Upstream LNG Technology
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Lecture – 50
Multicomponent distillation column design: Approximate method

Welcome. After learning about the analysis of distillation, considering binary components are there. We will be now been going to Multicomponent analysis for the design of the distillation columns. So, in this lecture, we shall be learning about the approximate method for the design of Multicomponent distillation column; the rigorous methods are taught separately in other subjects. So, I shall not be going into the details of the rigorous method.

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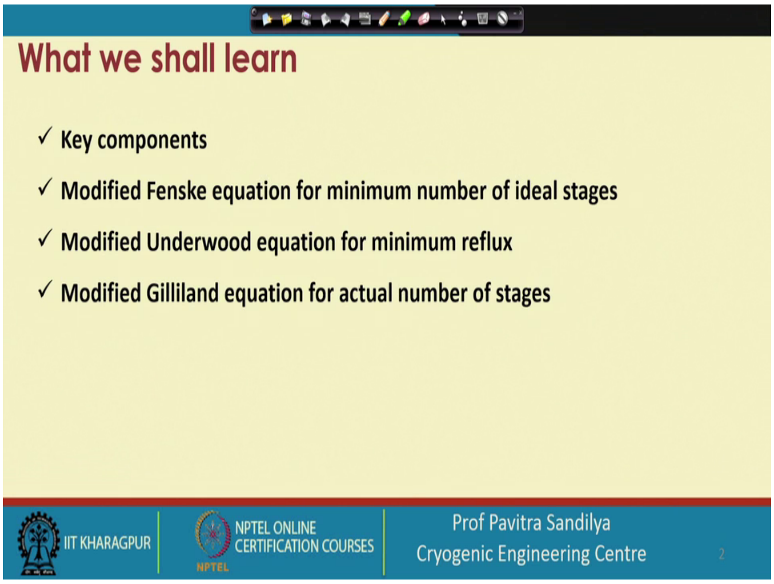

So, in this particular lecture, we shall be learning about the key component which are the basis for the design of the multicomponent systems, then we shall looking into the modified Fenske equation to find out the minimum number of stages modified under wood equation to find out the minimum reflux and modified Gilliland equation for finding the actual number of stages. Why I am saying modified because all these equations have already been dealt with under the binary distillation column design.

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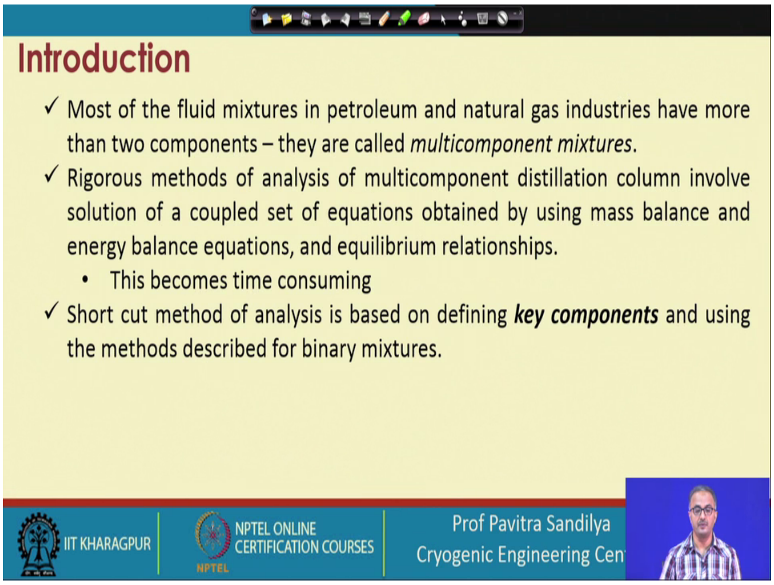

. So, first we come to the fact that why we need to have this multicomponent consideration because most of the fluid mixtures in the petroleum and the natural gas industries have more than 2 components. It is we known that the so many components in the natural gas right from the so many hydrocarbons.

So, many other impurities like nitrogen, helium, carbon dioxide, H2H, water so and so forth. So, that is why it is not right to construct them to be a binary mixture rather, then we call them a multicomponent mixture and multicomponent means whenever we have more than two components. So, rigorous methods of analysis of this multicomponent distillation would involve the solution of a coupled set of equations and which are obtained by writing the mass balance energy balance equation and the equilibrium relationships and if you want to solve this kind of equations, they become quite time consuming.

So, first for the firsthand performance analysis performance evaluation, what we do? Instead of going for the rigorous calculation, we take some shortcut method which is based on some key component definitions and using the or modifying the methods which we developed for the binary components.

