Principles of downstream techniques in Bioprocess – a short course

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Lecture – 03
Costing

Today am going to talk about costing. Costing of the equipments and how the equipment cost is going to impact on the final selling price of a product. In the last class, I did mention that, sometimes fermenter are expensive, sometimes the downstream steps are expensive and downstream steps may contribute to 30 to 60 % of the overall equipment cost as well as the overall manufacturing cost. So how do we judiciously select downstream equipments in addition to their efficiencies and separating principles.

How cost is going to play important role in your selection process and that is what we are going to talk about in today's lecture and am going to introduce many terms like depreciation, fixed cost, working capital, payback period and the net present value and so on actually and all those are very very important if we are going to select one equipment over the other. For example should I select filter for removing solids from a slurry or should I select centrifuge?

How do you decide? Based on efficiency of course, we will decide and then in addition, we can also use the cost factor as well how much will a centrifuge will cost, how much will a filter cost,
What will be the expenses for running a filter, what will be the expenses for running a centrifuge.
So sometimes you may make the decisions based on the costing and that is what is all about in today's lecture. So what are the contributions towards equipment cost.

It is not only just buying the equipment okay but then there are so many other things that may come into towards the running of the equipments.
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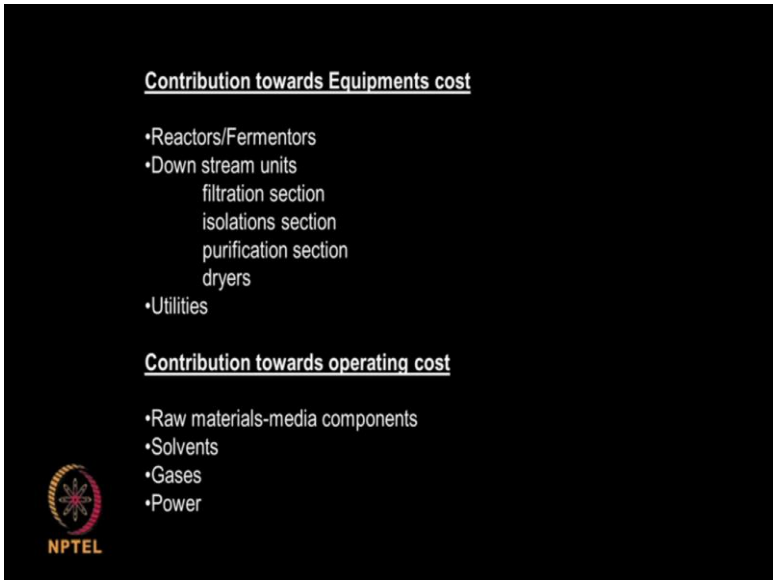

Okay so contributions towards equipment cost could be reactors, fermenter, then there could be cost of the downstream units like filtration units, isolation units that could be membranes that could be things like liquid-liquid extraction units. Then the purifications, could be different types of chromatographies, crystallizers and then the dryers and then in addition, we also have to consider the utilities because no biochemical engineering, manufacturing facility runs without cooling water or steam or hot oil chilled water gases and so on actually.

So all these contribute to the equipment cost. Now what are the things that contribute towards the operating cost. Operating means running material costs various raw material which will use in your media preparations, Solvents, may be using a lot of solvents in your extraction and other separation process. Gases, may be using gases and then power, the electricity which we use, so all these contributes towards the operating cost. So you have the equipment cost. Cost that is related to equipment and the cost related to the operating as well actually

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Now the cost of the equipment not only includes direct cost of the vessel. Suppose am buying a fermenter, which may cost 20 lakhs or 25 lakhs but then I will need to spend money on installing it. That means I will need to spend money on the civil work, fixing it and then I will need to put pipings for the raw materials to come in, for liquids to go out, for gases to escape, electrical fittings, insulations, contractor fee and somebody who comes and sets up the whole equipment.

So the cost of the entire fermenter may be, not only cost of the equipment, the fermenter... but all these so that the fermenter is made operational. So generally it can even end up twice or even three times the actual cost of the fermenter. For example, you may spend like 20 lakhs to buy a fermenter, I may spend another 20 lakhs to do the fixing of the fermenter, putting in pipes, putting in electrical fittings, putting in insulations, having people actually fixing the whole fermenter, so that may run up to another 20 to 25 lakhs actually.

So that is how you need to do the costing, so the cost of the equipment plus all other costs to make it operational or make it running.

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Now there is something called fixed cost and variable cost and I will am going to tell you what is fixed cost. Okay. These are the cost required to produce any product okay, they do not change based on the volume of the product whether I will make 100 tons per year or whether I will make 120 tons per year, the fixed cost will be always fixed. It do not change. For example if I am putting certain facilities administration am not going to change the number of people in the administration of facilities.

Whether I am making 100 tons or 120 okay, then I will be paying some interest on the loans I have taken. There will be something called depreciation expense, all these will be fixed irrespective of whether I make 100 tons or 120 tons per year. These are called fixed cost that means the number of people, people in the administration, people in the research and development, people in the technical service, people in the quality control..

Am not going to change the number of people whether I produce this year 100 tons next year 120 tones. Same thing, the amount of interest rate I may be paying is fixed whether I make 100 tons or 120 tones because the amount of interest I pay depends on how much money I had taken and that is always fixed. Same thing happens to the depreciation also. The amount of money that gets depreciated on those equipments will not change whether I make 100 tons per year in 2015 or 120 tons per year in 2016 that is why it is called fixed cost.

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So analogous to that we will also have the variable cost. So this variable cost will change or vary depending upon the volume of production or service am doing. So if am making 100 tons per year, I will have certain variable cost and if next year I make 120 tones, I will have different variable cost because the raw materials I will be buying is going to be more. Transportation will be more, sales be more, I may be using more electricity, more water, more utilities.

