Plant Design and Economics
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Lecture No-14
Methods of Capital Cost Estimates

Welcome to lecture 14 of plant design and economics. In this week we are talking about analysis of cost estimation and this today's lecture will talk about various methods for capital cost estimates. So, we will talk about various methods and these methods have different degree of accuracy so they are used for different purposes. We have already talked about order of manager estimates; we will talk about various other methods now.

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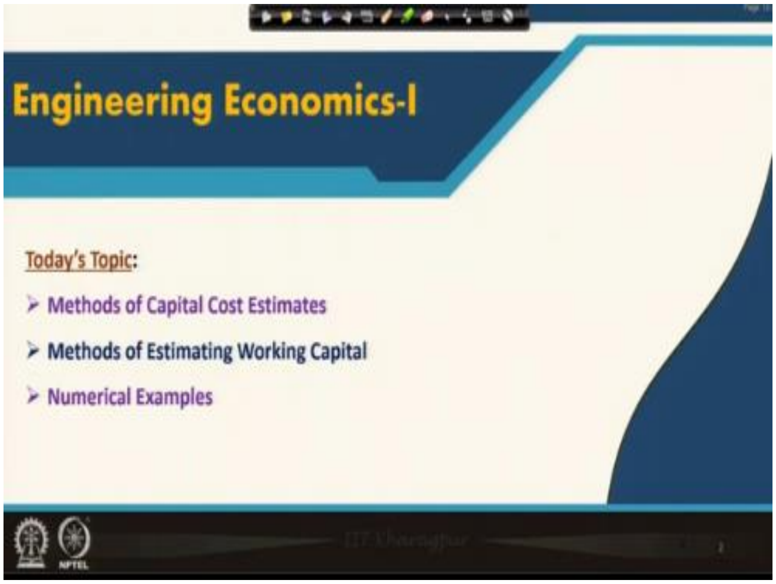

So today's topic will be we will start we will talk about methods of capital cost estimates then we will also briefly talk about methods of estimating working capital and then we will take few numerical examples.

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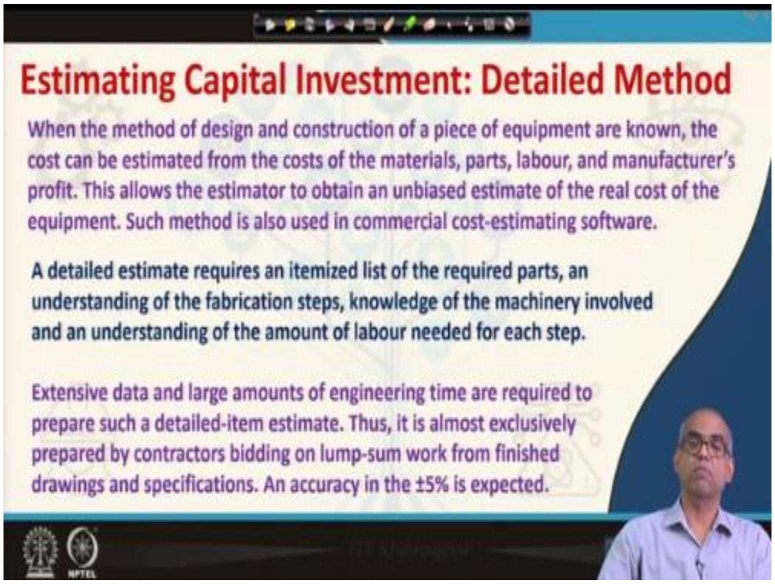

Now let us start with detailed method of estimating capital investment. When the method of design and construction of a piece of equipment are known, the cost can be estimated from the cost of the materials, parts, labour and manufacturers profit. This allows the estimator to obtain an unbiased estimate of the real cost of the equipment. Such methods are used in various commercial cost-estimating softwares that are available.

Commercial cost-estimating software will use various correlations and such correlations are based on such detailed method of estimating capital investment. So detailed method of capital investment requires extensive informations you need to know the method of design and construction make cost of the materials, parts, labour and manufacturers profit. So of course the accuracy of such estimate will be very high.

A detailed estimate requires an itemized list of the required parts, an understanding of the fabrication steps, knowledge of the machinery involved and an understanding of the amount of labour needed for each step. So it requires very extensive information about as each and every step of the process. Extensive data and large amount of engineering time are required to prepare such a detailed-item estimate.

Thus, it is almost always prepared by contractors bidding on lump-sum work from finished drawing and specifications. An accuracy in the range of plus minus 5% is expected.

