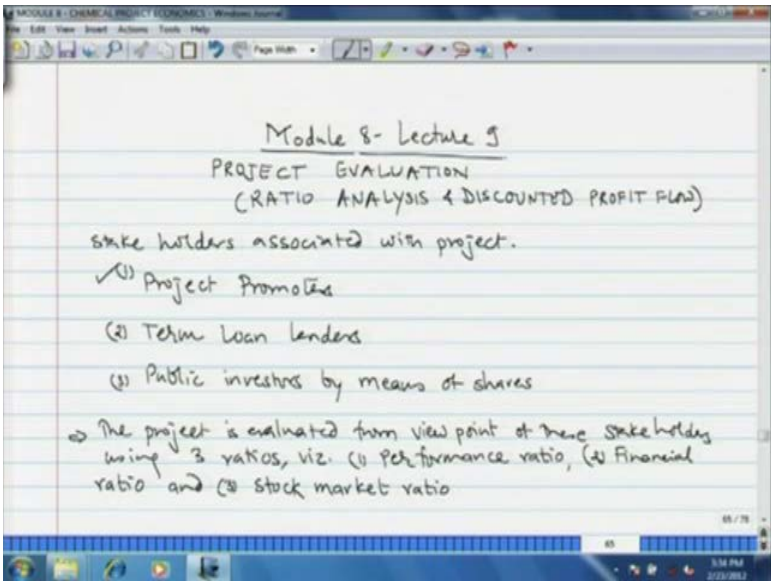
Process Design Decisions and Project Economics
Prof. Dr. V. S. Moholkar
Department of Chemical Engineering
Indian Institute of Technology, Guwahati

Module - 8
Chemical Project Economics
Lecture - 44
Measures of Profitability and Project Evaluation (Part II)

Welcome, for the past 2 lectures we have been looking at the criteria for Project Evaluation. In the previous lecture we saw 2 different criteria for project evaluation that is the breakeven analysis and incremental analysis. And then we shifted to a simple evaluation using ratio analysis; ratio analysis is a relatively simple technique for evaluation of the project from different angles. As I told you in previous lectures there are stake holders associated with the project.

(Refer Slide Time: 00:54)

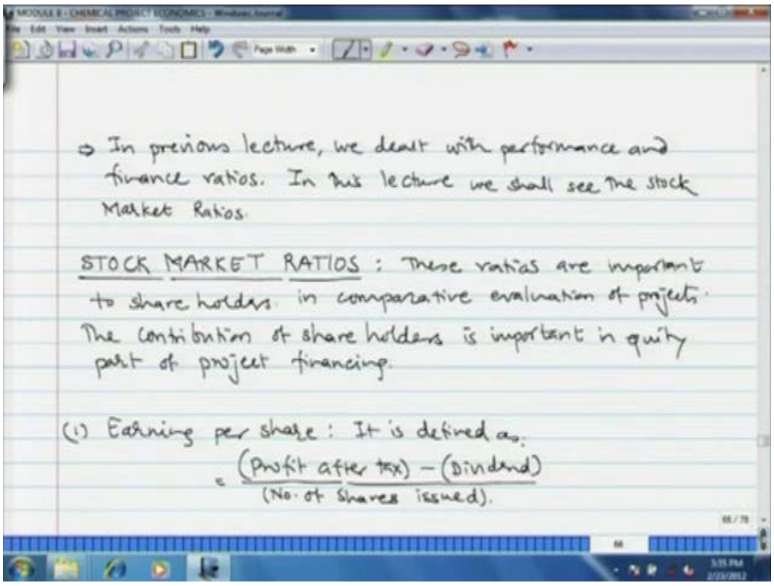


These are the project promoters, the people who invest money, invest capital in the project. Then there are term loan lenders like financial institutions banks, and finally the project also gets money or investment from public investors by means of shares. The promoters of the project are interested in very good performance, resulting in early payback of their investment.

The financial institutions or project financiers as we call them, they are looking for good performance of the project, but also the payment interest and repayment of the term loan as per the scheduled decided at the beginning of the project. And finally, the public investors who have invested money in the stock market by buying shares of the company.

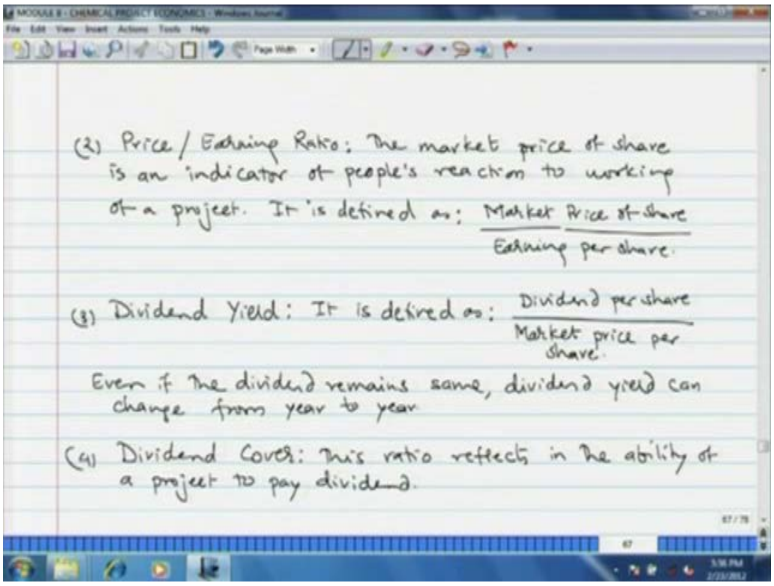
They would like to earn money by way of selling shares or earning dividends on them; however, they would like to have much higher interest rates on this investment rather than the investment in banks in the form of fixed deposit, which is called as 0 risk. In the previous lecture we saw different ratios from the view point of the project promoter and the term loan lender. Now today, we shall see what are the ratios of project evaluation from the view point of the stock market investors or share holders.

(Refer Slide Time: 02:21)



The stock market ratios are important to share holders in comparative evaluation of the projects and the contribution of share holders is important in the equity part of project financing typically about 40 percent of the investment is via the share holders. So, the first ratio for from view point of stock market is the earning per share, this is defined as the profit after tax minus a dividend, divided by the number of shares issued and higher the ratio the better the project. Then the second ratio is the price to earnings ratio, the market price of a share is an indicator of peoples reaction or peoples interest in working of a project. As the peoples interest increases the market price of the share increases.