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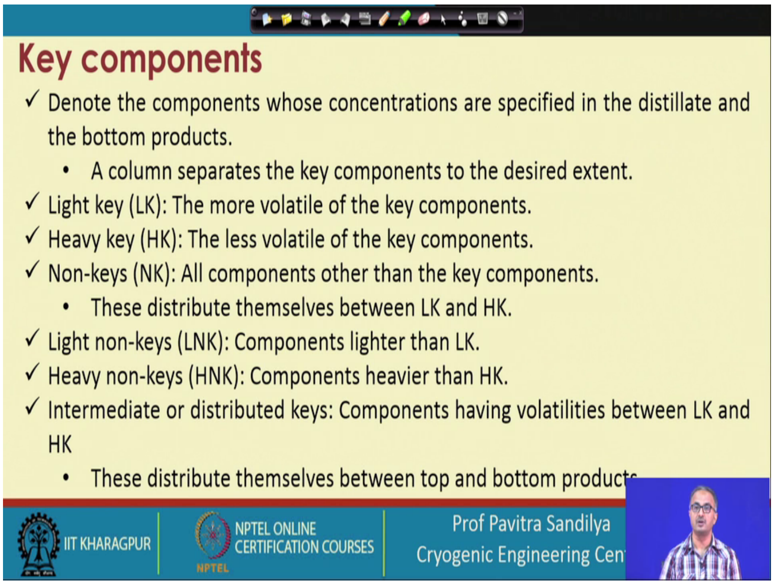

So, first let us figure out; what are the key components. So, key components denote the components whose concentrations are specified in the distillate and the bottom products. Now this choice is arbitrary, it will be depending on the type of component recovery, we intend to have accordingly. We shall be defining the key components a column separates the key components to the desired extend; that means, the basis of the design is on the separation of the key components.

So, in these key components, we have light key which is abbreviated like LK and these are the more volatile of the key components. So, we have two components which were with more volatile is the light key and other one is heavy key that is denoted by HK and the this is the heavier component now other than this light key and heavy key. We have the non key component, which are denoted by NK and these non key components distribute themselves between the LK and the HK, then we have light non keys.

It means these light non keys denoted by LNK are the components which are lighter than the light key and the heavy non keys denoted by HNK are those components heavier than the heavy key. What it means that the LNK, we will go along with the LK, whereas, HNK we will go along with the HK, we may have some components which are intermediate or distributed keys, whose volatilities maybe lying between the HK and the LK in those case, what will happen? This component will be distributing themselves between both the bottom product and the top product.

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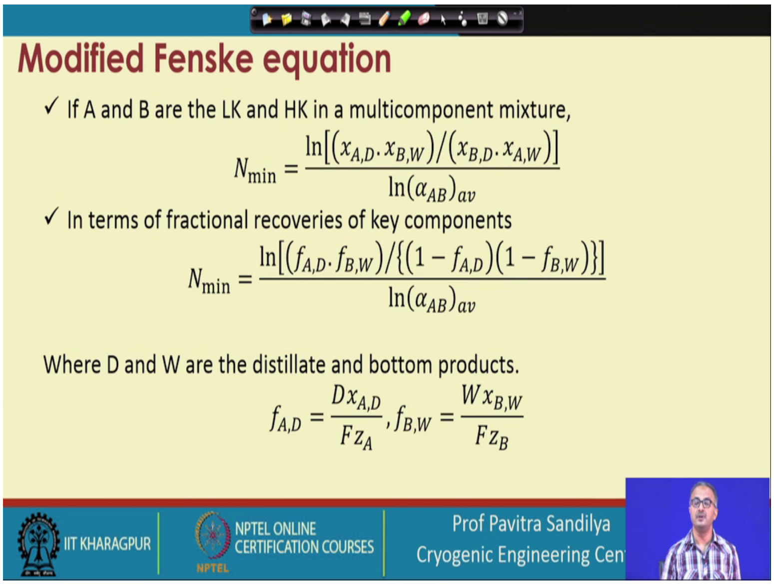

So, without going into the details of the derivation, what we do here is see that how the modifications have been done for the Fenske equation to find out the minimum number of ideal stages.

So, here we write the minimum number of equation in this equation we write this equation. So, we can find the A and B are the LK and the HK. So, A is the LK and B is the HK. So, the this x means that the mole fraction of the light key component in the distillate and this is the mole fraction of the heavy key component in the bottom, in this case, we are not using B as bottoms we are replacing the bottoms with AW. So, that we do not confused with the component B ok. So, we are using W as the bottoms. So, this is the mole fraction of the heavy key in the bottoms.

So, this is the mole fraction of the heavy key in the distillate with the mole fraction of the light key in the bottoms and this is the average relative volatility between A and B between the top and the bottom of the column average because as we know the temperature pressure vary along the distillation column. So, we take an average between the top and bottom of the column now this can also be represented in terms of the fractional recoveries of the components. So, this is how we are writing the fractional recovery; that means what fraction of the total amount of the light key or heavy key present have been recovered in the bottom product and the top product.