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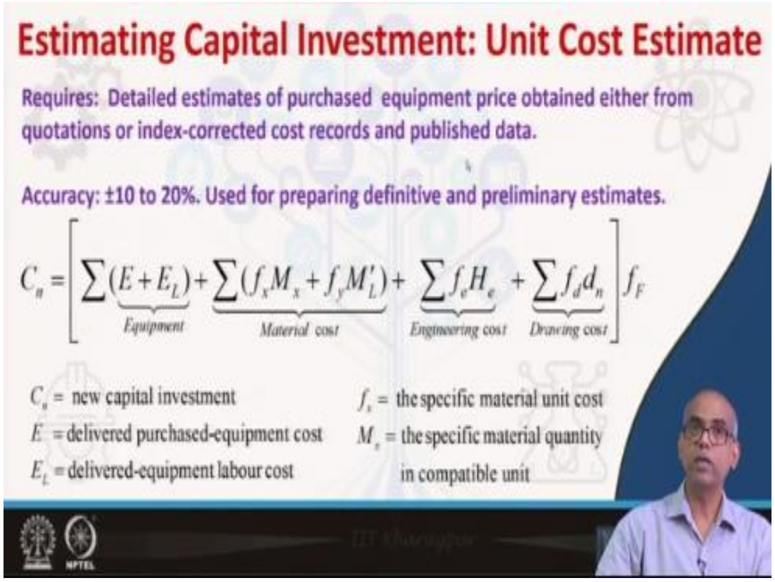

The next method for estimating capital investment, we talk about is based on unit cost estimate. So what is required is detailed estimates of purchased equipment price obtained either from quotations or index-corrected cost records and published data. Index-corrected cost records means that you have corrected the cost data for inflation. Now the accuracy of this method is between 10 to 20%.

So this can be used for preparing definitive and preliminary estimates. Now this method is based on unit cost estimate, so the costs are broken into cost of equipment, material cost, engineering cost, drawing cost etcetera. Now you will see that for material cost, engineering cost, drawing cost everywhere there is a factor f. So they represent unit cost. Let us say fx Mx. So fx is an specific material unit cost and Mx is the specific material quantity.

See both are in compatible unit, then fx times Mx will give you the cost of that specific material. So unit cost multiplied by the quantity of the material.

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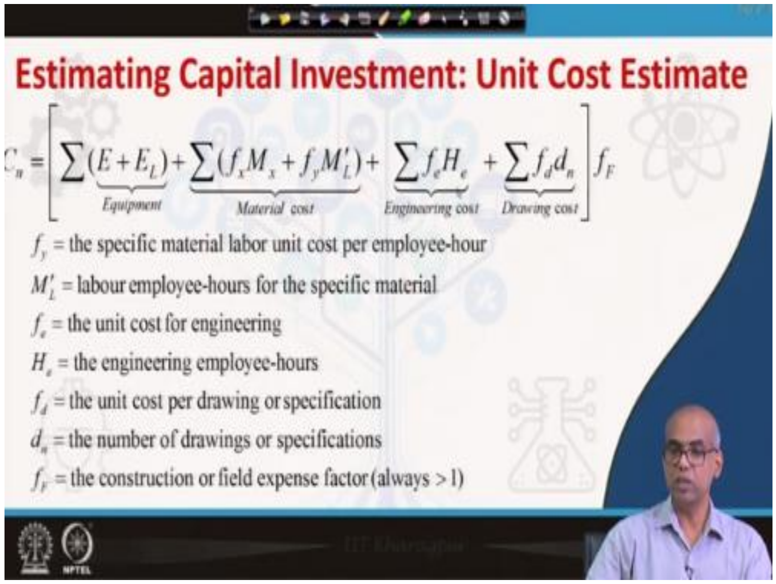

Similarly fy ML prime will be for labour, fe is the unit cost for engineering and He is the engineering employee hours. So their product will give you engineering cost. The same extends for drawing cost where f d represents unit cost per drawing or specification and dn is the number of drawings or specifications. E is the delivered purchase equipment cost and EL stands for delivered equipment labour cost.

So this way you can sum up all the cost and then multiply by a factor which we call construction of field expense factor, which is always greater than 1. So these estimates based on unit cost will give you about 10 to 20% accuracy, which is good for definitive and preliminary estimates.

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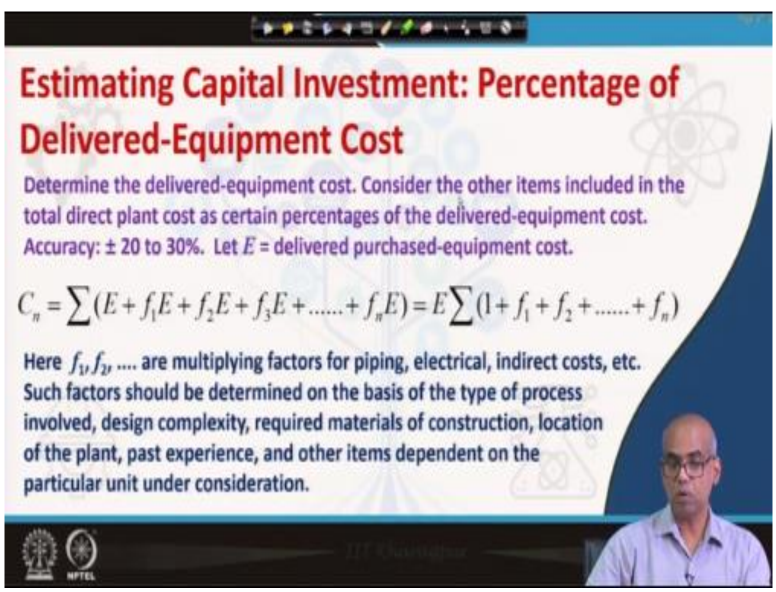

The next method of estimating capital investment is based on percentage of delivered equipment cost. First determine the delivered equipment cost and then consider the other items that are included in the total direct plant cost as certain percentages of the delivered equipment cost. So you get the delivery equipment cost. Then consider all other costs as certain percentage of delivered equipment cost.