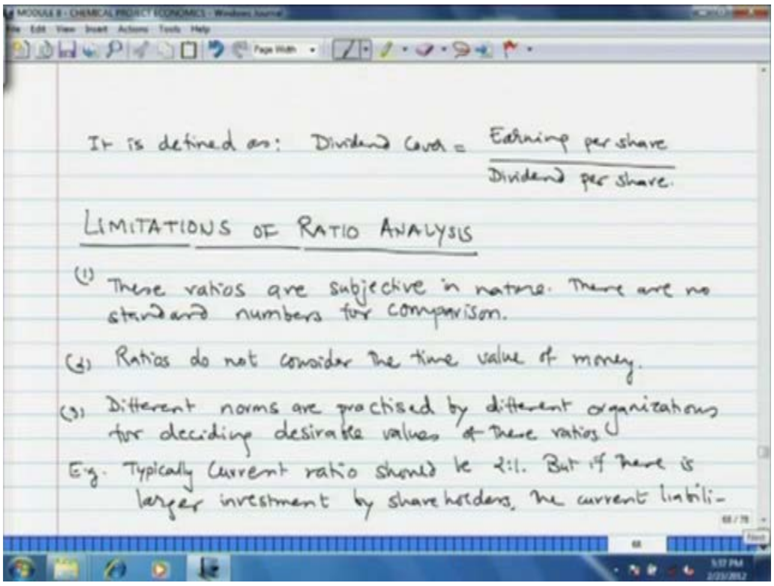
(Refer Slide Time: 03:17)



So, the price to earnings ratio is defined as market price of the share divided by earning per share. The third ratio that is used is the dividend yield ratio dividend is some kind of a interest or returns that the project owner pays over the capital borrowed by the from the public. So, the dividend yield is defined as dividend per share divided by market price per share depending on peoples interest, and also the overall national economy the market prices of shares are decided.

So, although the dividend per share may stay constant the dividend yield can vary from here to here, based on the market price of the share. Then the fifth ratio that is the forth ratio that is used is dividend cover, this ratio reflects in the ability of a project to pay the dividend and it is defined as the dividend cover is defined as earnings per share divided by dividend per share.

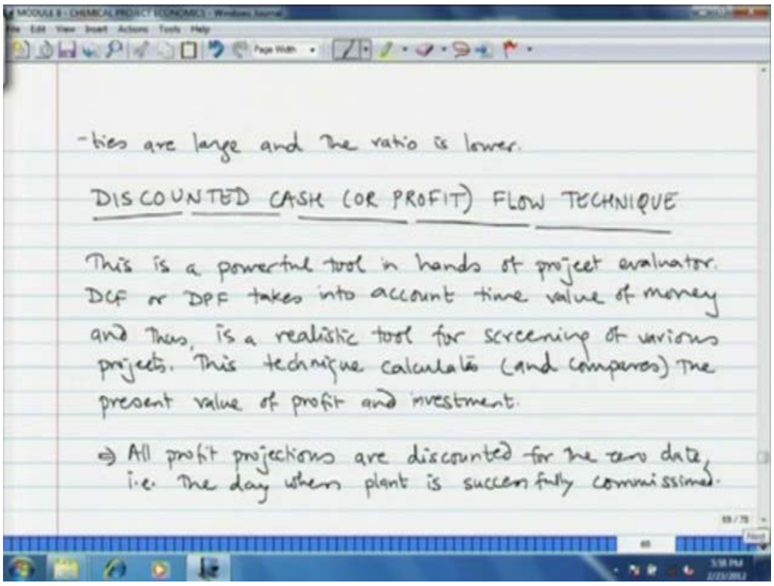
(Refer Slide Time: 04:13)



All of these ratios are quick way of evaluating the economic feasibility or out the output of a project; however, they have their own limitations. Now what are these limitations the major limitation is that these ratios are highly subjective in nature. There are no standard norms or standards numbers for comparison and the second demerit is that these ratios do not consider the time value of money.

For example, if I am envisaging a profit of let us say rupees hundred, lakh or 1 crore in the fifth year of the project, what that money means to me today that is not meant that is not given by any of these ratios. Now different companies follow different norms for deciding the desirable value of these ratios like I have given an example here is that a typical current ratio should be 2 is to 1, but if there is larger investment by the share holders.

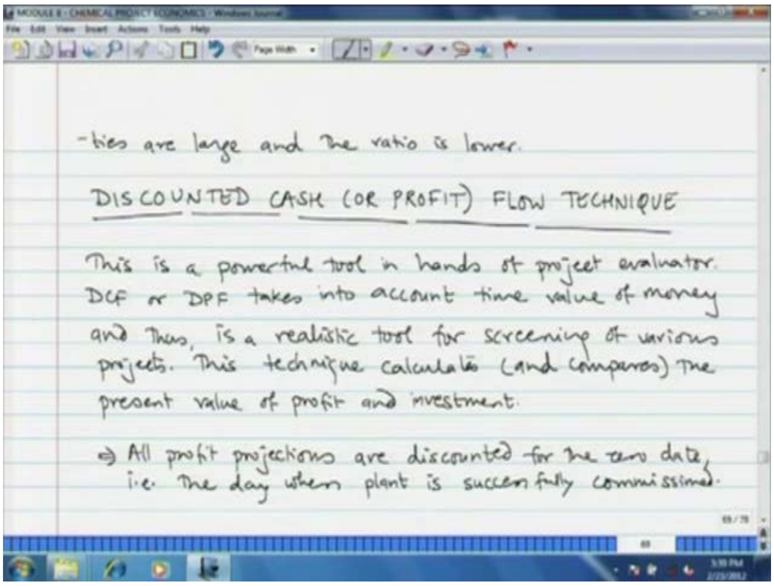
(Refer Slide Time: 05:16)



Then the current liabilities are large and then the ratio is lower. So, these are like for example, the payback period, the typical payback period should be between 3 to 5 years or maximum 7 years. So, if the payback period is more than 7 years, then the project is not very attractive. Similarly, the return on investment typically people say that at 20 percent return on investment is desirable; however, this varies from project to project.

So, that is the major limitation of the project that there is no definite norm or no definite numbers for comparison of the project everything is relative and subjective. So, these drawbacks could be overcome by using the discounted cash flow technique. Now this is a very powerful tool in the hands of project evaluator for taking into account a this takes into account also the time value of money.