So those will be more so depending upon the amount I am going to make, the cost also will vary that is why it is called variable cost. So the total cost is the sum of the fixed cost and the variable cost. So fixed cost is always fixed irrespective of how much I made, whereas variable cost vary depending upon the quantity of material I produce okay. So the raw materials, the consumables, electricity, the labour cost, the transportation, sales, commissioning, all these will be varying depending upon I am producing.

So the total cost is sum of both okay, so if I want to make a profit, I need to consider the total cost for manufacturing certain amount of my project in the year 2015. So this is very important number to have, so that you will add on top of it other cost like interest rate, depreciation and so on and then if you calculate your selling price of your product okay.

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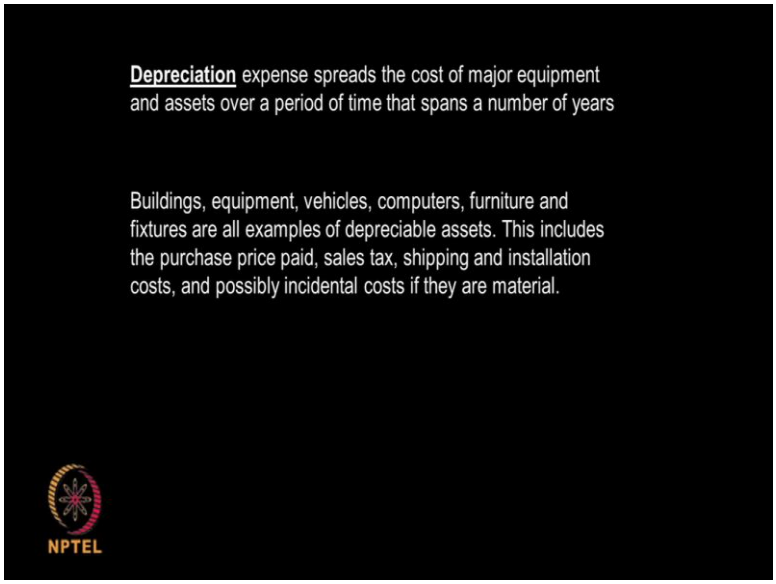

Okay there is something called depreciation. I would like to introduce what is depreciation because this is the expenses spread on the cost of the major equipment, over a period of time that is the life of the equipment. So for example if an equipment last for ten years and I bought the equipment for 10 lakhs then the cost of the equipments keeps going down every year by 1 lakh right? That means the actual value of that equipment is becoming cheaper and cheaper over the period of its life.

So depreciation is applicable for all hardware equipments like buildings, vehicles, computers equipments, furnitures, fixtures, your chromatography or fermenter, everything will have a depreciation value actually and the life depends, for example a high tech product like a computer may have two years lifetime whereas a building have a lifetime of 15 years. So a filter may have a life lifetime of 8 to 10 years.

So high tech equipments may have very short life whereas low tech equipments may have a very long life and there is something called resale value. That means how much value at you at which you can sell it at the end of the life. Sometimes nobody will buy that equipment. It may be selling as a junk that means it will not have any resale value okay, just like cars, if you have high end cars, it may have a resale value whereas if you have a very low-end cars at the end of 10 years or 15 years people will buy it as a junk.

So same thing is there actually, so depreciation is applicable to all equipments and assets and it spans over the life of that particular asset actually.

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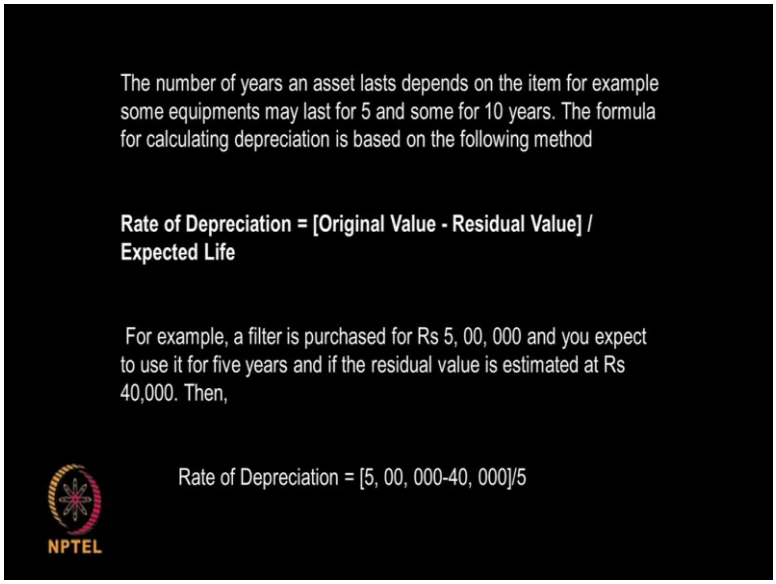

Before so it can last 5 years or it can last 10 years like I said a computers life can be even two years Actually, so there is a formula it is called the rate of depreciation. Original value - residual value. That is the resale value. So the resale value is not there, then that will become 0/ the expected life. Okay so that is what is called the rate of depreciation. For example I am buying a filter for 5 lakhs and then you expect it to last for 5 years and then its residual value or resale value is 40,000 rupees.

So what will be the rate of depreciation. 5 lakhs – 40,000/5, 5 is the total number of year, okay, so that is how you calculate the rate of depreciation. It is very important because when you are calculating the fixed cost, you need to consider the depreciation, so if there is a factory where you have spent about 10 crores of money for buying all the equipments, they will all have a depreciation. So next year it will be less than 10 crores so that amount needs to be added to the fixed cost.