So if the equipment cost is E, then all other cost will be like f1E, f2E, f3E etcetera where f1, f2 etcetera are multiplying factors for piping, electrical, indirect cost, etcetera. Such factors should be determined on the basis of the type of process involved, design complexity, required materials of construction, location of the plant, past experience and other items dependent on the particular unit under consideration.

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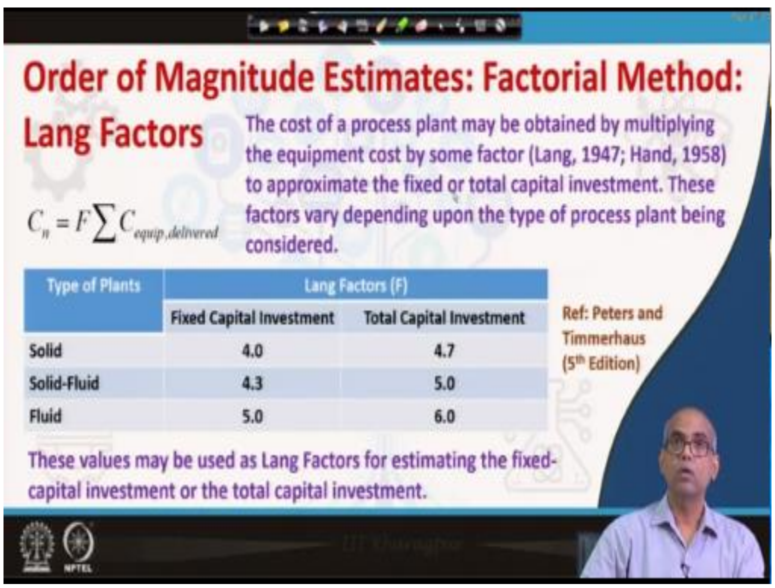

Next we talk about a very popular method known as method of Lang Factors. We also call this factorial method. The cost of a process plant may be obtained by multiplying the equipment cost by some factor to approximate the fixed or total capital investment. This factor is known as Lang Factor, this was initially proposed by Lang in 1947 and then later by Hand in 1958. These factors will vary depending upon the type of process plan, you are considering.

So if you have the total equipment cost, you simply multiply the equipment cost with Lang Factor and you will get an order of magnitude estimate for the fixed capital investment or the total capital investment. Note that this Lang Factor is used even these days. Now, look at this table. In this table the Lang Factors is given for various types of plants. Solid processing plant, solid fluid processing plant as well as fluid processing plant and the Lang Factors are given for both fixed capital investment as well as total capital investment.

These values may be used as Lang Factors for estimating the fixed capital investment or the total capital investment; you just have to multiply the Lang Factor with the total cost of the equipment.

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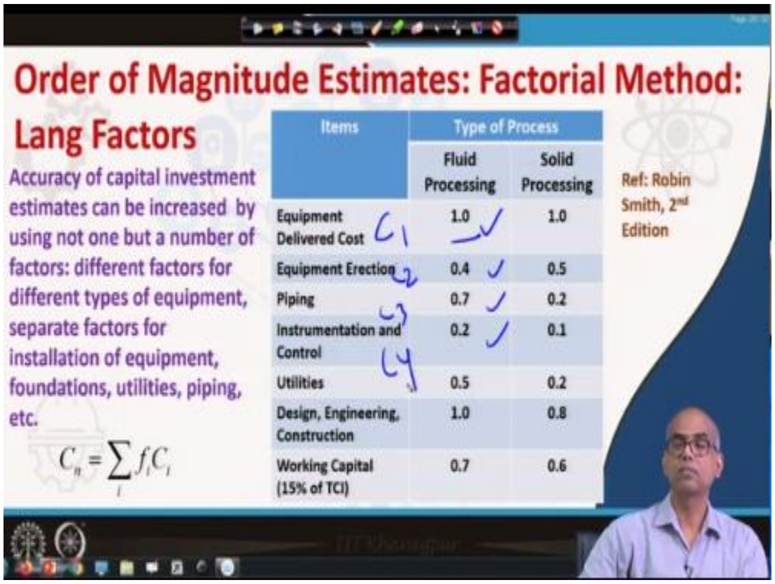

Now the accuracy of capital investment estimate can be increased by using different factors for different types of equipment, separate factors for installation of equipment, foundations, utilities, piping, etcetera. In the previous slide we have seen that we use one Lang Factor. So that was a lumped parameter and you use a single Lang Factor for your process instead of using a single parameter.