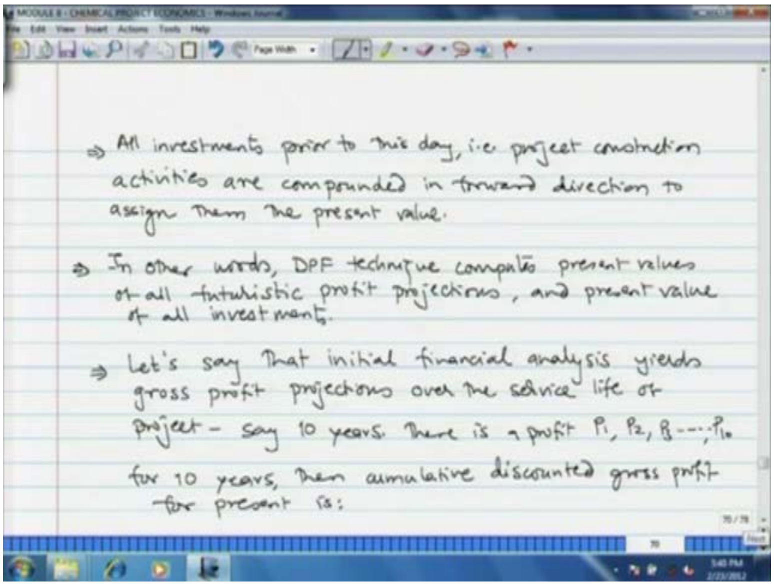
(Refer Slide Time: 06:05)



So, with discounted cash or profit flow technique, you can very easily evaluate the feasibility of the project. And more importantly because it takes into account a time value of money, it this tool is a very realistic tool for screening various projects. Now what is the basis for this particular technique is that this technique calculates and compares the present value of profit and investment. Profit is something after project commissioning, investment is still project commissioning.

So, at the assuming that the time of project commissioning to be 0 time, this particular techniques tries to compare the future value of investment. And the present value of profit at time 0 that is at project commissioning. So, that is what we see here, all profit projections are discounted for the 0 date that is a date when plant is successfully commissioned.

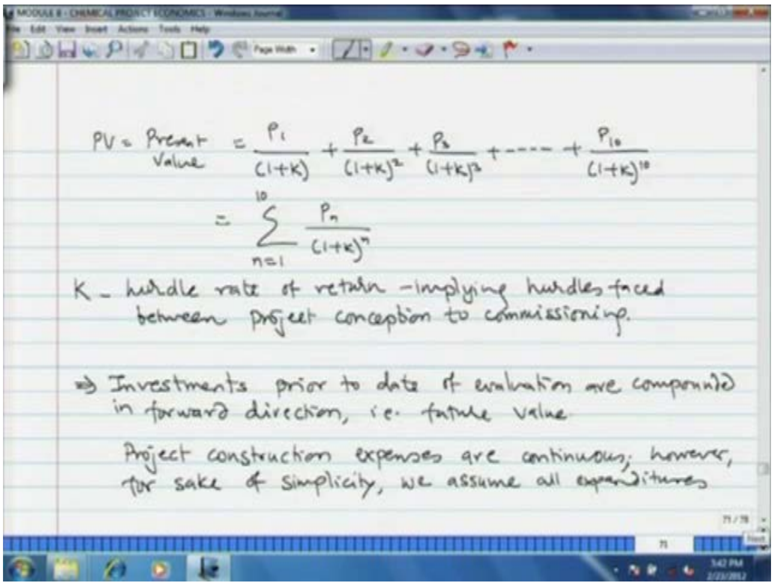
(Refer Slide Time: 07:05)



And all investment prior to this date that is the project construction activities are compounded in forward direction to assign them the present value, or in other words DPF technique computes the present value of all futuristic profit projections and present value of all investment. Now let us say that the initial financial analysis yields the gross profit projection over the service life of the project, which we assume to be let us say 10 years as p 1, p 2, p 3, p 4 up to p 10.

Now as I told you in the previous lecture the total capacity of the plant may not be function in right from day 1. The project is designed for certain capacity, but all of that capacity is not utilized from day 1. So, typically about 60 percent of the capacity is utilized in the first year, then about des goes up to let us say 70 to 80 percent in the second year. Then about 90, 95 percent in the third year and then forth year onwards the project utilizes it is full capacity. Therefore, the profit per year is not same, we that is why we have given different values of the profit p 1, p 2, p 3 up to p 10 for 10 years.

(Refer Slide Time: 08:28)



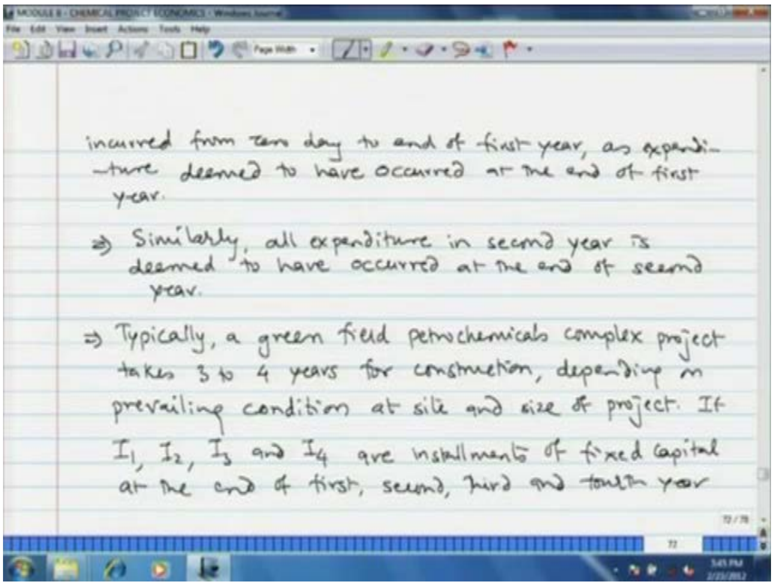
We have to see the cumulative discounted gross profit for the present; that means, we assume that profit p 1 which is at the end of first year is equal to p 1 divided by 1 plus k at time 0. Now here we are using the time value of money, the concepts of which we have seen in the previous lectures. We are now doing the compounding of and then first compounding and then discounting, so if profit at the end of year 1 is p 1.

Then it is current value is p 1 divided by 1 plus k, similarly profit at the end of second year is p 2 and it is value at time 0, at present condition is p 2 divided by 1 plus k square and so on. And so forth, p 3 divided by 1 plus k cube and then p 10 divided by 1 plus k to the power 10. Now the total pre sent value of profit over 10 years of operation is summation n equal to 1 to 10 p n divided by 1 plus k to the power n. So, this is the present total present value of the profit that we are going to earn over 10 years of operation.

Now what is this k, which we have used because this should be the rate of interest in principle as we have seen in the lectures of time value of money. Now k is called as hurdle rate of return. It essentially implies a hurdle space between project conception to commissioning, project conception to commissioning is no simple business, is no simple task. There are hundreds of hurdles that are there, so depending on these hurdles the rate of return increases or decreases.

