider the project to be acceptable but definitely the project is not desirable for investment when return on investment is less than the minimum acceptable rate of return.

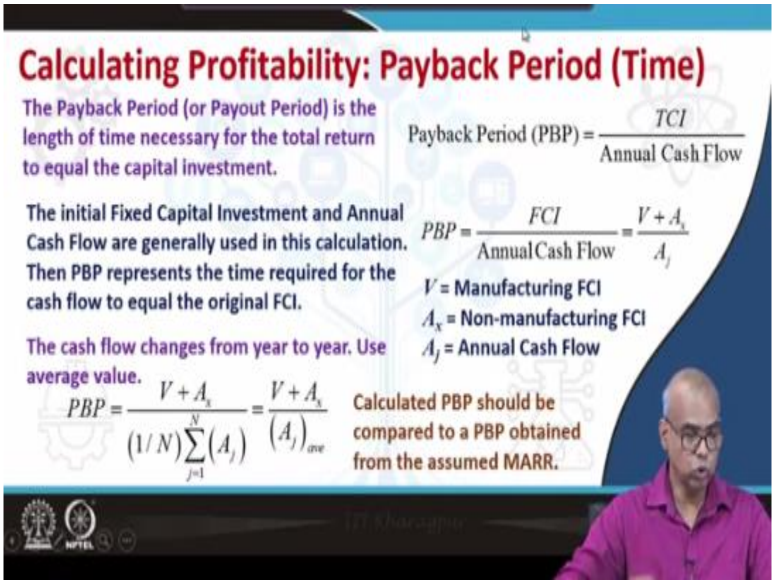
(Refer Slide Time: 10:10)



Now we will define a term known as turnover ratio, turnover ratio representing the ratio of gross sales to the fixed capital investment, turnover ratio of gross sales divided by fixed capital investment. The reciprocal of turnover ratio is called capital ratio. For chemical industries, the turnover ratio is about 1, values up to 5 are common for very efficient processes. Reducing fixed capital can increase the turnover ratio. Look at the fixed capital investment goes in the denominator of the definition.

So reducing fixed capital can increase the turnover ratio, how will you reduce the fixed capital? More productive fixed capital can be obtained by more compact flow sheet design and higher productivity of equipment by process intensification and integration. Lower working capital implies reducing inventories. How do you reduce inventories? By computer integrated manufacturing and just in time delivery, that means there is no delay in delivery, your inventories will reduce.

(Refer Slide Time: 11:32)



Now let us move on to another method for calculating profitability, which does not take into account the time value of money. This is known as payback period or payout time, we also call it simple payback period or simple payback time. The payback period or payout period or payback time is the length of time necessary for the total return to equal to the capital investment. So the payback period is equal to total capital investment divided by annual cash flow.

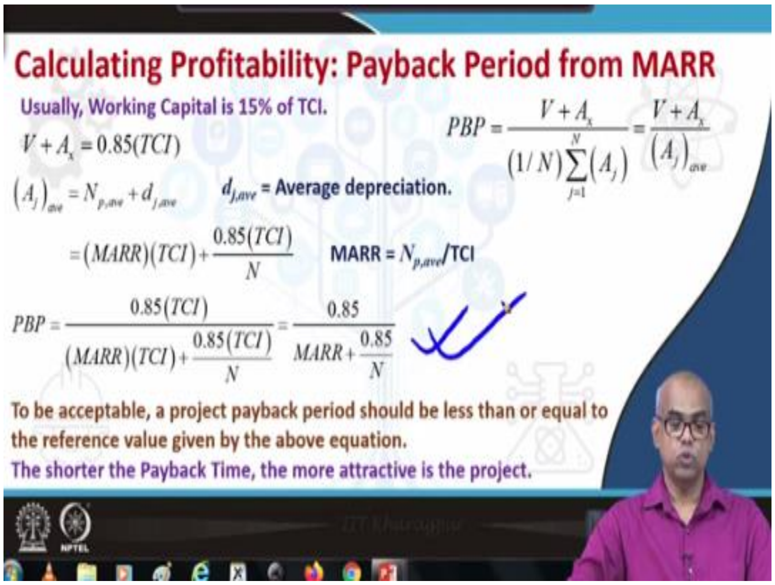
This will give you the time necessary for the total return to equal the capital investment. The initial fixed capital investment and the annual cash flow are generally used in these calculations. So the payback period is often expressed as fixed capital investment divided by annual cash flow. The payback period represents the time required for the cash flow to equal the original fixed capital investment according to this definition. Now the fixed capital investment is the sum of manufacturing fixed capital investment V and non manufacturing fixed capital investment Ax.