If I use various parameters different factors for different types of equipment, separate factors for installation of equipment, foundations, utilities, piping etcetera. My accuracy of the capital investment estimate will increase. So instead of using Cn = f into sigma Ci, I will now use Cn= sigma fiCi. So this will give me a better estimate, it will lead to higher accuracy. But you need to know for different types of processes and different items these factors some of these factors are shown in the table here.

All you have to do is you have to take this factors and multiply this with their corresponding cost except and then sum them up, so we will get a better estimate.

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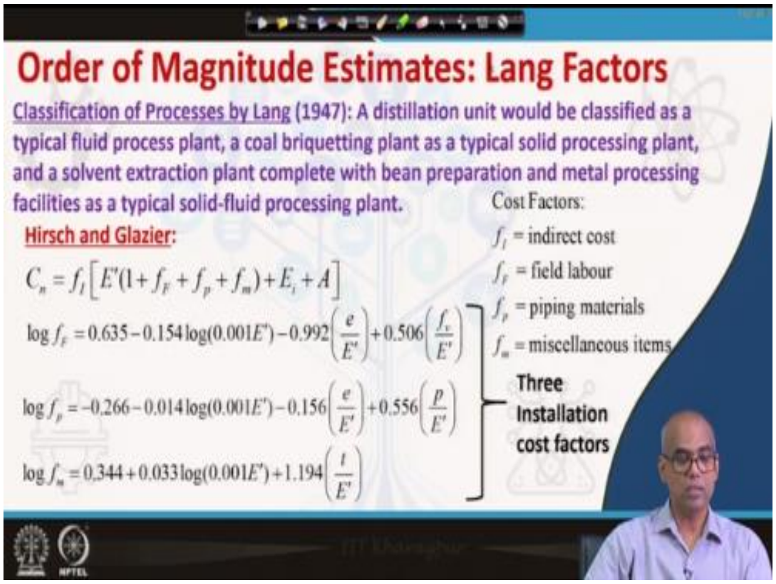

We talked about different processes like solid processing plant, fluid processing plant, and solid fluid processing plant. Now this classification was proposed by Lang in 1947 as follows. A distillation plan you need would be classified as a typical fluid process plant, a cold recording plant as a typical solid processing plant and a solvent extraction plant as a solid fluid processing plant. Now, it will be easy for computation if we make use of equation instead of tables.

So here is an expression for capital cost investment A capital cost investment estimate proposed by Hirsch and Glazier. You look at this equation, this equation involves several cost factors such as fI indirect cost, fF cost factor for field labour, fP cost factor for piping materials fm cost factor for miscellaneous items. Now, for these for three different installation cost factors fF, fP and fm, there are three equations proposed.

So one can make use of this equations and then compute because it is easy to code these equations and you can easily compute the capital cost for the process.

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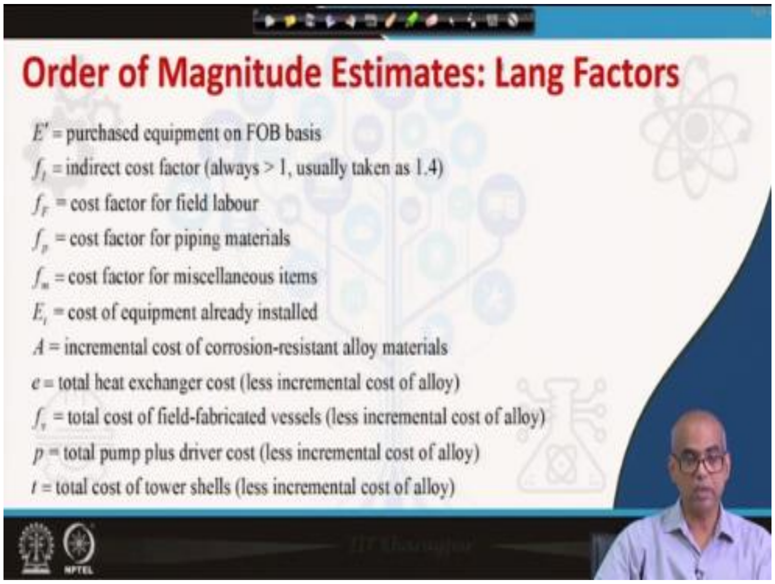

The various terms that are involved in this equations are given here.

