Plant Design and Economics
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Lecture No-12
Capital Cost Estimate

Welcome to lecture 12 of plant design and economics. We have started engineering economics in this week and we are talking about analysis of cost estimation in this week. Today we will talk about capital cost estimates.

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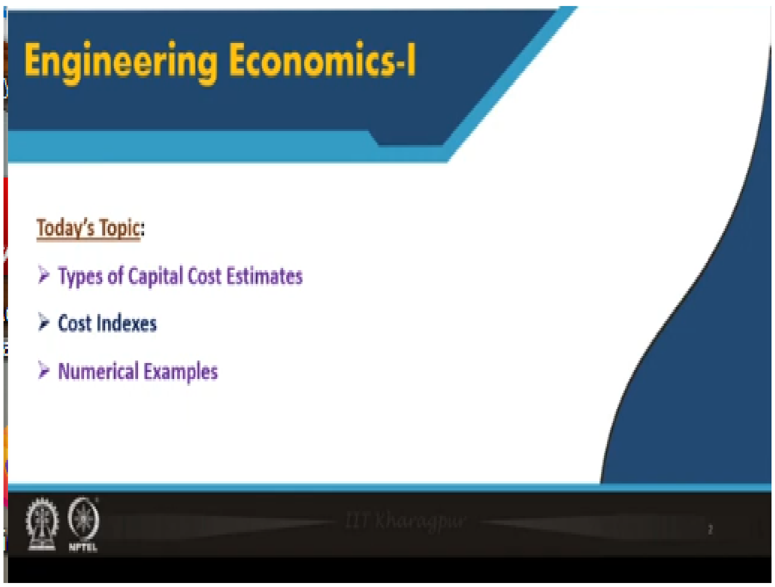

So this will be today's topic. We will talk about various types of capital cost estimates. Then we will talk about cost indexes or indices and then we will take two simple numerical examples.

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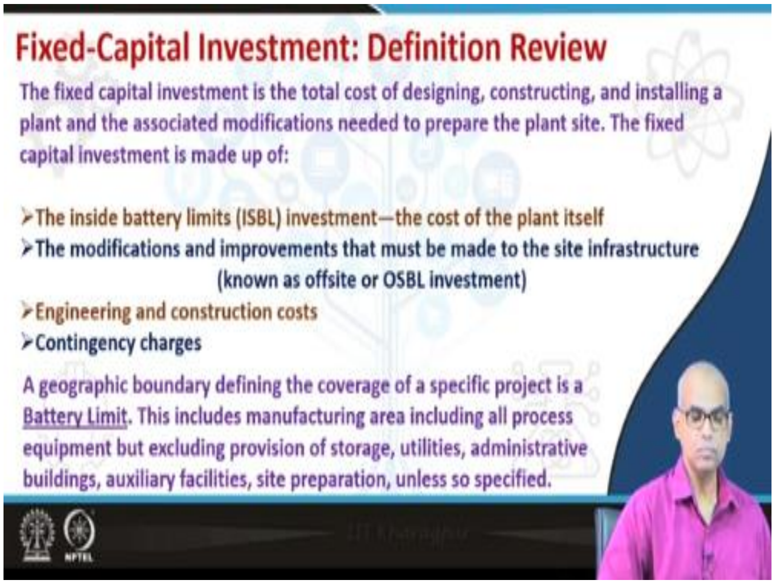

Let us review the definition of the fixed capital investment that you have learned in previous class. The fixed capital investment is the total cost of designing, constructing and installing a plant and the associated modifications needed to prepare the plant side. The fixed capital investment is made up of: the inside battery limits known as ISBL investment that is the cost of the plant itself.

The modifications and improvements that must be made to the site infrastructure known as offside or OSBL investment offsite battery limit investment, engineering and construction costs and contingency charges. So be familiar with these terminologies inside battery limits and offsite battery limits. A geographic boundary defining the coverage of a specific project is the battery limit.