And let the annual cash flow be represented as Aj, Aj represents annual cash flow in jth year. Now the annual cash flow will generally change from one year to another. So under such a situation, we can use average value for the annual cash flow. What you do is, we sum up all the Aj's, the annual cash flows are summed up for all the years j equal to 1 to capital N and then divide that by the number of years N, in that case, I get average annual cash flow.

So the payback period is V which is manufacturing fixed capital investment plus Ax, which is non manufacturing capital investment divided by average annual cash flow. Now the calculated payback period according to this expression needs to be compared to a payback period obtained from the assumed minimum acceptable rate of return. So you assume a minimum acceptable rate of return and then find the payback period based on that minimum acceptable rate of return and you also find the payment period using this expression.

Now these two values need to be compared, shorter the payback period, better is the profitability. So a shorter payback period will be chosen. Now how will you compute the payback period for a given minimum acceptable rate of return?

(Refer Slide Time: 15:28)



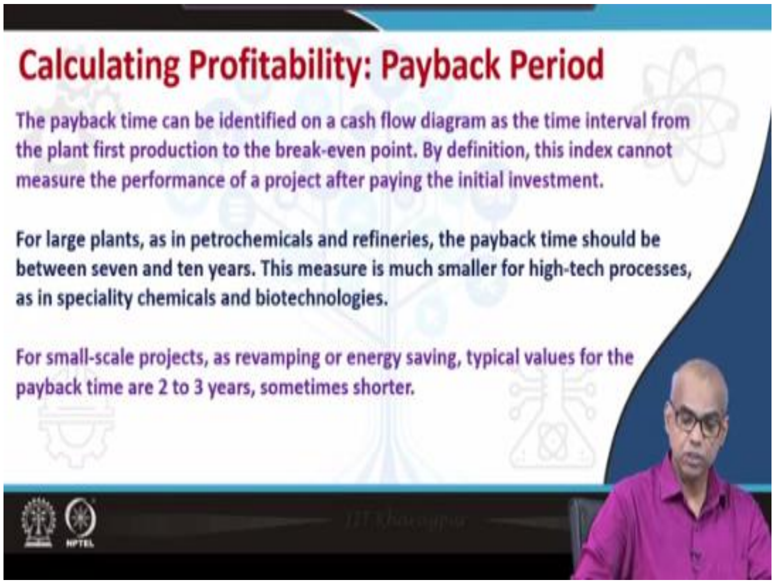
Now we know the working capital is 15% of total capital investment. So V + Ax which represents the fixed capital investment will be 85% of total capital investment, V + Ax equal to

0.85 into TCI which represents total capital investment. Now average annual cash flow will be the sum of average annual profit plus average annual depreciation. Now the depreciation amount is the fixed capital investment, which is 0.85 into TCI. 0.85 into TCI will be depreciated over a period of N.

So 0.85 into total capital investment divided by N will give me the average annual depreciation. Now according to the chosen minimum acceptable rate of return we can write, minimum acceptable return equal to average annual profit divided by total capital investment, this gives me the average annual profit is minimum acceptable rate of return multiplied by total capital investment. I have an expression for the numerator as well as for denominator, let us put these values.