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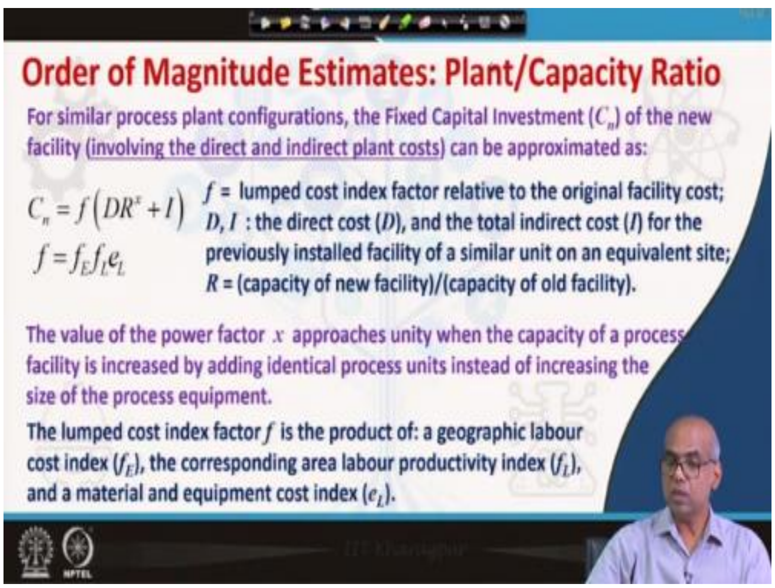

Next, order of magnitude estimate can be obtained from plant capacity ratio for a similar process plant configurations the fixed capital investment of the new facility involving the direct and indirect plant cost can be approximated as Cn= f into D into R to the power x + I. In this equation f is a lumped cost index factor relative to the original facility cost, D stands for direct cost, I stands for total indirect cost for the previously installed facility of a similar unit on an equivalent side.

And R is the capacity ratio which is obtained as capacity of new facility divided by capacity of old facility. So if you have the direct cost and indirect costs for a plant and, then you have this lumped cost index factor relative to the original facility cost f then it will be possible for you to estimate the cost for new facility with a different capacity. The value of the power x approaches unity when the capacity of the process facility is increased by adding identical processes units instead of increasing the size of the process equipment.

The lumped cost index factor f is the product of a geographic labour cost index, the corresponding area labor productivity index and a material and equipment cost index. How to compute these lumped cost index factor f, will be shown by taking a numerical example shortly.

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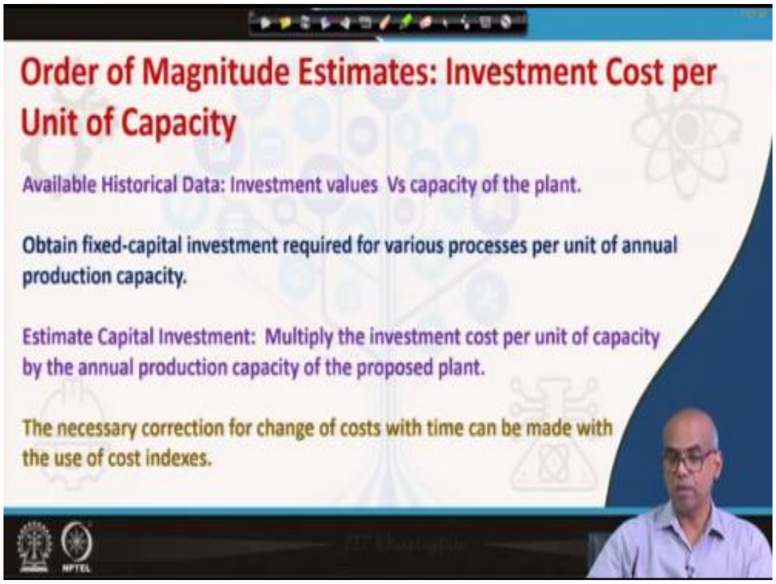

The next method for order of magnitude estimate is based on investment cost per unit of capacity. Suppose you have data available on investment values versus capacity of the plant. Then you can obtain fixed capital investment required for various processes per unit of annual production capacity. Now we can estimate capital investment by multiplying the investment cost per unit of capacity by the annual production capacity of the proposed plant.

The necessary correction for change of cost with time can be made with the use of cost indexes that we have talked before.

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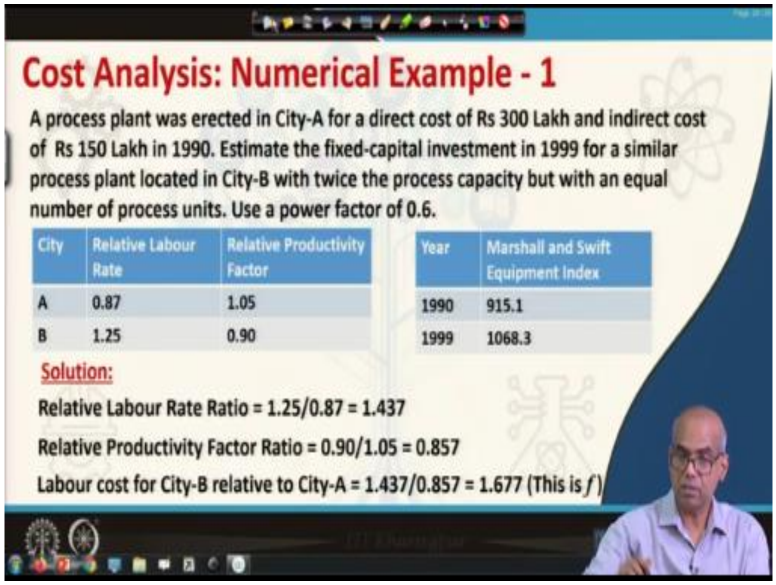