This includes manufacturing areas including all process equipment, but excluding provision of storage, utilities, administrative buildings, auxiliary facilities, site preparation, unless so specified.

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These are the breakdown of fixed capital investments that are direct cost. So we have discussed in previous class that there are direct costs and indirect costs. Direct costs are directly related to manufacturing. So what are the breakdown of fixed capital investment that comes under direct cost? Purchase equipment: where you talk about all equipment in flow sheet, spares, fracture, etcetera. Purchase equipment installation: structural support, insulation, painting, etcetera.

Instrumentation and controls: purchase, installation, calibration, software. Piping: fittings, valves, insulation, etcetera. Electrical systems: which will include motors, switches, wire, fittings, lighting etcetera. Buildings: process buildings, auxiliary buildings, utility buildings. Maintenance of site development: also known as yard improvements, road making, railroad making, parking lot etcetera.

Service facilities: which will include utilities, water treatment, fire protection etcetera. Land, which will include surveys and fees, property cost.

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Now breakdown of fixed capital investment that are indirect cost, Engineering and supervision: which will include administrative design, cost engineering, consultancy travel expenses. Legal expenses: you need legal advice so you have to pay for its acquisition of regulatory approval, contract negotiation. So you have to pay for all such services. Construction expenses: it includes construction tools and equipment, supervision, accounting, warehouse, security guards safety, medical facility taxes, field test, insurance all such expenses, Contractors fee, contingency.

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Now let us talk about types of capital cost estimates, that you will see if an estimate depends on the amount of design detail that are available with you and also that you receive the cost data available as well as the time that spent on preparing the estimates. Accuracy of an estimate depends on the amount of design details that are available that you receive the cost data available and the time spent on preparing the estimate.

So accuracy of estimate depends on the design details that are available, the accuracy of the cost data available, and the time spent on preparing the estimate.

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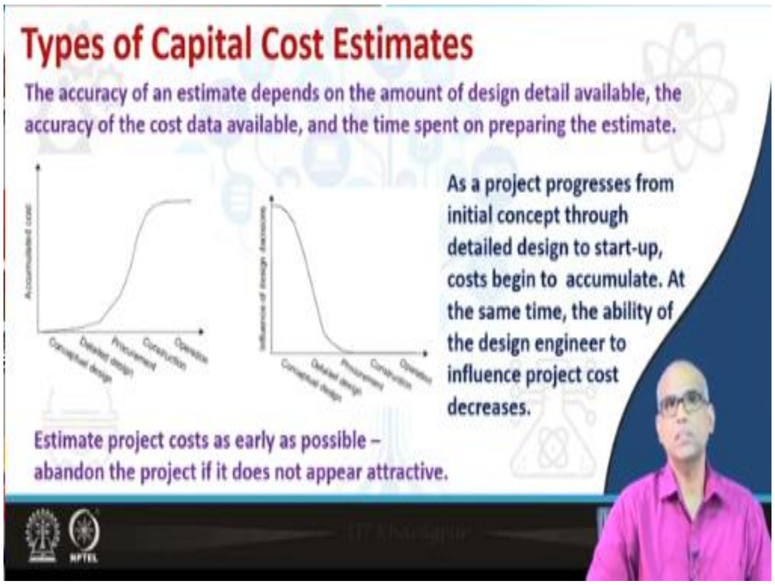

As a project progresses from initial concept through detailed design to start up, costs begin to accumulate. At the same time the ability of the design engineer to influence project cost decreases. If you look at this figure you will see that as time progresses the accumulated cost increases. Particularly when procurement starts, then the accumulated cost starts increasing sharply.

And at the same time the influence of the designer on the project cost decreases sharply as time progresses from conceptual design to detail design and when procurement starts designer almost loses all influence on the project cost. So it is very important that we estimate the project cost as early as possible and as accurately as possible so that the projects that are not attractive can be abandoned without wasting much time.