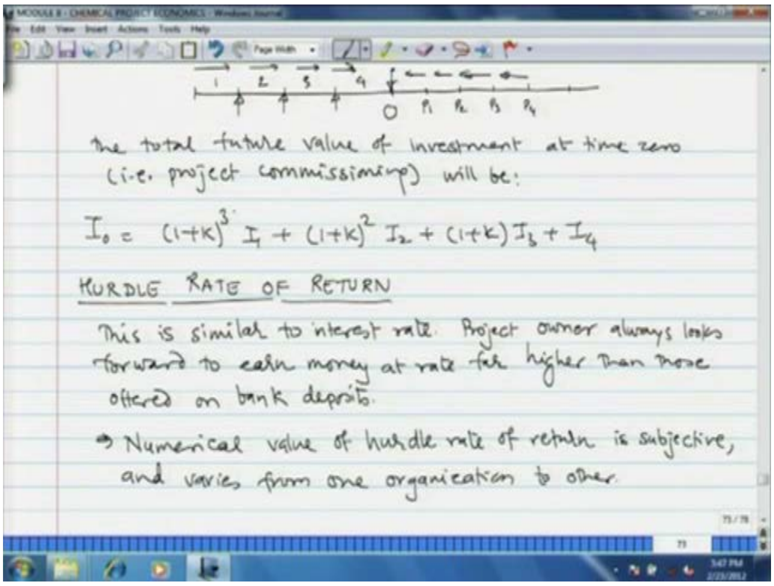
The greater the hurdles lesser the rate of return and therefore, instead of using a simple i interest rate i common interest rate i. We have used a value k, now investment prior this is about the profit the present value of the profit. Now investment prior to the date of evaluation, these have to be compounded in forward direction that is to the time 0 a future value. Project construction expenses are continuous, but for sake of simplicity. We assume that all expenditures incurred from 0 day to the end of first year as expenditure deem to have occurred at the end of first year. Now this will help us make computation easier, so although we are going to spend money over the entire year of the project. We assume that the total money is spend at the in a single installment at the end of the at the year end. So, similarly all expenditure in the second year is deemed to have occurred at the end of second year so on.

(Refer Slide Time: 11:09)



And so forth, this way we have to make the future or estimate the future value of our investment, suppose instead of investing in business. If we had invested in bank then how much would have accrued in the period of construction. Now typically it takes about 3 to 4 years for green field petrochemicals complex project to build. Now this time also varies from project to project, but if you see a typical number then it is about 3 to 4 years depending on the prevailing conditions at the site and then the size of the project so on and so forth. Now if we assume that I 1, I 2, I 3 and I 4 are the installments of fixed capital at the end of first second third and fourth year.

(Refer Slide Time: 11:59)



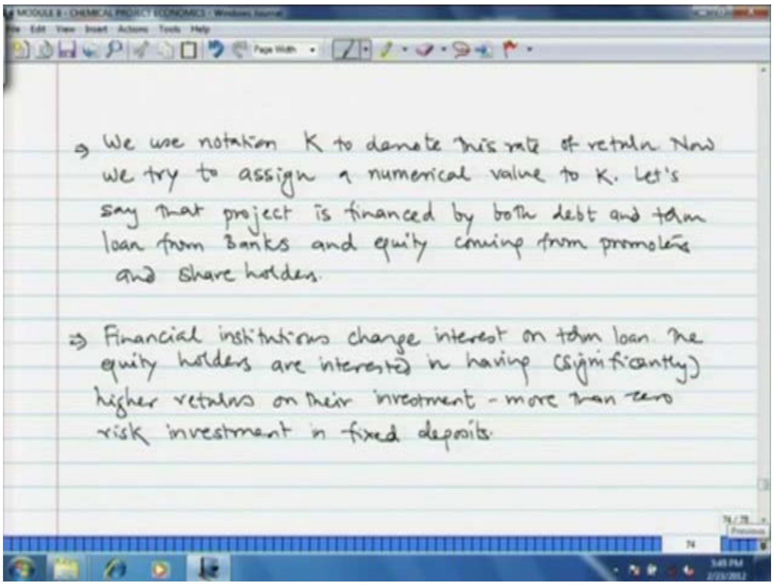
Then the total future value of investment at time 0 that is at the time of project commissioning will be equal to I 0 that is 1 plus k cube into I 1 plus 1 plus k square into I 2 plus 1 plus k in into I 3 plus I 4. So, essentially we are considering let us say a time line where the project commissioning is 0 and the investment or construction of the plant occurs in 4 years first year, second year, third year and forth year. We are going to spend money at these points at the end of first year, at the end of second year, at the end of third year, at the end of forth year.

And then the profit is along the positive time axis, here we have profit p 1 p 2 p 3 p 4, we have already discounted these profit is to time 0 by the summation that we saw just now. And now we have to compound these investment in future direction and then compare the 2 things at time 0. Now the first installment I 1, if it was installed in bank then it would have accrued the interest 1 plus k to the power 3.

Now k is hurdle rate of return, how to evaluate that and how it is related to the interest rate offered by bank that we are going to see in few minutes, but k is very similar to an interest rate. So, 1 plus k to the power 3, because this the investment I 1 is made at the end of first year and it is there for 3 year so on and so forth. And I 4 is the investment at time 0, at time 0 u also invest the working capital.

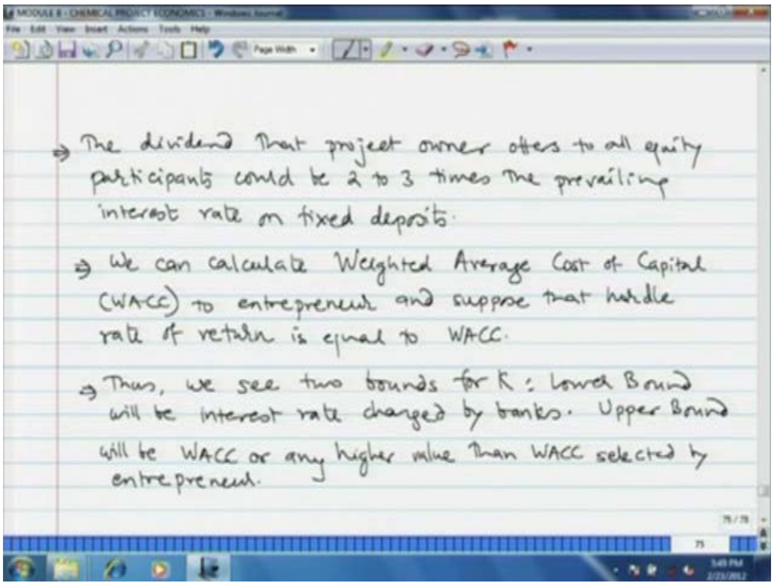
So, a working capital is also part of I 4. So, that is it, so the total future value of investment at time 0 is I 0 equal to 1 plus k cube into I 1 plus. This also we can write in the form of a summation that we shall see later that summation, but let us first see the concept of hurdle rate return. How it is related to interest rate in bank? Now, as I told you hurdle rate of return is very similar to the interest rate, the project owner will always look forward to earn money at rate far higher than those offered by bank deposits. Bank deposit is typically offer 8 to 9 percent interest. So, the investor who is investing in a in a project would like to earn at least double or even triple of that interest rate the return should be that high. So, the numerical value of the hurdle rate of return is very subjective and that varies from one organization to another.