For example even in our cars, when you buy a car, for say 7 or 8 lakhs and next year the cost, the price of the car will be less than the original price, based on the depreciation value especially when the insurance is put on the car, they calculate depreciation value and then the insurance is calculated based on the depreciation value.

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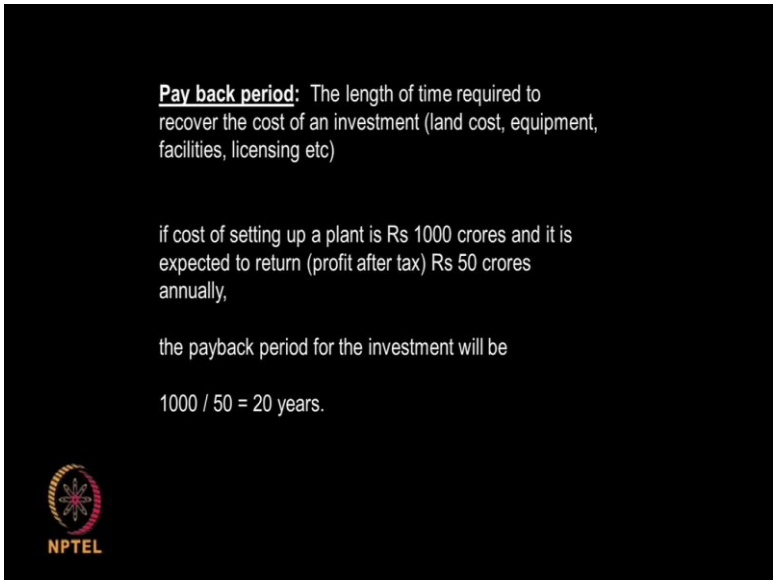

So then there is something called payback period. How many years I will take to get the amount of money I have invested okay that is very very important. I would like to have a very small payback period so that whatever I invested I get the money back very fast. For example if I have put thousand crores to put up a plant okay and every year am getting 50 crores that is profit after tax, you subtract all expenses, tax everything, you are getting 50 crores as your profit okay.

Then the payback period will be I am putting 1000 crores, am getting 50 crores annually, so 1000/50 is 20 years that means in 20 years, am getting the entire money I have put in there and this is very important because if I have two projects and I want to plan which one to put my money especially as a venture capitalist, I would like to know what is the payback period and if the payback period is smaller than I would like to put my money in that because I will get the money back very fast when compared to a project where the payback is much longer.

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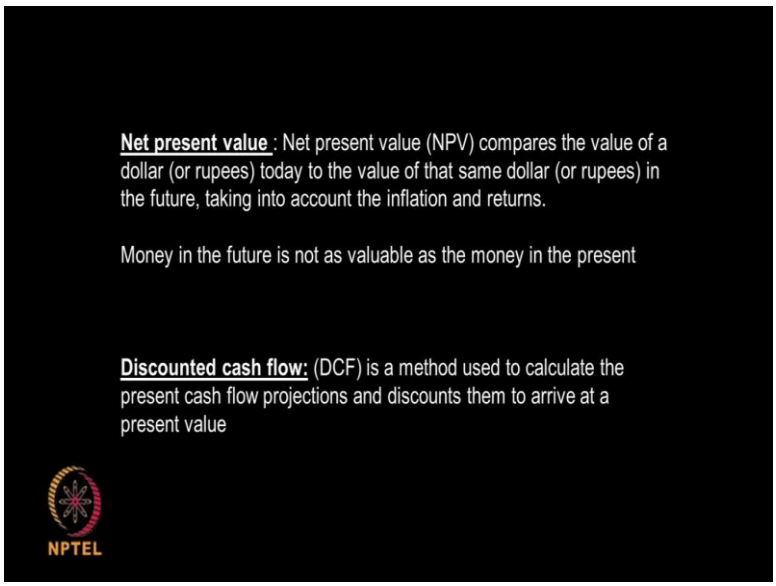

Net present value this is also very very important. It compares the value of a money today, to the value of the same money in the future okay. We all know that money loses its value as we go along. For example we always say our father could spend with 100 rupees, what we take now almost 1000 rupees. So their value of the money has gone down, may be our grandfathers would have used may be 10 rupees to get the same value.

So the value of the money goes down and the net present value is very very important for us to calculate. So a 1000 rupees in the year 2016 is not the same thousand rupees in 2015 so it is much less and if somebody says you give me 1000 rupees today and I will pay you 1000 rupees in 2016 actually, you are losing money because the net present value of that 1000 in 2016 could be much less. It could be even 950 rupees or even 900 rupees depending upon the personal interest.

So why does it happen? It happens because of the value of money goes down, there is inflation the prices of all the items, services go up, so money has loses its value as time goes on actually and there is something called discounted cash flow and this is the method we use to calculate the present cash flow projections. That means, if I will am running a plant and I will get 1 crore in 2016 and 1 crore in 2017 and 1 crore in 2018 and so on I will cannot say 1 + 1 + 1 3 crores is what is the current net present value or current value right?

Because as I will said your 1 crore in 2016 could be much less than 1 crore in 2015 and the 1 crore in 2017 will be much less than in 2015 much less and the one in 2018 will be much much less. So the current cash flow if I will bring it down to the current date will be much less.