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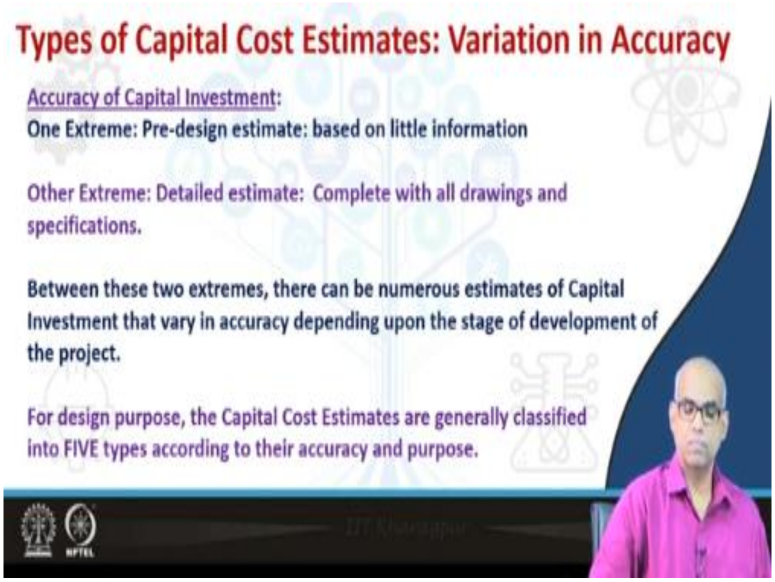

Now consider as one extreme a pre-design estimate which will be based on very little information, whereas the only information that you will have at that time is the scale of the operation or the size of the project. So the estimate that we will make that time will be very rough estimate. The other extremes: when you are ready with detailed estimate that means you have completed all drawings all specification everything.

Now between these two extremes, there can be numerous estimates of capital investment that will vary in accuracy depending upon the stage of development of the project. So to start with you will have a predesigned estimate which will be based on very little information and will be very rough estimate but as the time progresses as you go ahead in the stage of development of the project. You come at the end detail estimate and then it will be very accurate estimate.

For design purpose the capital cost estimates are generally classified into FIVE types according to their accuracy and purpose. So all types of estimates have purpose; between the two extremes that we talked about there will be several other estimates of varying accuracies and all such estimates have a purpose. Now, let us look at those FIVE different types of estimates which vary in accuracy and have different purposes.

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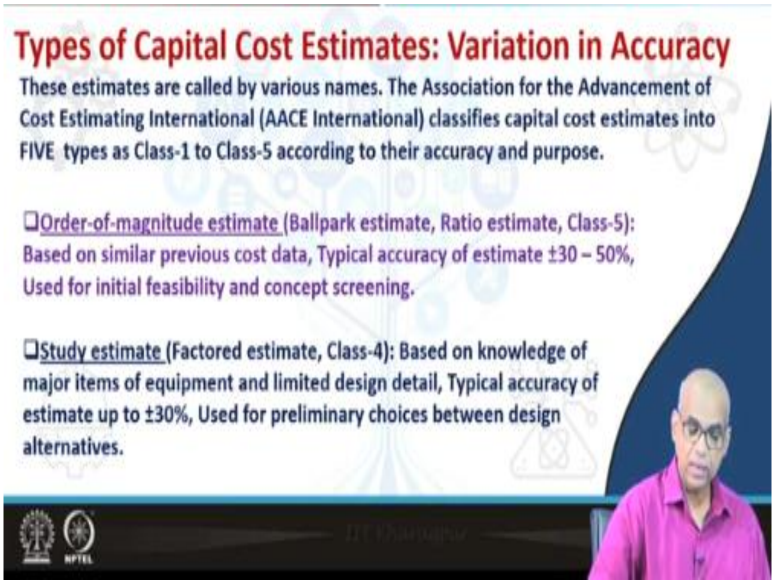

Now these estimates are called by various names. The association for the advancement of cost estimating international AACE International classifies capital cost estimates into FIVE types as class 1 to class 5 according to their accuracy and purpose. Class 1 is a highest accuracy and class 5 is of lowest accuracy. So what are those FIVE different classes? First order of magnitude estimate: this is also known as ballpark estimate, ratio estimate or class 5 estimates.