(Refer Slide Time: 14:52)



We are using the notation K to denote the hurdle rate of return, now we try to assign a numerical value for K. Let us say that our project is financed by both debt and the term loan from bank and equity coming from promoters and share holders. So, we have contributions in the form of debt and term loan from bank and in the form of public money equity or shares. The financial institutions charge interest on the term loan and the equity holders are interested in having significantly higher returns on their investment more than the 0 risk investment in fixed deposits.

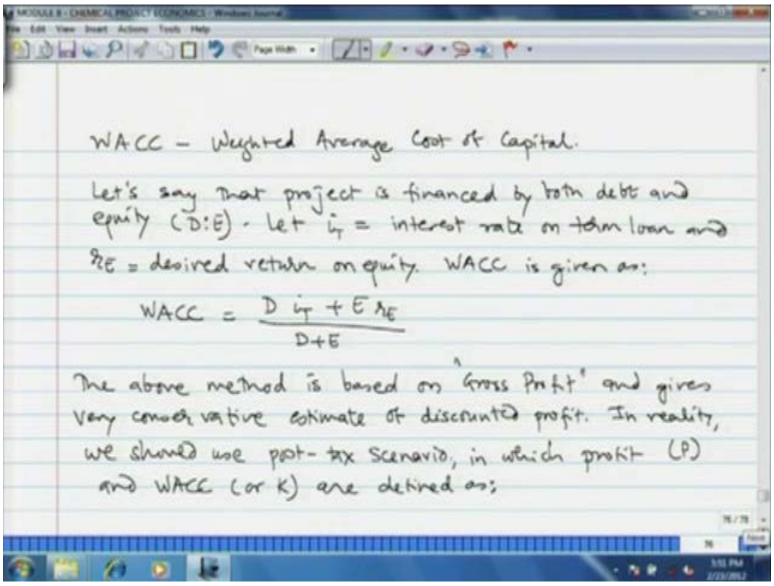
(Refer Slide Time: 15:33)



So, dividend that the project owner has to offer in order to attract the investment to all the equity participants could be about 2 to 3 times the prevailing interest rate on bank deposit is as i just said. So, with this information we can calculate the weighted average cost of capital that denote by W A C C to the entrepreneur and suppose that the hurdle rate of return is equal or greater than this W A C C.

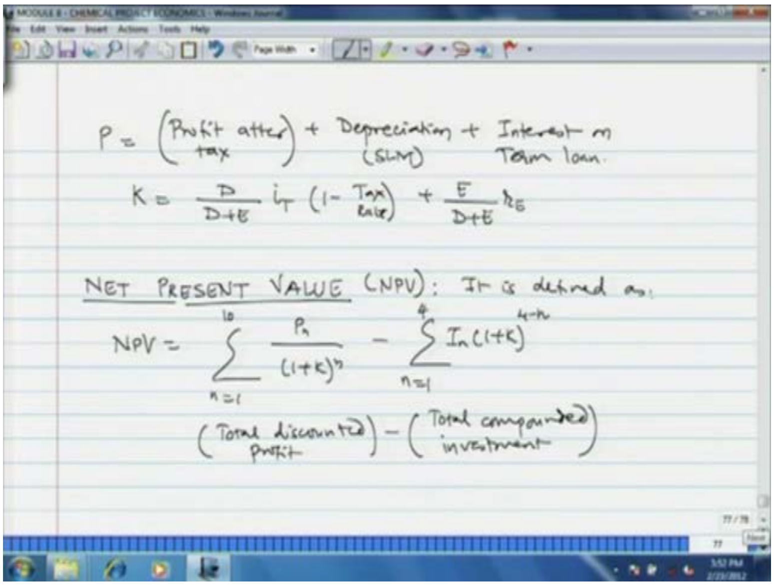
So, if we do that then we immediately get two bounds for the hurdle rate of return K. the first the lower bound is the interest charged by the banks, which is typically for interest rate for investment it could be typically about 15 or 18 percent interest rate. So, that lower bound is the interest rate charged by the bank and the upper bound will be the weighted average cost of capital or any higher value than W A C C that is selected by the entrepreneur.

(Refer Slide Time: 16:41)



Now let us see how we can calculate the weighted average cost of capital as I just said that we assume that the project is financed both by debt and that is term loan and the equity. Now, let i T be the interest rate on the term loan and r E be the desired return on equity. If this is the case then the W A C C is given by D into i T plus E into r E divided by D plus E, so that is the weighted average cost of capital. Now this method of calculating W A C C is based on the gross profit and not the profit after tax, gross profit total profit. And therefore, it gives very conservative estimate for the discounted profit.

(Refer Slide Time: 17:44)

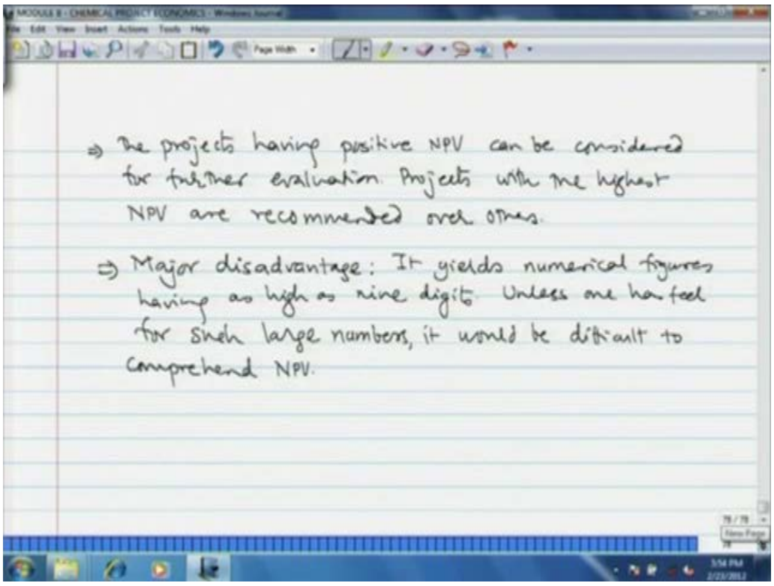


In reality we have to use the post tax scenario in which the profit p and the W A C C the Weighted Average Capital Cost or K is defined as is the profit after tax plus depreciation that we assumed to be straight line method plus the interest on term loan. And K the hurdle rate of return is D divided by D plus E into i T into 1 minus the tax rate plus E that is equity divided by D plus E into r E that is the hurdle rate of return.