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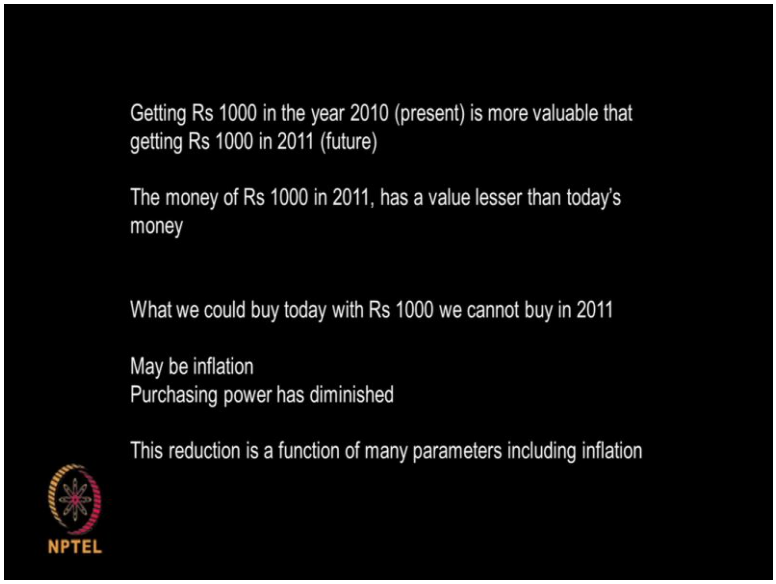

And there is a formula for calculating the discounted cash flow and I will show it here actually. So a 1000 rupees in the year 2000..... say 2010 is more valuable than getting the 1000 rupees in 2011 that is future, for example okay, so the money of rupees 1000 in 2011 has a value lesser than today's value. So how do we calculate that okay. So there is something called the discounted cash flow by which you can calculate because the purchasing power has come down and down actually because of that plus inflation and prices (())(15:04) and so on.

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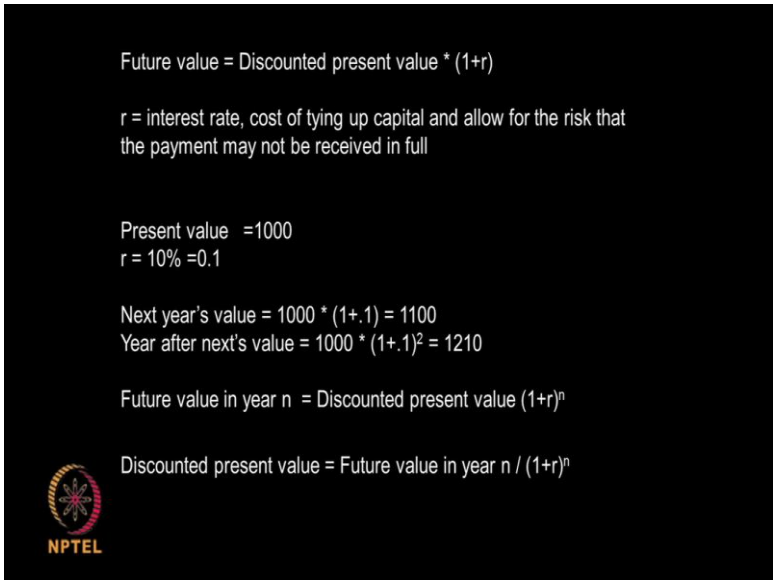

So future value is the present value into okay 1 + r, where r we will call it as the interest rate. Okay, so the future.... so today's 1000 could be equivalent to much larger than 1000, based on this formula that is 1+r, r is the interest rate that is cost of tying up capital and allow for the risk that the payment may be made and so on actually. Generally r is taken as 10 % this is what generally followed. So 10 % means r = 0.1.

So the future value that is in the next years, value of 1000 rupees of today will be 1000 into 1+0.1 that is 1100, that means a 1000 rupees today is equivalent to 1100 rupees next year or a 1100 rupees next year 2016 is equivalent to your 1000 rupees in 2015. So I can extend this further so if I will consider 2017, then a 1000 rupees today is equivalent to 1210 in 2017. So a 1210 in 2017 is equivalent to 1000 in 2015. A 1100 in 2016 to 1000 of today and that is what is called the discounted present value.

So how do you calculate? The same for the formula can be put in this way or in the reverse way. The future value is discounted present value into 1 + r raised to the power n or discounted present value will be equal to future value in year n / 1 + r raised to the power n. So this is coming in the denominator for calculating present value because it will keep coming down. A 1210 in 2017 = 1100 in 2016 and it = 1000 in 2015 so it is coming down okay, so that is why it comes in the denominator.

It is a very useful formula to understand the cash flow because when you setup a company and when you spend some money in the capital, your profit is not coming all today. Your profit is coming in 2016, 17, 18, 19 and you cannot add up all these and call it as a total profit. Because money has losing value every year. So we need to use this type of discounted present value concept, to calculate what is the value of the money as of today, when compared to the money that is given 1 year from today or 2 years from today or n years from today and that is what is called the cash flow and this is very very important for us to understand okay.

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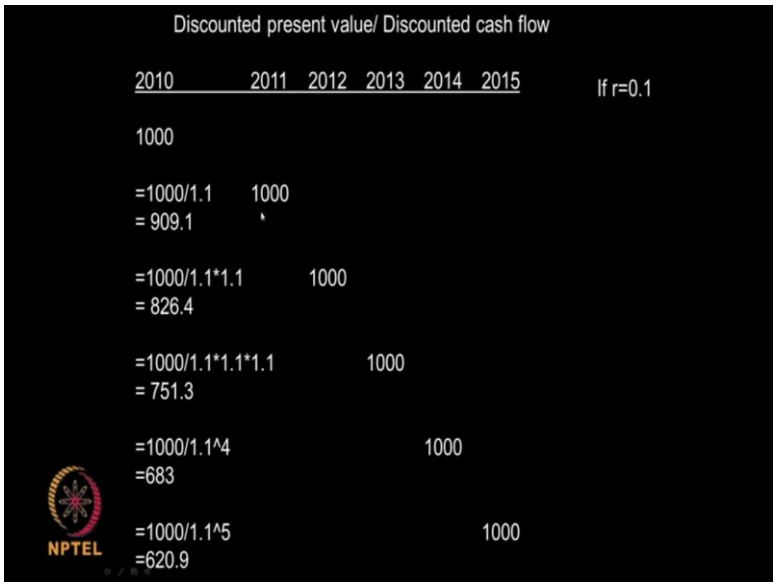