After simplification, you will get the payback period as 0.85 divided by minimum acceptable rate of return + 0.85 divided by N. So this is how you can compute the payback period for a chosen minimum acceptable rate of return. To be acceptable, a project payback period should be less than or at least equal to the reference value given by this equation. The shorter the payback time the more attractive is the project. So when you compare multiple projects you choose the one which has the shortest payback time.

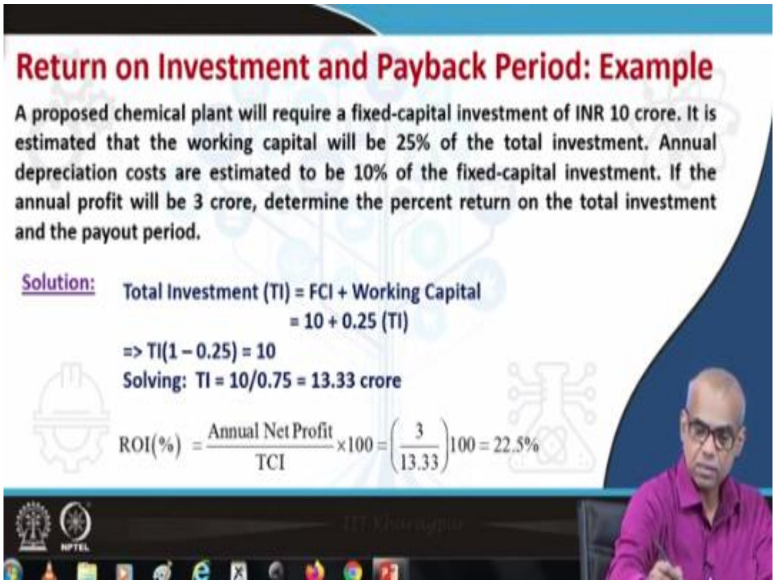
(Refer Slide Time: 18:00)



The payback time can be identified on a cash flow diagram as the time interval from the plant from the plant first production to the break-even point. We have seen this when you talk about cash flow diagrams. By definition, this index cannot measure the performance of a project after paying the initial investment. For larger plants, as in petrochemicals and refineries the payback time should be between 7 and 10 years.

This measure is much smaller for high tech processes, as in specialty chemicals and biotechnologies. For small scale projects, as revamping or energy savings, typical values for the payback time are two to three years, sometimes even shorter.

(Refer Slide Time: 18:50)

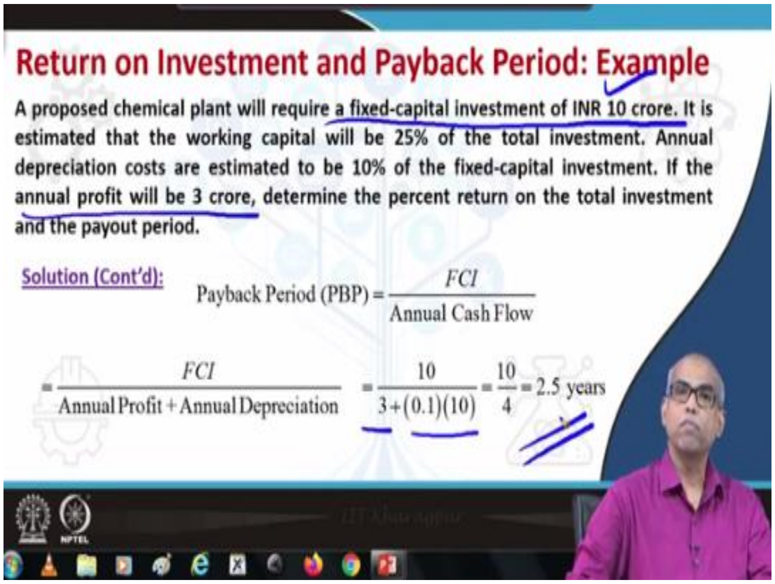


Now let us take an example on the return on investment and payback period. A proposed chemical plant will require a fixed capital investment of rupees 10 crore. It is estimated that the working capital will be 25% of the total investment. Annual depreciation costs are estimated to be 10% of the fixed capital investment. If the annual profit will be three crore, determine the percent return on the total investment and the payout period.