Now let us talk about few examples; A process plant was erected in City-A for a direct cost of rupees 300 lakh and indirect cost of rupees 150 lakh in 1990. Estimate the fixed cost capital investment in1999 for a similar process plant located in City-B with twice the process capacity but within equal number of process units use a power factor of 0.6. So, the data given for City-A and City-B the relative labour rate and relative productivity factor.

And also in both the years 1990 and 1999 the Marshall and Swift equipment index are given. So what you have to do here we can make use of the equation that we have seen here. Cn= f into D into R to the power x + I. Note that direct cost indirect cost are given R is known, x is known, we have to find out f from the data. So let us now find out the value of the f, relative labour rate ratio is obtained as 1.25 by 0.87.

Then you find out the relative productivity factor. So, relative productivity factor can be obtained as 0.90 by 1.05. Now the labour cost for City-B relative to City-A will be given by the ratio of relative labour ratio to relative productivity ratio. So 1.437 by 0.857 so this gives me 1.677. So, this is that lumped cost in the equation we talked about. So what we do is first you find out the relative labor rate ratio City-B relative to City-A.

So we get that 1.25 divided by 0.87, then relative productivity factor ratio City-B to City-A. So I get that as 0.857. So ratio of this 2 will give me labour cost for City-B relative to City-A and I get this values 1.677, so this is my f.

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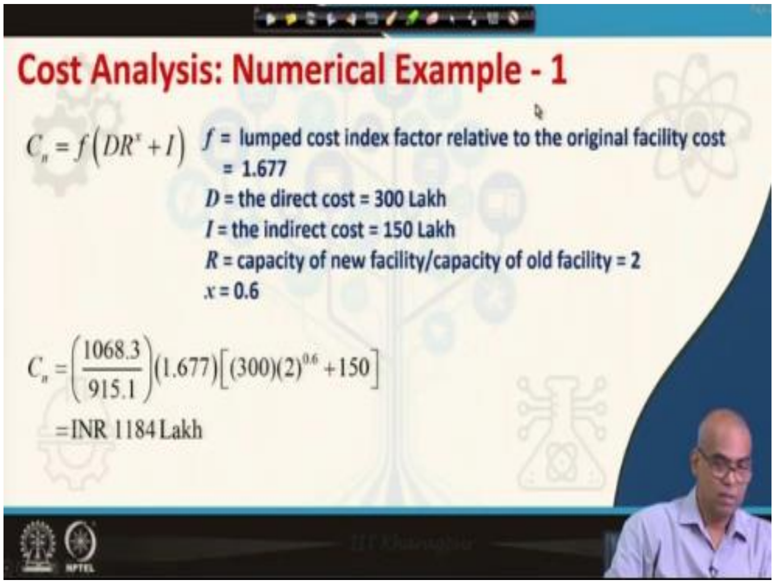

The lumped cost index factor relative to the original facility cost. So now it becomes straightforward application of the equation. D the direct cost is given as 300 lakh then direct cost is given as 150 lakh or the capacity ratio of the new facility divided by the capacity ratio of the old facilities to twice the capacity is given in the problem and the x is given as 0.6. So put all the values in this equation and we get estimate as 1184 lakh.

So this problem shows you how to take care of lumped cost index factor relative to the original facility cost.

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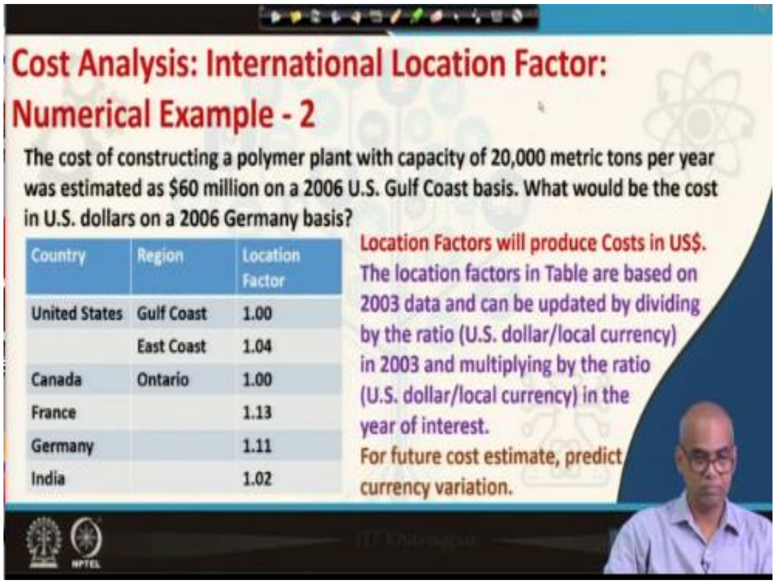

Now we take another problem which will show you how to handle international location factor. Consider the cost of constructing a polymer plant with capacity of 20000 metric tons per year was estimated as 60 million dollar on a 2006 U.S. Gulf Coast basis. The Gulf Coast represents region here. What would be the cost in U.S. dollars on a 2006 Germany basis? So, these are the data for various countries and various regions, we have the location factors.