So as I will said, if I will have 1000 today, if I will say 2010, 1000 today and if I will 2011, 1000 is equivalent to 1000 / 1 + 0.1 raised to the power 1. So it becomes 909, so in 2012, if I will get 1000

rupees that = 1 + 1.1*1.1, that is 826. So in 2013, if I will get a 1000 rupees, that = 1000 / 1.1 1.1 1.1 multiplied together that is 1.1 cube that is 751 and so on. So that means in 2015, if somebody says its 1000 rupees in 2010, it is equivalent to 620 rupees okay.

And if somebody two.. 1000 rupees in 2014, that will be 683 rupees of 2010, you see if somebody two..... 1000 rupees 2013 that = 751 rupees in 2010. So if somebody says I will give you 1000 rupees in 2011, 12, 13, 14 and 15 and you are in the year 2010, you cannot just say I will be getting 5000 rupees from him, but I will be getting actually. 909 + 826 + 751 + 683 + 620 that is called the discounted cash flow. That is called the present based on the present value of the 2010 year that will be the discounted cash flow.

And this is important as I will said when you are calculating profits because your profits are not coming in one single year but it is spread over many years in the future, next 10, 20 years so the amount of money of say 1000 rupees in 2020 or 2030 is not same as 1000 rupees of today okay and that is where we use this formula.

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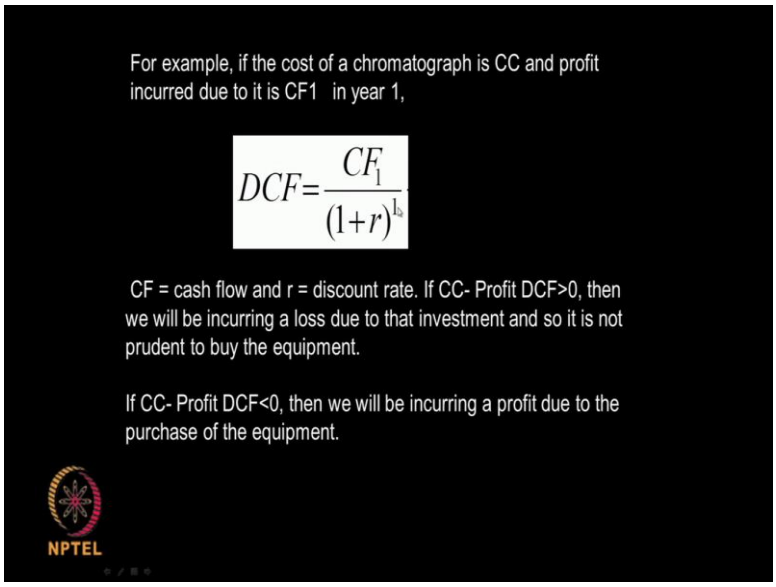

And this is the formula, the discounted cash flow = the cash flow in that year / 1 by r raised to the power, if it is 1 year it is 1, 2 years you put 2, if it is n year you put n and that is how we calculate the discount at discounted cash flow okay. So I would have spent some money today and then am going to get money back next year and so on and so on.. So I will calculate the discounted cash flow and then I will see whether the discounted cash flow is greater than my CC okay

Or if it is less than my amount of money, I will have put in and if it is less, then obviously we can

say I will am under loss. If I will am going to get more cash flow when compared to the amount of money I will have invested, then I would say it is a profit. So if I will have suppose, I will buy a chromatography for a cost of CC and I will am getting profit every year, you know CF1 in the year 1, CF2 in the year 2, CF3 in the year 3 and so on.

So what I will do? I will do CF1 /1 + r + CF2 /1 + r square + CF3 / 1 + r 3 and so on and I will calculate the total DCF, that is discounted cash flow, I have spent CC amount of money to buy the chromatography okay. So if CC - DCF is greater than 0, that means CC is larger than this year that is discounted cash flow so obviously am running under loss.

If CC - DCF is less than 0, that means DCF is larger than CC, then I will am making a profit of them and that is how I will need to make decisions. To say should I will buy a chromatography and so on actually.

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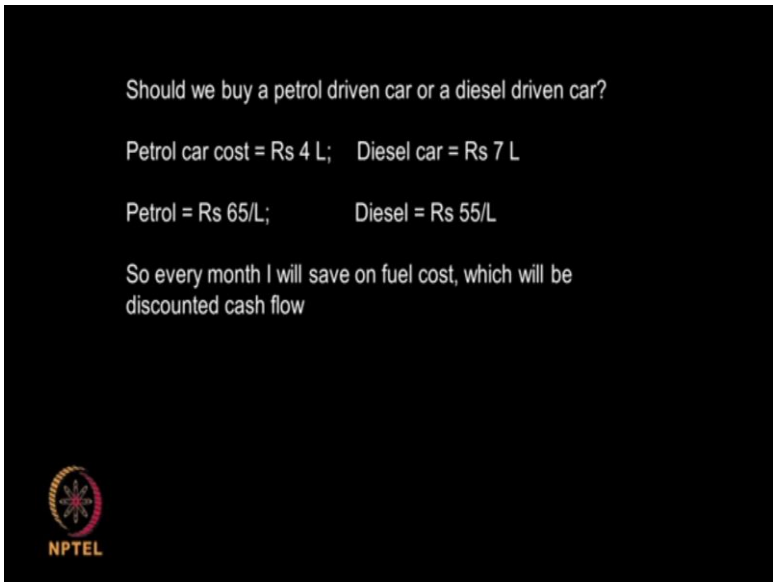