This estimate is based on similar previous cost data. Typical accuracy of estimate will be plus minus 30 to 50% and this estimate is used for initial feasibilities study or concept screening. Next study estimate: also known as factored estimate, according to ACCE International classification, it will be known as class 4 estimate. This estimate is based on knowledge of major items of equipment and you also have limited design detail at this stage. Typical accuracy of such estimate will be up to be plus minus 30%.

This is used for preliminary choices between design alternatives. You will have several alternative designs and study estimates can be used for preliminary choices between such design alternatives.

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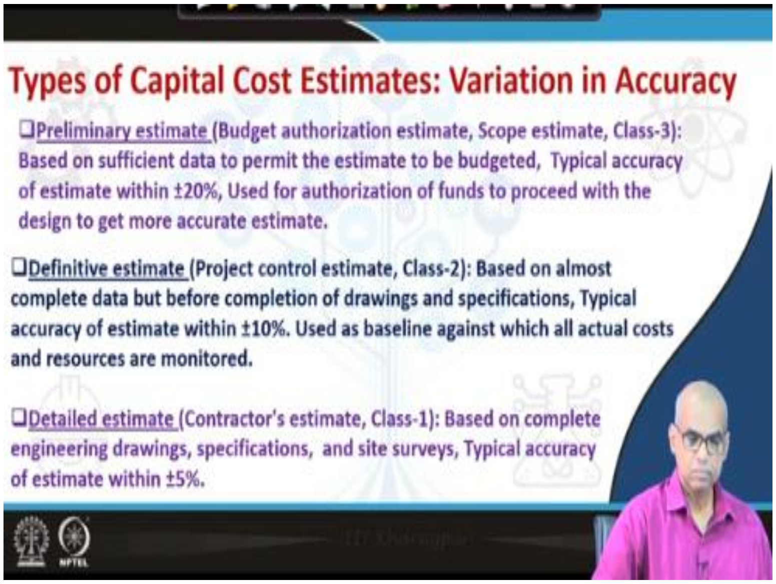

Next preliminary estimate: also known as budget authorization estimate, scope estimate or class 3 estimate. This estimate is based on sufficient data to permit estimate to be budgeted. Typical accuracy of estimate will be within be plus minus 20%. This is used for authorization of funds to proceed with the design to get more accurate estimate. Next definitive estimate also known as project control estimate or class 2 estimate.

This is based on almost complete data, but before completion of drawing and specification. Typical accuracy of estimate will lie within be plus minus 10%. This is used as baseline against which all actual cost and resources are monitored. So management will use this estimate as a base line against which all actual cost and resources will be monitored. Detail estimates: known as contractors estimate or class 1 estimate.

This is based on complete engineering drawings specifications and site surveys. The typical accuracy should be within be plus minus 5 %. So these are FIVE different types of estimates with varying accuracy and purpose.

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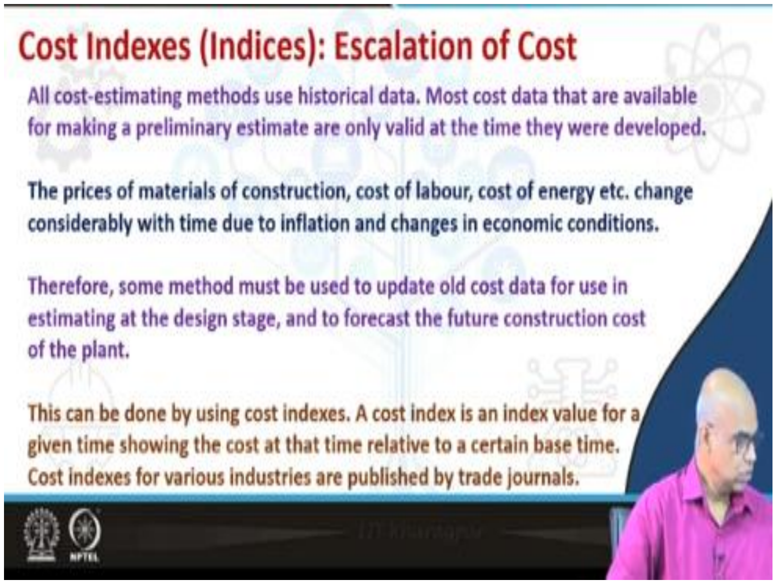