The use of these location factors will produce the cost in US dollar. The location factors in the table are based on 2003 data, so these data are based on year 2003. So if you are using in some other year, let us say in the current year this has to be updated and how will you update? Will update the 2003 data by dividing by the ratio U.S. dollar by local currency in 2003 and then multiply by the ratio U.S. dollar by local currency in the year of interest, say current year.

Now if you want to make future cost estimate, then you also have to take care how the currency will change in future. So you have to make you have to predict currency variation for future cost estimate. So here all you have to do is you have to update the 2003 data. First for the location change Germany and then year change 2006.

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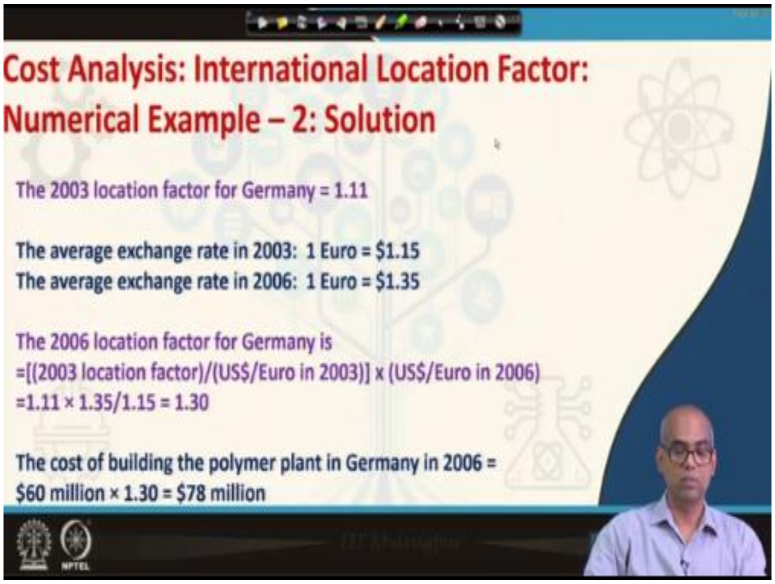

So the 2003 location factor for Germany was 1.11. Let us say the average exchange rate in 2003 was 1 Euro = 1.15 U.S dollar. So the average exchange rate in 2006, let us say it was 1 Euro= 1.35 U.S dollar. So the exchange rate in 2003 and exchange rate in 2006 between Euro and U.S dollar are given. So the 2006 location factor for Germany will be the 2003 location factor divided by U.S dollar by Euro in 2003 and multiplied by U.S dollar by Euro in 2006.

So just put these values now and if you do the computation you get 1.30. So once you have this value the cost of building the polymer plant in Germany in 2006 can be computed as multiplication of 60 million dollar with 1.30. So it becomes 78 million dollars, U.S dollar. So this is how you can take care of international location factor.

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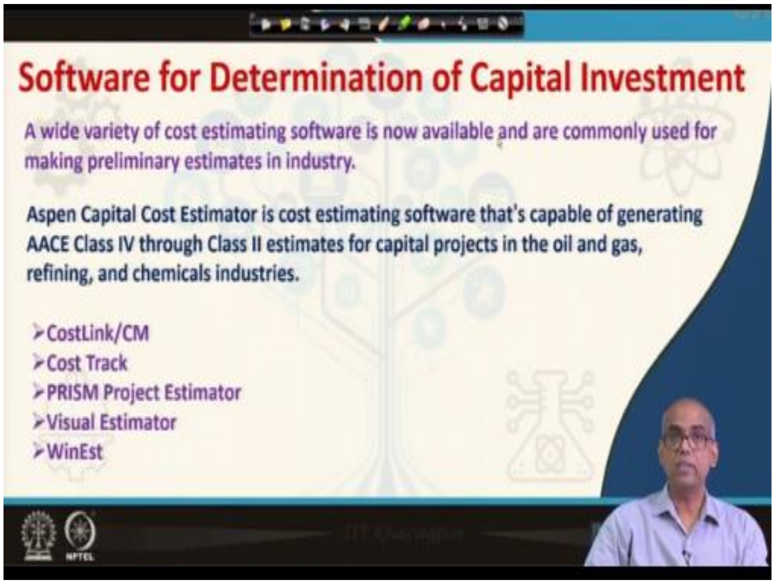

Now, software for determination of capital investment a wide variety of cost estimating software is now available and are commonly used for making preliminary estimates in industry. You may not have handy all the data that are available. So this day is very common that you make use of several softwares that are available for estimation of cost. Aspen capital cost estimator is cost estimating software that is capable of generating AACE class 4 through class 2 estimates for capital projects in the oil and gas refining and chemicals industries.