Okay we can use this very effectively when you are buying a car. We all make decisions, should I will buy a diesel car or a petrol car? You know diesel car will cost more, petrol car will be cheaper but then petrol is more expensive than diesel, so whenever am running the car, I will save on the fuel but that saving on fuel is not immediate, I will am going to save in 2015, 2016, 2017, 2018. So the profit on savings will be over the next 10 years of the car's life but the amount of money,

I will have spend will be immediate, that means I will be spending more on the diesel car while purchasing, so I will can use this discounted cash flow approach to see is it very effective or very profitable by a diesel car or is it very profitable by a petrol depend car. You understand, so am I will am spending more money to buy a diesel car, am spending less money to buy a petrol car but I will

be spending more on the fuel cost on petrol when compared to cost on diesel but the savings is not going to be immediate.

It is going to happen for the next 10 years when I will am running the car, so my profit keep coming over the next 10 years. So I will need to use this type of cash flow approach to see is it profitable to have a diesel car or is it profitable to have a petrol car okay.

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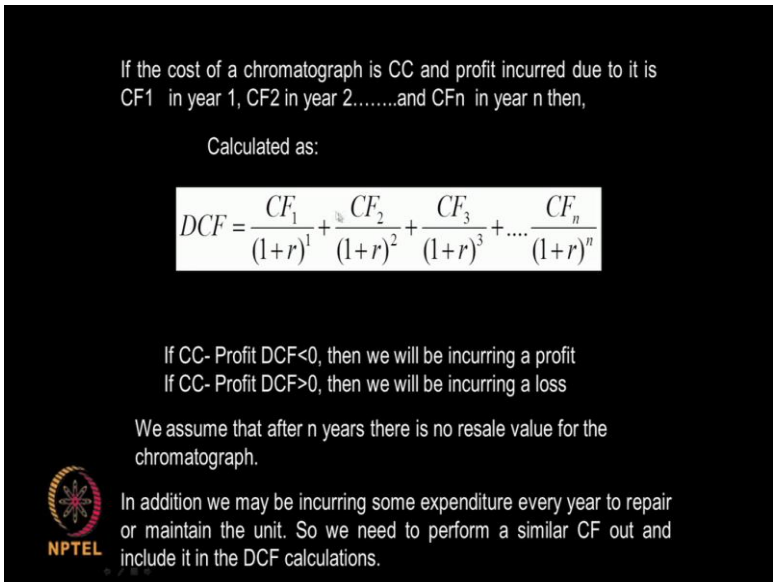

So same thing okay and this is what the formula is we talked about. DCF, discounted cash flow we need to add this over the next 10 or 15 years of the life of that product actually okay. If it is a petrol driven car or diesel car, you need to do the same thing or if it is the chromatographic column, you need to do the same thing okay.

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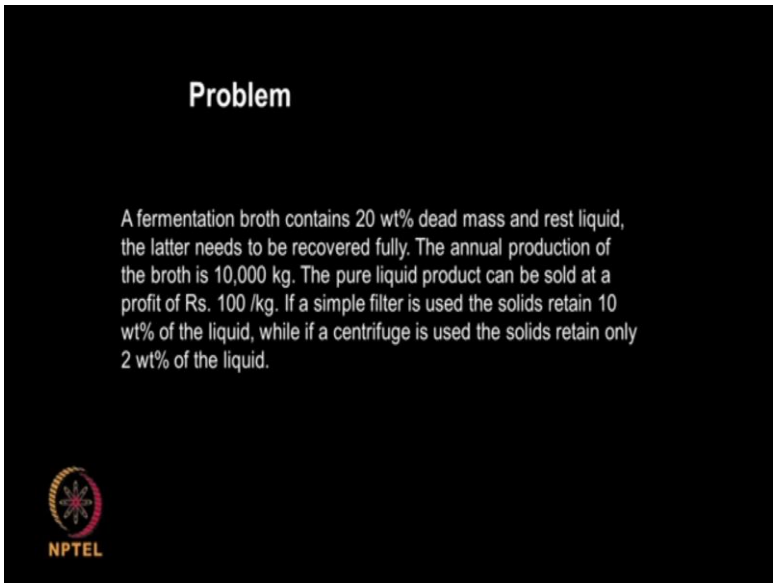
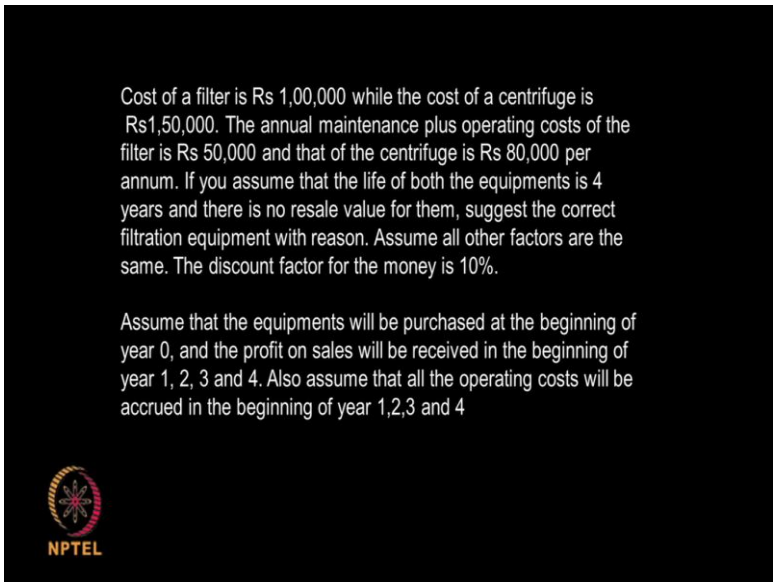


So we can use this in our downstream, for example I am wanting to decide, should I will buy a filter to remove the dead biomass or should I will buy a centrifuge to remove the dead biomass. Okay. So

if I will use a filter, filter is very cheap, the centrifuge is very expensive but when I will use a centrifuge I will be able to remove all the liquid very efficiently and if I will use a filter, the efficiency of removal of the liquid is not so good.