What is total investment? Total investment is fixed capital investment + working capital. Now if I say total investment as TI, the working capital is 25% of the total investment. So working capital is 0.25 into TI and fixed capital investment is given as 10 crore, 10 + 0.25 of TI is total investment here. From here you can solve for total investment, which will come as 13.33 crore. So the return on investment is annual net profit divided by total capital investment multiplied by

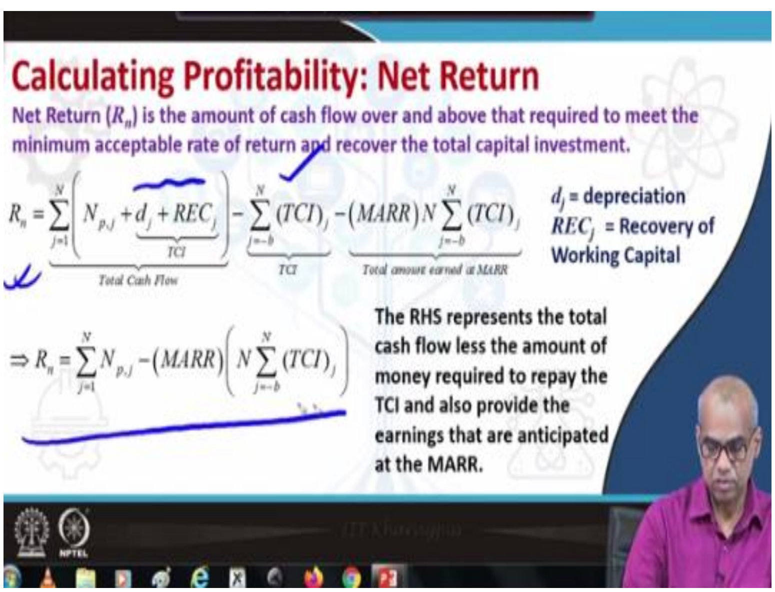
100, which is obtained as 22.5%.

(Refer Slide Time: 21:02)



Now what is the payback period? Payback period will be the fixed capital investment divided by annual cash flow and the annual cash flow will be net annual profit + annual depreciation charge. So, annual depreciation charges are 10% of fixed capital investment 10 crore. The fixed capital investment 10 crore is depreciable, 10 percent of that is the annual depreciation and the annual profit is 3 crore. The payback period Will be fixed capital investment 10 crore by 3 plus 0.1 into 10, so this will be evaluated as 2.5 years.

(Refer Slide Time: 22:12)



Next we learn another method for calculating profitability is called net return. Net return is the amount of cash flow over and above that required to meet the minimum acceptable rate of return and recover the total capital investment. So we define net return as the amount of cash flow over and above that required to meet the minimum acceptable rate of return and recover the total capital investment. So in terms of equations, it is represented as follows.

Now look at closely the right hand side part of the equation. In this equation Np represents the net profit in year j, dj represents the depreciation in year j and REC represents the recovery of working capital. TCIj represents the total capital investment in the year j and the year j here runs from -b to N, N is the project line and - b corresponds to the first investment made to the project and 0 corresponds to the start-up operation.

We have seen that your investment starts much earlier than the startup operation. So if we say, time t equal to 0 represents start-up operations. We have started investing time t equal to - b. So the total capital investment has to be summed over minus b prime corresponding to minus b two times corresponding to N which is the life of the project, so and MARR represents the minimum acceptable rate of return. Now look at each term again.