And thus we can get this is how we can give a numerical value for K, typically K is taken to be between 15 to 20 percent, this is the typical value for petrochemical project. If K is lesser than that then the project is not attractive. Now let us see the concept of net present value of the project, net present value is that the difference between the present value of the profit and future value of the investment at time 0. And here we can write assuming 4 years construction period and 10 years of business operation period.

We can write 2 summations, the first summation is for the present value of the profit, summation n from 1 to 10 P n divided by 1 plus K to the power n. So, this is the total discounted profit minus the summation n running from 1 to 4 I n into 1 plus K rest to 4 minus n. This is for the total compounded investment at time 0, this is in the we had seen this particular second summation in the expanded form just now, where we had written I 1 into 1 plus K to the power 3 plus I 2 into 1 plus K to the power 2. So, that summation we can write in compact form as this the and the net present value is the difference between total discounted profit minus total compounded investment.

(Refer Slide Time: 19:44)

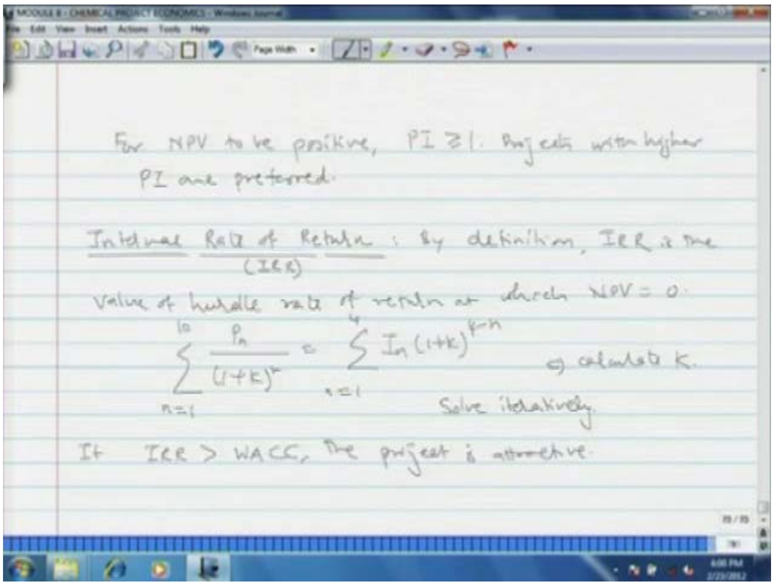


Now the projects that have highest or positive NPV net present value can be considered for further evaluation. The project with the highest NPV are recommended over other projects, we have several process alternatives as we had seen in previous modules. Everywhere as you go through the process design, design level 1 input, output structure level 2 recycle structure level 3. And this is how at each level you have to evaluate the economic potential of course, that economic potential does not take into account a time value of money, but before even you go for that you have to consider the net present value and decide whether it is worth investing more time and money in designing the project to greater detail.

Now the major disadvantage of the NPV, is that it often yields numerical large numerical figures as large as having 9 digit is because it is essentially the total profit it could be in crores, 20 crore, 30 crore, 100 crore. So, you will get a very large number and to comprehend that number we have to have a feel for such numbers, like for example, is 20 crore profit enough for a let us say 10,000 tons per day of methanol plant.

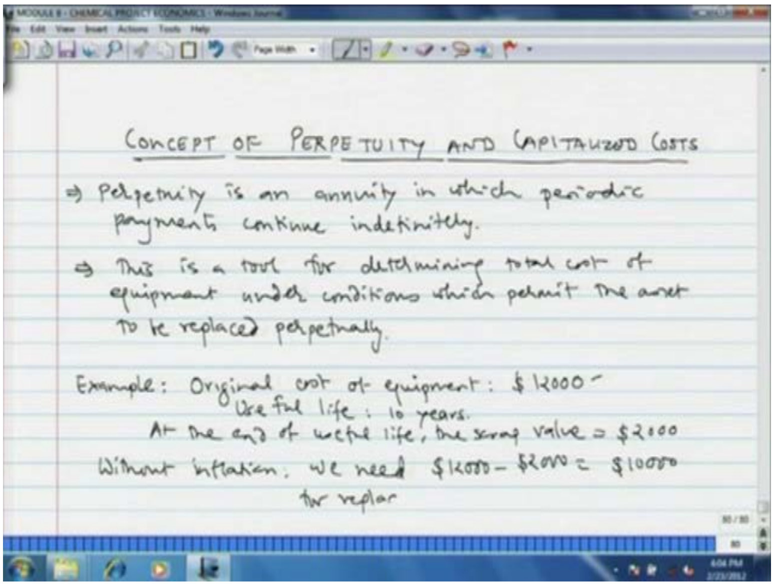
So, that thing we have to have some feel for that particular number. So, unless and until one has feel for such large numbers it will be difficult to comprehend net present value. Then what is the solution? The solution is in terms of the profitability index, now profitability index is a defined as summation and basically the ratio of those summations. In net present value we had taken the difference of summations, here we will take the ratio of summation. Now obviously, because of ratio the bound lower bound for NPV is 1sorry the lower bound for profitability index is 1.

(Refer Slide Time: 22:29)



So, for NPV to be positive profitable index PI should be greater or equal to 1 and then projects with higher profitable index are preferred. Now another method for project evaluation is the internal rate of return, and by definition the internal rate of return which we denote by acronym IRR. IRR internal rate of return is the value of hurdle rate of return at which the net present value is 0; that means, here we have to equate the 2 summations and then calculate K. Now of course, these calculations are not explicit, because the unknown K appears on both sides of the equation and therefore, these have to be solved iteratively. Obviously, if IRR is greater than W A C C, if the internal rate of return is greater than Weighted Average rate of Capital the project is attractive.

(Refer Slide Time: 25:01)



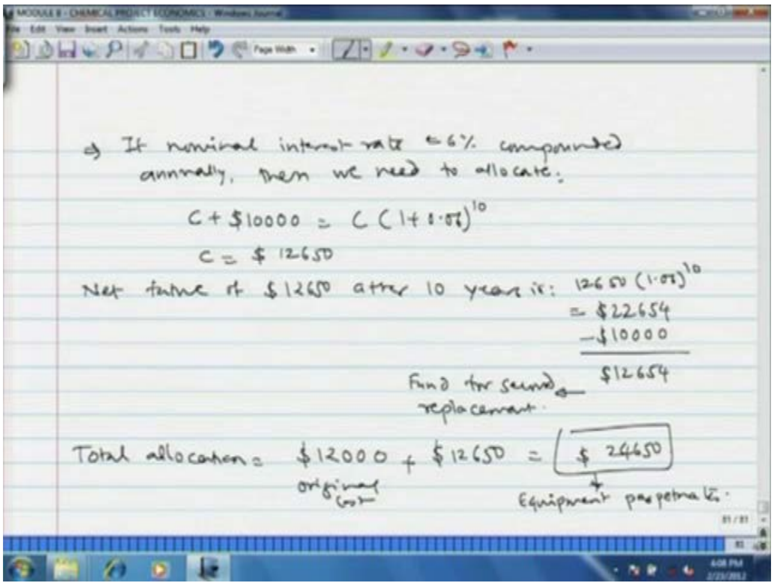
Now given these evaluation, the project is attractive now let us see at the end the concepts of perpetuity and capitalized cost, when we are designing a particular process we will have several options for a particular equipment for same operations. And then how to choose between these equipments or these alternatives, moreover sometimes we may have to replace certain equipment with another equipment when we are modifying a process or implementing new technology.