So if the liquid is my desired product with a centrifuge I will can recover more product, so I am going to spend more money in purchasing a centrifuge, I will pay less money to purchase a filter but I will make more product in a centrifuge because it is more efficient I will make less product in a filter because it is less efficient so I will make more profit with the centrifuge but the profit is going to happen for the next 10 years, if that is the life of the centrifuge or the filter so. What should I do? (Refer Slide Time : 24:57)



Should I will buy a filter or a centrifuge and that is what this problem is all about actually and exactly it makes use of the discounted cash flow approach and we can calculate as you can see here the cost of this filter is 1 lakh, cost of the centrifuge is 1.5 lakh so just like car petrol and diesel centrifuge is more expensive than the filter but then am going to get more product out of the centrifuge when compared to a filter.

More product means more profit, so I will am making profit more, in the centrifuge less profit but the profit is going to happen in the next five years. So I will need to calculate the discounted cash flow and net present value okay and see is it more efficient to have is it more profitable to have a centrifuge or a filter. It is a typical example of where lot of costing comes in as you can see, I will use the concept of discounted cash flow, so I will need to decide

Should I will go for a filter or a centrifuge. Just by looking at it you may say filter is cheaper, so go for it, but then I will am also going to get more product because centrifuge is more efficient, it will take out more product.

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So but then the more profit is coming next year, next year, next year and so on for the next 5 years. So how do I will really judge that? That is where this concept of discounted cash flow comes into picture. So that is what I will am doing actually. I will see the yield of the product, I will see if the centrifuge is used how much product I will get, if a filter is used how much product I will get, so if I will use the filter, the profit will be 7.2 lakhs, if I will use the centrifuge, the profit will be 7.8 lakhs.

So every year I will keep getting profit, so the filter cost 1 lakh, centrifuge cost 1.5 lakhs which is the expense I will need to put in immediately. Immediately means years 0 but the profit is coming 1 year after another in the next 5 years and then I will also spend some money on maintenance of the filter and centrifuge. So may be centrifuge maintenance is higher so again you can do maintenance also on the discounted cash flow.

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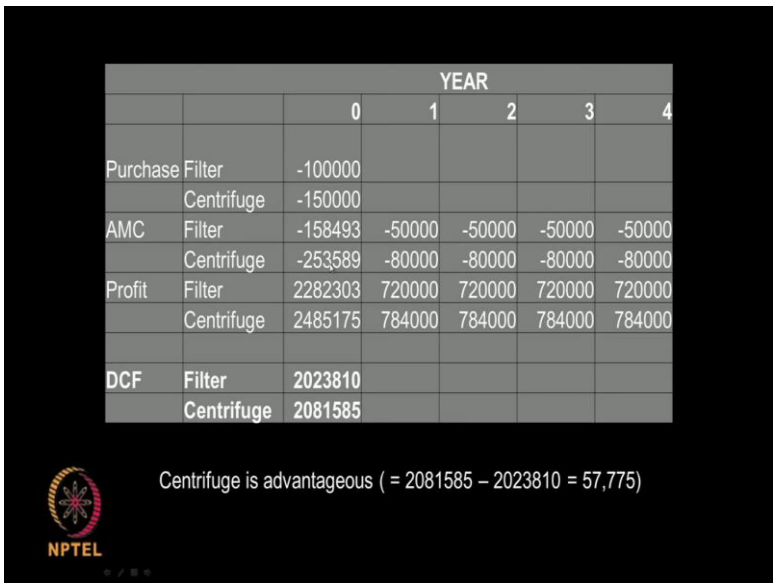

So I will make an excel sheet like purchase, this is the cost am spending and then profit coming

over the next 5 years, then I will calculate the discounted cash flow from year 1 to 0 here 2 to 0 here 3 to 0 here 4 to 0 and then when I will do all these calculations, I will see that centrifuge is more advantageous than a filter okay. I will make a extra profit of 57,775 although I will spend 1.5 lakh by in centrifuge, this is very useful problem because many times you make decisions.

Most of the times you make decisions, based on the yield, purity, operability but cost plays a very important role ultimately. It is the cost of the equipment that is going to decide because if you remember the previous class, I will talked about downstream units, the cost of operating a centrifuge, the cost of operating various units and so on. So you need to understand the costs plays a very important role and decisions can be made based on this cost.

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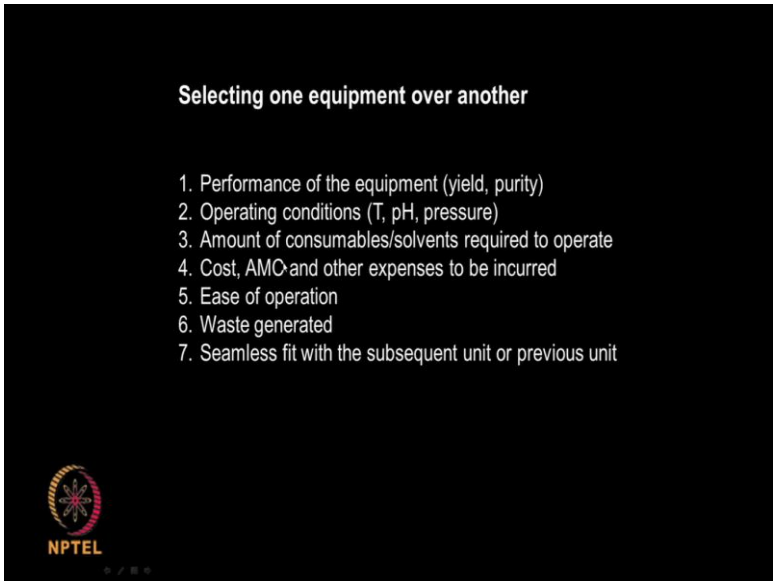