Now we will define something known as cost indexes or indices. All cost estimating methods use historical data. Most cost data that are available for making a preliminary estimates are only valid at the time they were developed. So, you must escalate the cost, why? Because the prices of materials of construction cost of labour, cost of energy, etcetera change considerably with time due to inflation and changes in economic conditions.

Therefore some method must be used to update old cost data for using estimating at the design stage and to focus the future construction cost of the plan. So this is escalation of cost. This can be done by using cost indexes. A cost index is an index value for a given time showing the cost at that time relative to a certain base time. I repeat, a cost index is an index value for a given time showing the cost at that time relative to a certain base time.

So, if you have cost at a certain base time and you know the cost indexes then you will be able to find out the cost at some other time relative to the base time. Cost indexes are for various industries are regularly published by various trade journals as well as various statistical agencies. So these are very useful for design engineers.

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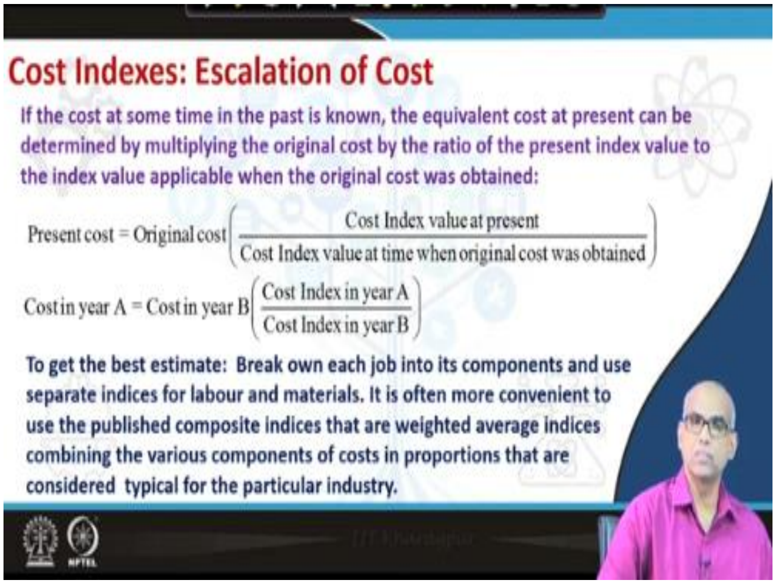

If the cost at some time in the past is known the equivalent cost at present can be determined by multiplying the original cost by the ratio of the present index value to the index value applicable when the original cost was obtained. So if you know the cost at some past time and if you know the index, cost indexes at that time and as well as at present time then will be able to find out the cost at the present time, how?

Like this, present cost equal to original cost multiplied by cost index value at present divided by cost index value at time when original cost was obtained. So to find the present cost you multiply the original cost by the ratio cost index at present divided by cost index when original cost was obtained. This you can also write as cost in year A equal to cost in year B multiplied by cost index in year A divided by cost index in year B.

To get the base estimate you should break down one if you should break down each job into it is components and you separate indices for labour and materials. It is often more convenient to use the published composite indices that are weighted average indices combining the various components of cost in proportions that are considered typical for the particular industry. Such composite indices are regularly published by various state journals as well as statistical agencies.