Here we list some other softwares for cost estimation. Cost Link, Cost Track, Prism Project Estimator, Visual Estimator, WinEst etcetera.

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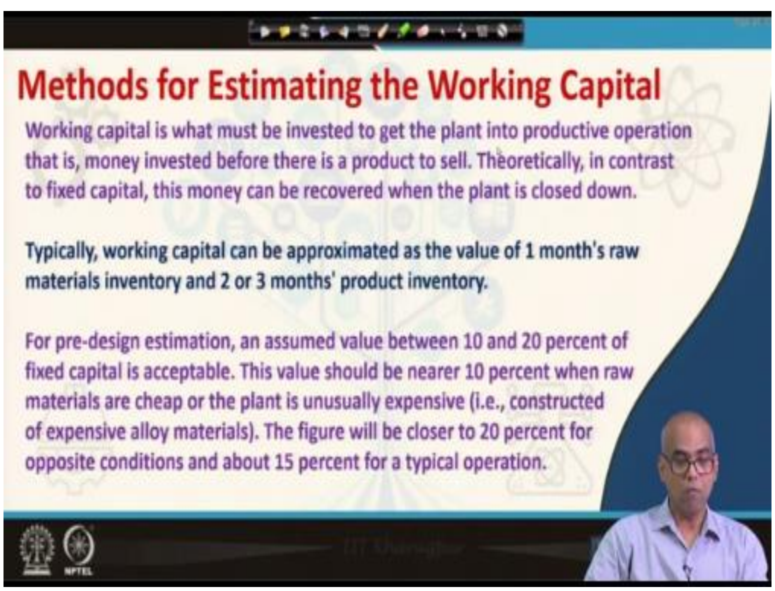

Now, let us briefly talk about some methods for estimating the working capital. Working capital is what must be invested to get the plant into productive operation that is money invested before there is a product to sell. Theoretically, in contrast to fixed capital this money can be recovered when the plant is closed down. Typically, working capital can be approximated as the value of 1 month's raw materials inventory or 2 to 3 months product inventory.

For pre-design estimation and assume value between 10 to 20% of fixed capital is acceptable. This value should be nearer 10% when raw materials are cheap or the plant is unusually expensive that is constructed of expensive alloy materials. The figure will be closer to 20% for opposite conditions and about 15% for a typical operation.

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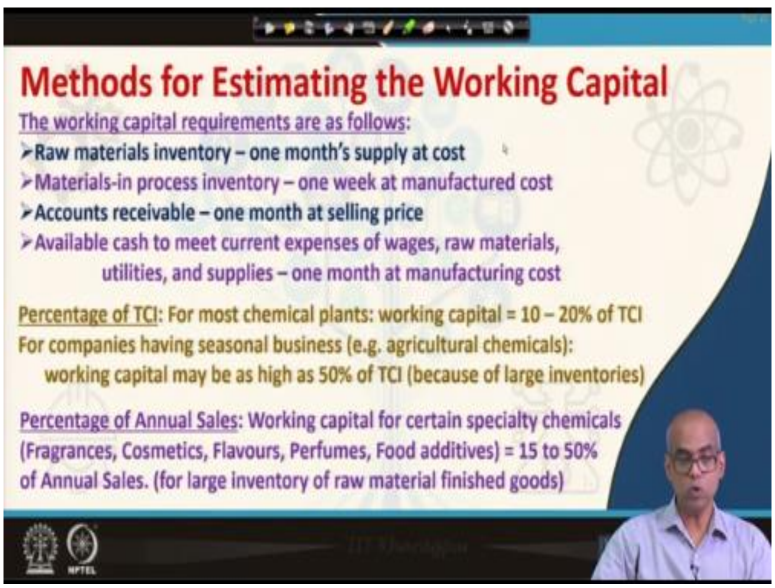

The working capital requirements are as follows: Raw materials inventory-1 month supply at cost, Materials in process inventory-1 week at manufactured cost, accounts receivable-1 month at selling price, available cash to meet current expenses of wages, raw materials, utilities and supplies-1 month at manufacturing cost. In terms of percentage of total capital investment for most chemical brands, working capital is taken as 10 to 20% of total capital investment for companies having seasonal business.

Such as agricultural, chemicals, working capital may be as high as 50% of total capital investment because of the large inventories that are required for such industries. In terms of percentage of annual sales, working capitals for certain specialty chemicals, such as fragrance, cosmetics, flavors, perfumes and food additives, we consider the working capital estimate as 15 to 50% of annual sales. Such industries required large inventory for raw materials and finished goods, with this we stop our discussion here.