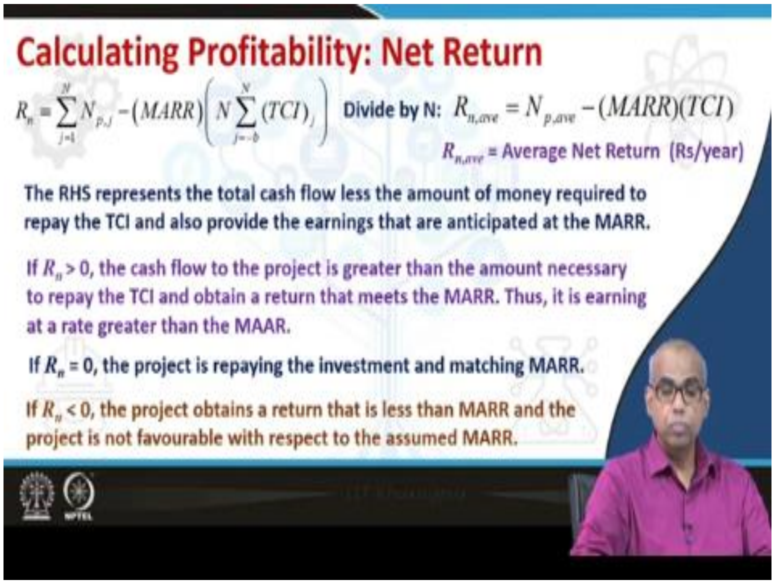
We know that if we add depreciation with the net profit what we get is cash flow, the net cash flow, so over the entire life of the project when we add the net annual profit and all depreciation and the recovery of the working capital. When these quantities are summed over the entire project life, we get the total cash flow for the project. So the first part in the right hand side represents the total cash flow in the project. What is the second part?

Second part represents the sum of the total capital investment that you made in every year starting from j equal to minus b to N. This represents total capital investment and the third part represents the total amount earned at the minimum acceptable rate of return. How? We have seen previously that we can say the minimum acceptable rate of return as Np average. Average net profit divided by total capital investment.

So, average net profit is the minimum acceptable rate of return multiplied by total capital investment. This part represents the total capital investment this is the minimum acceptable rate of return. So, their product represents average profit. Multiply this average profit by N project life what you get is the total amount that you have earned. The last part of this equation represents the total amount earned at the minimum acceptable rate of return.

So, the right hand side entirely represents the total cash flow less the amount of money required to repay the total capital investment and also provides the earnings that are anticipated at the minimum acceptable rate of return. Note that the total depreciation plus the recovery part represents the total capital investment, which is depreciable. So dj plus RECj summed over the entire project life will represent the total capital investment, they cancel each other. So you can simplify this expression as this.

(Refer Slide Time: 29:27)



So now if this equation is divided throughout by N, what you get is the average net return Rn by N is the average net return will be equal to this divided by N is average profit and this divided by N will give you a minimum acceptable rate of return multiplied by TCI or total capital investment. So the right hand side represents the total cash flow less the amount of money required to repay the total capital investment and also provides the earnings that are anticipated at the minimum acceptable rate of return.

Now if the net return value is greater than 0, the cash flow to the project is greater than the amount necessary to repay the total capital investment and obtain a return that makes the minimum acceptable rate of return. Thus, it is earning at a rate greater than the minimum acceptable rate of return. If net return value is equal to 0, the project is repaying the investment and matching minimum acceptable rate of return.

If Rn is less than 0, the project obtains a return that is less than the minimum acceptable rate of return and the project is not favourable with respect to the assumed minimum acceptable rate of return. So the project is favorable when the net return value is preferably greater than 0 or at least equal to 0. But if the net return value is less than 0, the project is not at all favorable with respect to the assumed minimum acceptable rate of return.

So with this we complete our discussion on the 3 different methods for calculating profitability which do not consider the concept of time value of the money. In the next class, we will talk about the methods that do consider the time value of the money with this we stop our discussion here.