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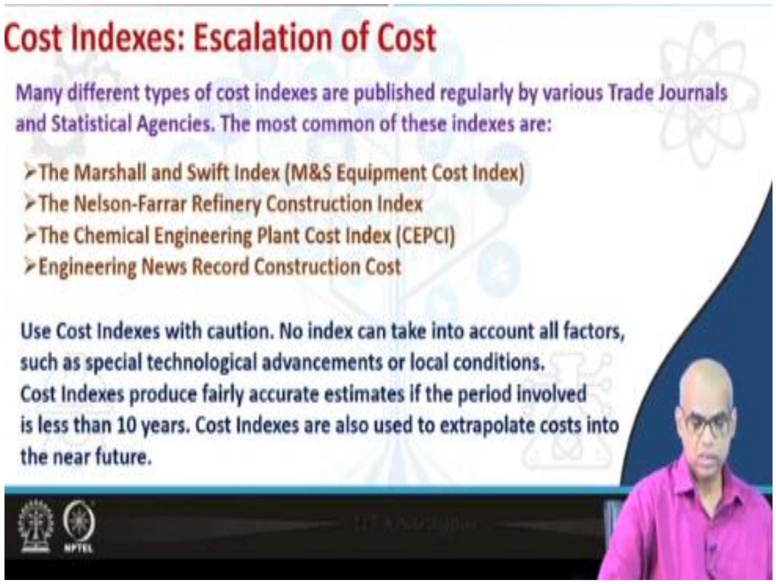

Many different types of cost indexes are published regularly by various trade journals and statistical agencies. The most common of these indexes are: the Marshall and Swift index known as Marshall and Swift equipment cost index. The Nelson-Farrar refinery construction index; the Chemical Engineering Plant Cost Index, Engineering News Record Construction Cost, there are more cost indexes available in literature, but these are the most common indexes that will be using in this course as well as in your professional life.

Use cost indexes with caution. No index can take into account all factors, such as special technological advancements or local conditions. Cost indexes produce fairly accurate estimates if the period involved is less than 10 years. So they work well when the period involved time period involved is within 10 years. Cost indexes are also used to extrapolate costs into the near future. So for forecasting also you can use the cost indexes where you will extrapolate cost into the near future.

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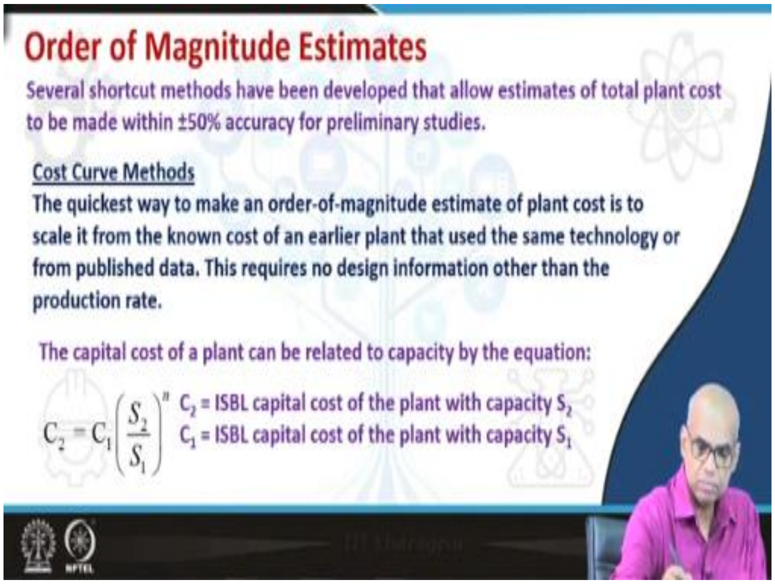

Now, we will talk about one method for order of magnitude estimates. There are several short cut methods that have been developed which will allow you to estimate the total plant cost. Roughly with an estimate of be plus minus 50% accuracy, which will be good for preliminary studies. So, several short term methods are available for such purposes. Let us talk about one such shortcut method.