So, we need to have some tool of evaluation for these kind of changes and what we are going to see now is simple tool for selecting between the options, alternatives, equipment and then also making decision about replacement of certain equipment in the process. By definition perpetuity is an annuity in which periodic payments continue indefinitely. So, that point we note perpetuity is an annuity in which periodic payments continue indefinitely.

Now this type of annuity is of particular interest, because it helps in determining the total cost of equipment or other asset under conditions which permit the asset to be replaced perpetually without considering inflation. So, that point we also note this is a tool for determining total cost of equipment under conditions which permit asset to be replaced perpetually.

Now let us see this thing with an example let us say that the original cost of a particular equipment is 12000 dollars, let us say there are compressor which has this cost a useful life of this equipment is 10 years and at the end of the useful life the scrap value of this equipment is 2000 dollars. So, if we assume that the cost of equipment 12000 dollars remains same for 10 years which of course, is unlikely, but we can assume for simplicity. Then without inflation we need original 12000 minus plus scrap value 2000 10000 dollars for replacement of the piece of equipment every 10 years.

(Refer Slide Time: 29:27)

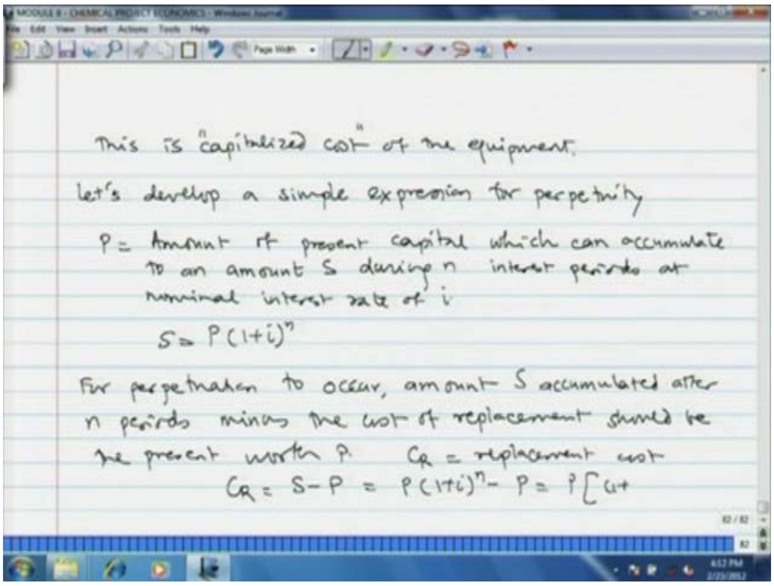


Now if we have to do that then we need to allocate sufficient funds right from the day the equipment is purchased. So, that the fund grows or earns enough value for the periodic replacement, if we assume that the nominal interest rate is 6 percent compounded annually. Then we need certain amount of money that would amount to the cost of replacement and then let us see how we can do that that point we note. If nominal interest rate is 6 percent compounded annually.

Then we need to allocate we need 10,000 dollars every 10 years at capital C plus 10,000 dollars and then C turns out be dollar twelve 12,650. If you solve this you get this, so the net value of net future value of the funds that we allocate 12,650 dollars after 10 years is 12650 into 1.06 rest to 10 that is dollar 22,654 out of which we deduct 10,000 dollars for replacement of the reactor. And we get back the principle with let us say 4 dollars more and this becomes the fund for third replacement second sorry second replacement.

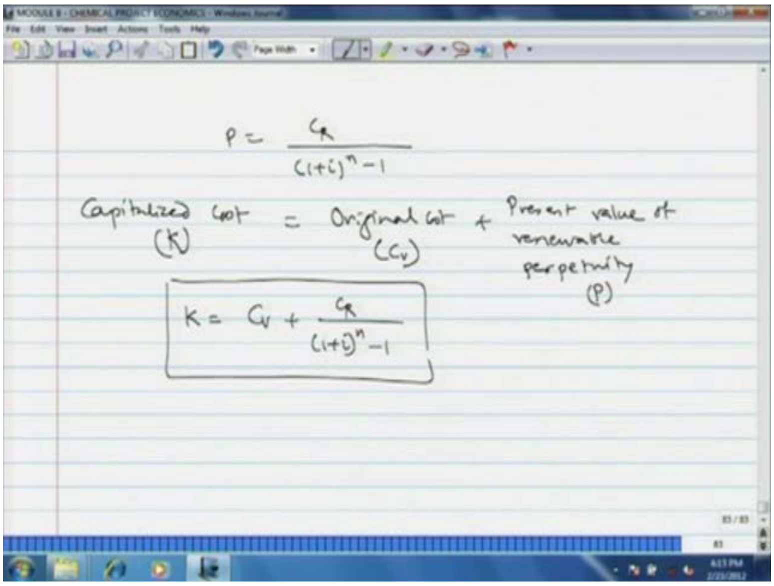
Therefore, if we have to keep on replacing the reactor every 10 years, we have to allocate 12,000 dollars total allocation is dollar 12,000 which is initial value original cost plus the money that we need to invest for replacement assuming no change in the price is equal to dollar 24,650. With this much of investment the equipment will perpetuate it self, you can keep on replacing it every 10 years for in infinite period of time.