So, this fracture recovery have been defined like this that this is the amount of the light key that is going along with the feed and out of this how much has been taken out from the distillate this is the amount of the heavy key component, which has entered with the feed and how much has been the taken out from the bottom because even though, they are light key, heavy key are supposed to go predominantly in the distillate and the bottoms respectively. However, some amount will also go in the other direction that is why we need to define this kind of fractional recoveries and this is generally never equal to 1 or 100 percent, we always lose some of the other in either the distillate or the bottoms.

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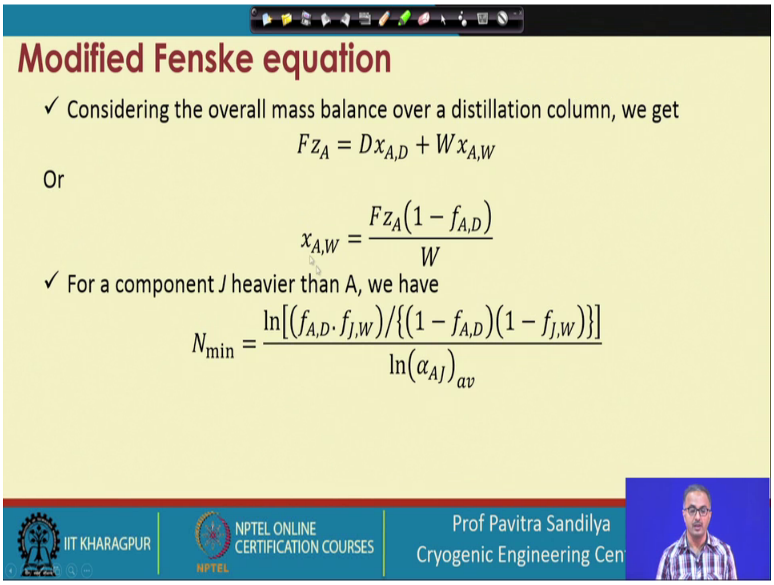

Now, if we consider the overall material balance of the column considering, there is only one feed there is only one distillate and there is only one bottoms. So, we write this is the energy mass balance equation, we you already seen and if we just the added the equation and put the things in terms of the fractional recovery, then we find that the amount of the light key the mole fractional light key in the bottom is given by the amount of the bottom the flow rate bottom flow rate, the feed flow rate the amount of the mole fraction of the light key in the feed and this is the fractional recovery.

Now, suppose we had any component j that is heavier than A; that means, this may not be the key component, it may not key component, but is it is heavier than a then what we can do we can use simply this same equation the same equation we can use, but in this case we shall be replacing the B with J. So, we can find that this is the way we can find out the minimum number of ideal stages if for separating a right key from a component which is not the key component.

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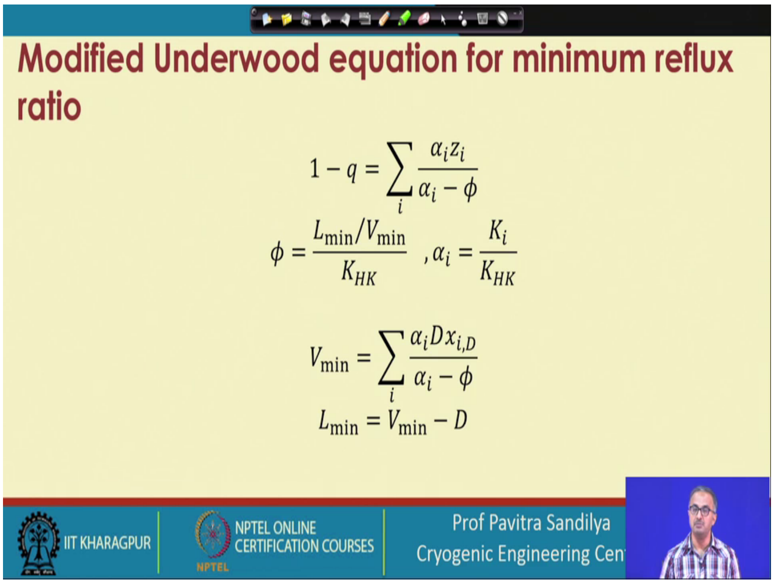

Now, we go to the modified under wood equation to find out the minimum reflux again without going into the derivations of those equation we write the final equation. So, this is the equation one minus q and this equation and here we find that phi is this alpha i is this. Now here we find the alpha i has been defined with respect to the heavy key and the phi has been defined in terms of the heavy key and this is the value of the V min, this is the value of the L min and from this, we can find out the reflux ratio from the mass balance equation.