Which come under order of magnitude estimates is known as cost curve methods: the quickest way to make an order of magnitude estimate a plant cost is to scale it from the known cost of an earlier plant that used the same technology or from published data. So you can make an order of magnitude estimate of a plant cost. From the known cost of an earlier plant that use the same technology or you can also do it from published data. This requires no design information.

The only information that is required is production rate. Now, look at this equation. If C2 is the ISBL capital cost of the plant with capacity S2 and C1 is inside the battery limit capital cost of the plant with capacity S1 then these costs are related with their capacity by this expression. So the capital cost of a plant can be related to the capacity by the equation C2 equal to C1 into S2 by S1 to the power n. Where C2 is the inside battery limit capital cost of the plant with capacity S2 and C1 is inside battery limit capital cost of the plant with capacity S1. What about exponent?

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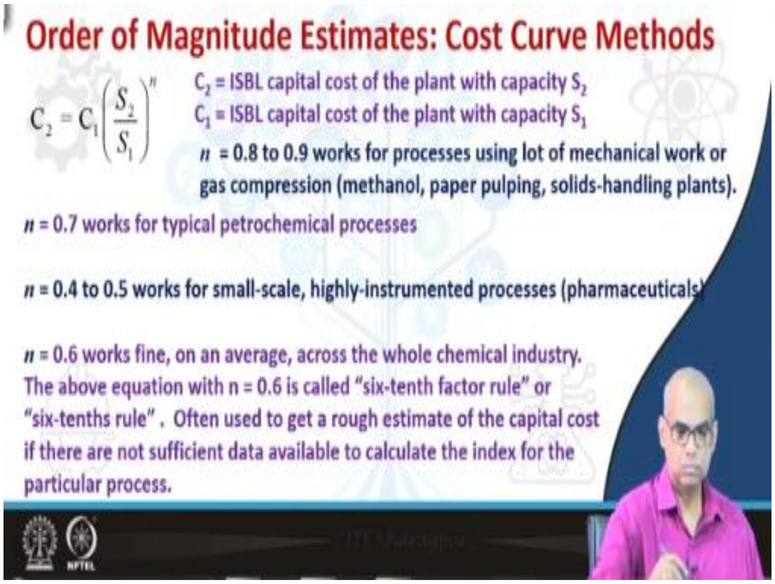

Now, exponent n is different for different processes n equal to 0.8 to 0.9 will work well for processes which has lot of mechanical work or gas compressions such as methanol, paper pulping, solids handling plants, etcetera. n equal to 7 works for typical petrochemical plants. n equal to 0.4 to 0.5 works well for small scale, highly instrumental processes, such as speculative chemicals, pharmaceuticals, etcetera. n equal to 0.6 works fine on an average across the whole chemical industry.

This is important, so n equal to 0.6 works fine on an average across the whole chemical industry. This equation C2 = C1 into S2 by S1 to the power n with n equal to 0.6 is known as six tenth factor rule or simply six - tenth rule. This is often used to get a rough estimate of the capital cost if there are no sufficient data available to calculate the index for the particular process.

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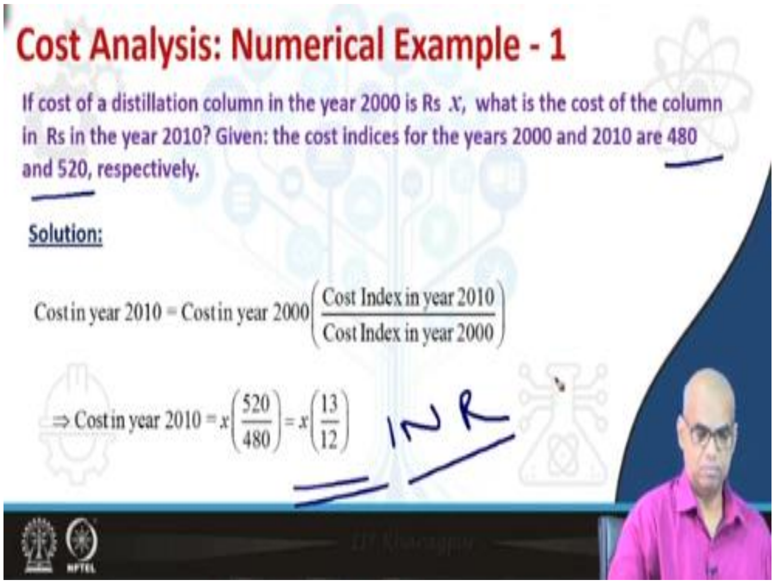