(Refer Slide Time: 32:42)



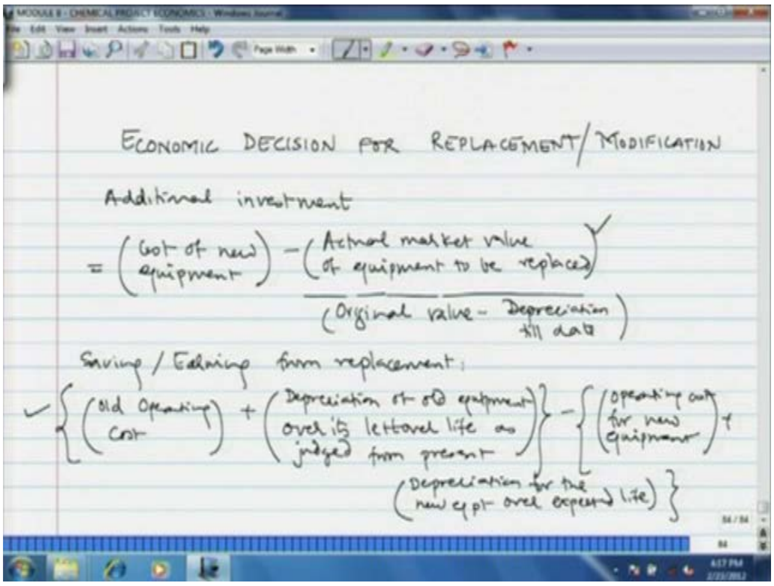
And then this is the capitalized cost of the equipment, this is very often used for comparing between alternate choices. Now let us try to derive simple expression for the perpetuity, let P be the amount of present capital which can accumulate to an amount S during n interest period at nominal interest rate of i. So, relation between these quantities is S is equal to P into 1 plus i to the power n, now for perpetuation to occur amount S that is accumulated after n periods minus the cost of replacement should be equal to the present worth P. And thus if we represent C R as the replacement cost which is the original cost minus the scrap value that is C R is equal to S minus P, then putting S in terms of P.

(Refer Slide Time: 35:57)



And then we get expression for P as C R divided by 1 plus r to the power n minus 1, then the capitalized cost K is equal to the original cost which we denote by letter C v plus present value of the renewable perpetuity which is P. So, we have a simple expression here K is equal to C v plus C R into divided by 1 plus i to the power n minus 1. Now there are certain other considerations also used for replacement of the equipment that we shall see.

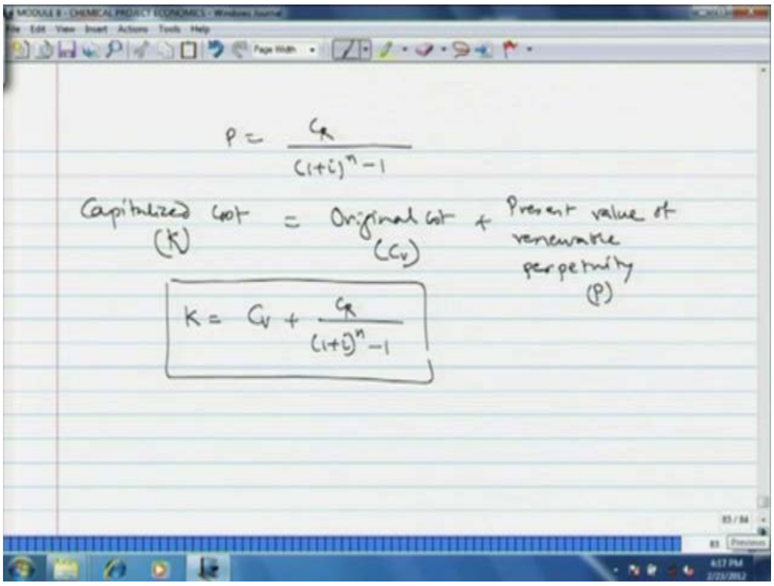
(Refer Slide Time: 37:12)



Now, for replacement or modification, now the additional investment for the modification or replacement will be the cost of new equipment minus the actual market value of the replacement of the equipment that we are trying to replace. Now this there is another method for calculating this particular thing is the original value minus the depreciation fund that is accrued that is alternate. However, we have to take the actual market value, because we may been error while estimating the depreciation at the beginning of the project, so we go for the actual market value.

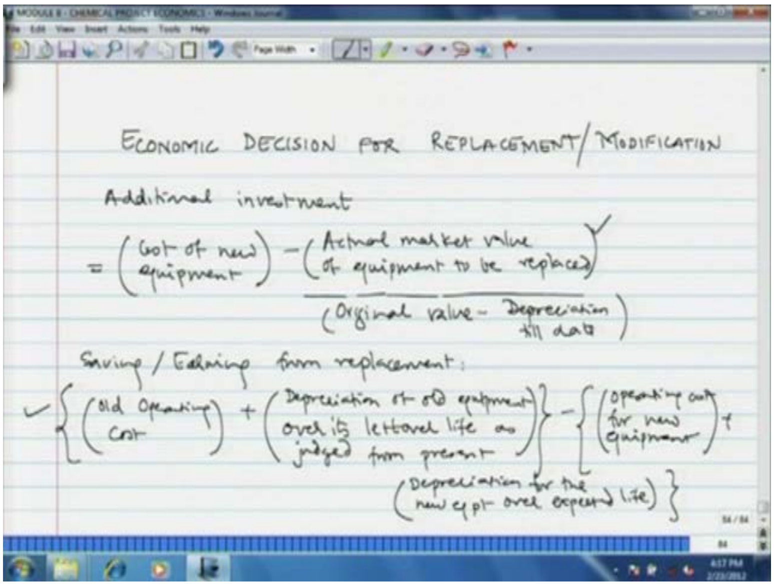
Now the saving that we expect to get saving or earning from replacement is the old operating cost plus the depreciation of old equipment over it is expected life or you will say left over life as judged from the present minus the sum of operating cost for new equipment plus the depreciation for the equipment over it is expected life. So, this is the net saving or earning that we are going to get from replacement and this should serve as another tool for making the decision of replacement.

(Refer Slide Time: 40:59)



So, perpetuity is a definition for choosing between the equipments different equipment.

(Refer Slide Time: 41:05)



And then this saving or earning for replacement is a criteria for replacement of old equipment with new 1 with better performance. So, this essentially completes our treatment theoretical treatment on project economics. So, let us summarize what we have learnt in this entire module, we started with the project basically the introduction to the project cost, the project site process selection, what are the aspects related to process selection, technology selection what are the criteria for site selection.

Then we saw in detail the project cost estimate the components of capital cost, the components of operating cost, and then how they are related, how they can be inter converted. Thereafter, we developed a simple model for investment where we can calculate the total capital investment only on the basis of the onsite cost or the total capitalized installed cost of the major equipment in the process.

Thereafter, we came to the profitability analysis, we saw different measures of profitability the breakeven analysis, the incremental analysis, ratio analysis. And today we have seen the discounted cash flow technique and a technique of perpetuity and replacement. So, this essentially completes a theoretical treatment in this module, in the next 2 lectures we will we shall try to solve problems based on this the theory that we have learnt. And then how we can apply theory for the evaluation of different projects and equipment and replacement. So, this essentially completes theoretical treatment in this module in the next 2 lectures we will we shall try to solve problems based on this the theory that we have learnt.