So when you are selecting an equipment, it is not only yield, purity, temperature, pH, pressure, amount of consumable, cost, annual maintenance, contract, other expenses you are going to put in, how easy to operate, how much waste is generated, can I will move from one unit to another unit operation, all these we need to consider actually. So when we are designing equipments we are talking about cycle time, operating parameters hardware. Designing equipments involves design equations vendor details safety margin and so on actually.

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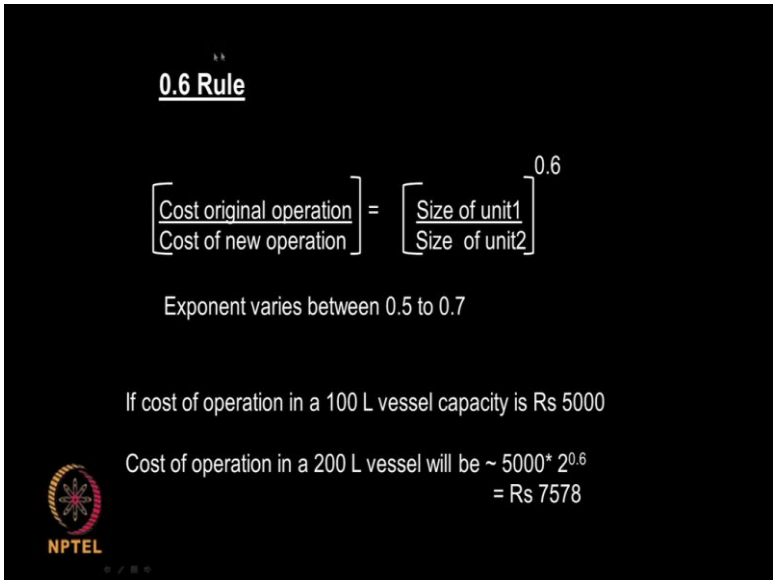

Another interesting rule, this is called the 0.6 rule. So if I will have an equipment say 100 litre filter and it costs certain amount and if I will want to approximately calculate what will be cost of 200 litre? Then I can use this type of rule and it is called 0.6 rule. Interesting.. Cost of original / cost of new = size of original / size of new raised to the power 0.6. Generally this number can vary between 0.5 to 0.7 okay. So generally we can take it as 0.6.

So if I will am operating a 100 litre vessel and it cost me 5000 rupees, how much it will cost me to operate a 200 litre vessel? So all I will have to do is, I will put in here cost of original operation is rupees 5000, new operation here, I will put 100 I will put 200 so it will approximately tell you it cost me rs.7578.

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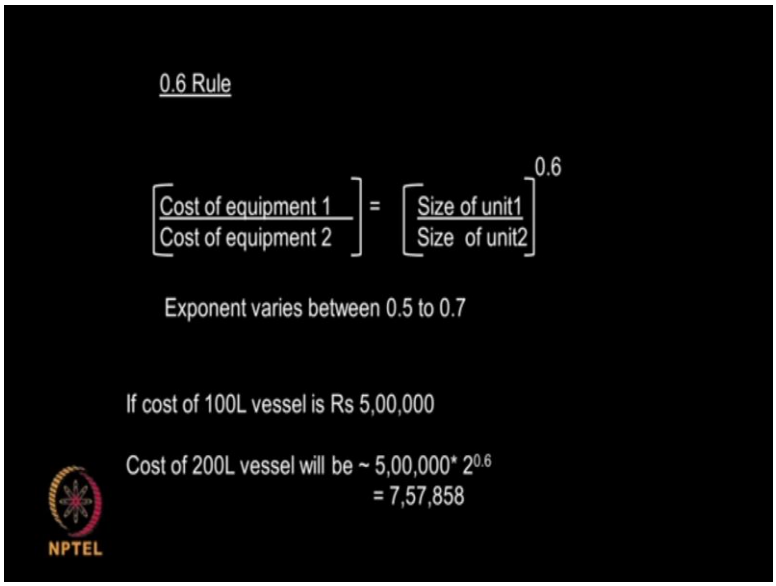

Interesting, so same rule can be used for calculating the cost of the equipments also. So if cost of equipment 1, I will know suppose 100 litre equipments, I will know its cost is 5 lakhs and 200 litre I

will want to know approximately what is the cost, I will can use this formula where this is called 0.6 rule because we are putting a 0.6 here in the exponent so a 100 litre cost 5 lakhs so a 200 litre vessel cost how much okay. So you put 5 lakhs here in the bottom is unknown, you put 100 here, you put 200 here

And when we calculate it gives you 7.57 lakhs. So cost of 200 litre vessel could be.. This is the approximate especially when you are doing an approximate calculation. This is very very useful but actually you may ultimately go to the vendor and find out the actual cost but initially as a ballpark figure you want to know how much it costs then this type of 0.6 rule is very very useful both for costing an equipment as well as operating an equipment.

So today we saw lot of interesting costing related terms payback period, net present value, depreciation and these 0.6 rule, fixed capital, working capital and so on actually. These are very important when deciding on cost of downstream and especially when you are deciding on which equipment to buy and so on actually. Okay.

Thank you very much!!