Now let us take two, simple numerical examples. These things can be solved based on the concepts that we just discussed. If cost of a distillation column in the year 2000 is rupees x, what is the cost of the column in rupees in the year 2010 is given the cost indices for the years. 2000 and 2010 are 480 and 520 respectively. So, this is a state forward application of cost indexes. So we can write cost in year 2010 is equal to cost in year 2000 multiplied by cost index in year 2010 divided by cost index in year 2000.

Now, let us simply put the numbers. So cost in year 2010 is x into 520 divided by 480 which you can simplify as x into 13 by 12. So, this rupees will be the cost of the distillation column in year 2010.

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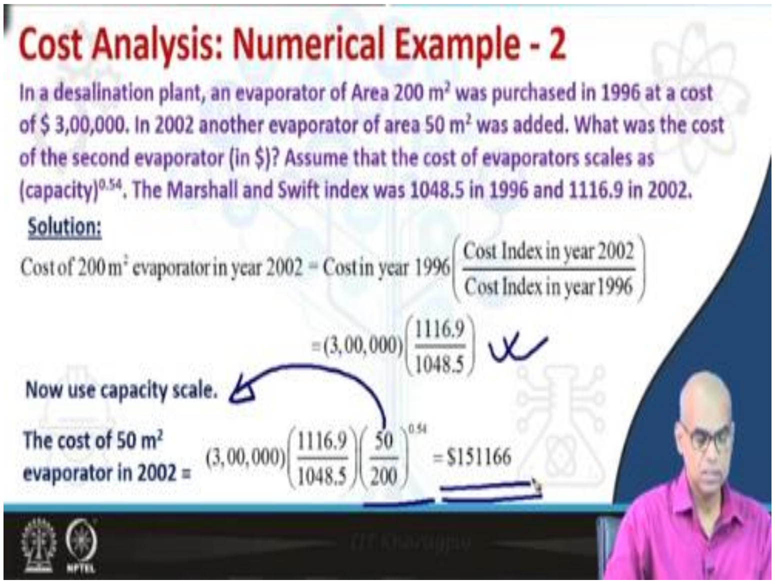

Now, let us take another simple example. In a desalination plant, an evaporator of area 200 meter square was purchased in 1996 at a cost of dollar 3,00,000. In 2002, another evaporator of area 50 meter square was added. What was the cost of the second evaporator in dollar? Assume that the cost of evaporator scales as capacity to the power 0.54. The Marshall and Swift was 1048.5 in 1996 and 1116.9 in 2002.

So this problem as one more additional step when you compare it with the previous problem that is the statement that the cost of evaporator scales is capacitor to the power 0.54. Now, so what we will do is you first find the cost of the evaporator in year 2002, the cost of the evaporator with area to 200 meter square in is known in year 1996, so let us first find out the cost of the evaporator? Same evaporator of area 200 meter square in year 2002.

What will be that? That you can straight away use cost indices to find out. So cost in year 1996 multiplied by the ratio of the cost indexes in 2002 to 1996. So this becomes the cost of the 200 meter square evaporator in year 2002. Now, let us apply the scale we will use the capacity scale. So the cost of 50 meter square evaporator in year 2002 will be discussed multiplied by 50 divided by 200 to the power 0.54.

So 50 is the Capacity of this new evaporator and 200 is the area of the; or capacity of the previous evaporator. So, if you compute this you will get the cost of the 50 meter square evaporator in the year 2002. So in future we will see more such problems. Today will stop our discussion here, thank you for watching.