So, this I am not going detail, we shall be learning from more about these things when we do to some tutorial or this kind of problems later.

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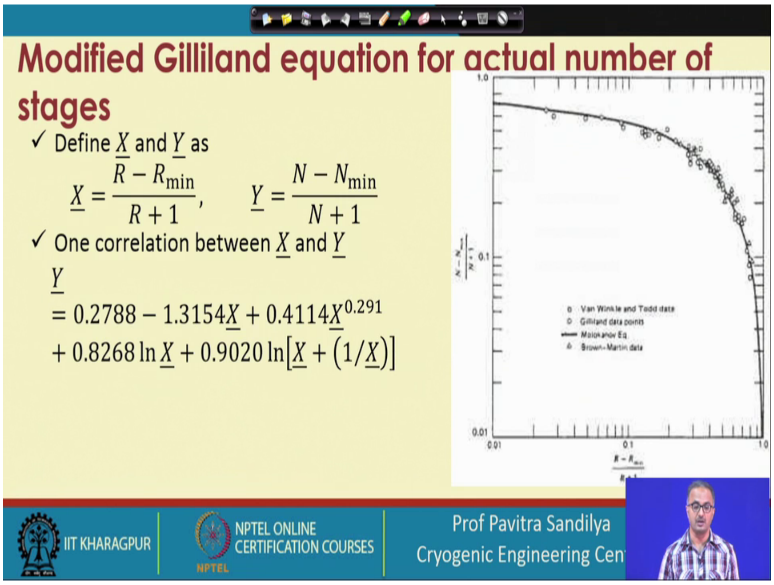

Next we come to the Gilliland equation for the actual number of stages, here, we find that this is the curve for the finding the number of stages, here, we have define 2 things. One is X underscore and Y under bar. So, this is the way, we defined on the X axis, we define R minus R min by R plus 1, on the Y axis, we have N minus N min by N plus 1. This R min has been obtained from the under wood equation the N min has been obtained from the Fenske equation and from this, if we get this value and this value and the R value will be specified of generally which will be generally specified as sum multiple of the R min.

So, once I know the R value, once I know the R min value, I can locate it on the X axis and then go to this particular curve and read out the value of this Y which is N minus N mean by N minus 1 plugging the value of Y, we know the value of N min and we can find out the actual number of stages.

That means, this is giving me the real number of stages required for a given separation now many analytical may expression have also been given one of them is given here that how to correlate this Y with the X. So, this is one of the there are many other relations also proposed in the literature. So, this is one of the equations which is used for finding the number of real stages from the reflux ratio.

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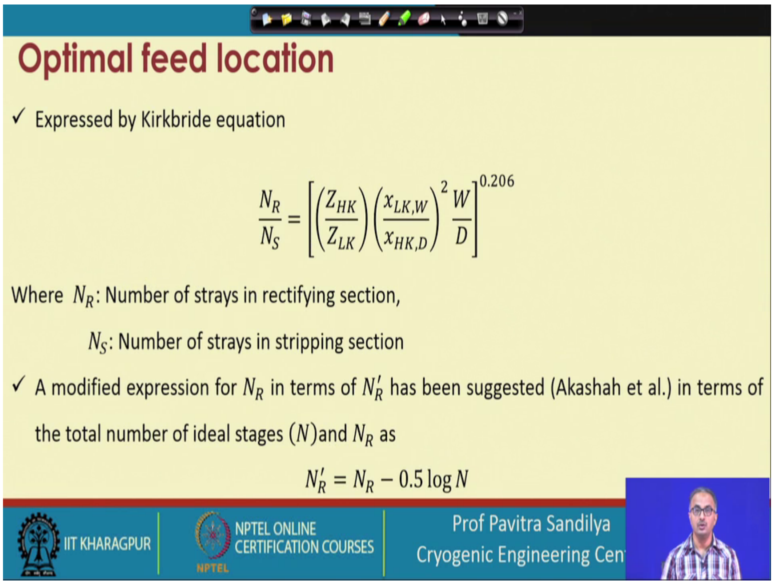

To find out the optimal feed location this particular equation has been suggested by Kirkbride.

So, here we find that we have the value Z that is the compensative factor and these are the mole fractions of the light key in the bottom the mole fraction of the heavy key in the distillate and this is the bottom flow rate is the distillate flow rate. So, by putting these values and NR and NS are the number of trays, sorry, this is a spelling mistake trays in the rectifying section, this is the number of trays in the stripping section and from this we can find this particular ratio.

So, this will also give me where that how many where we shall be feeding the introducing the particular feed and Akashah modified this particular expression for the NR in terms of the total number of ideal stages and this is the modification they have done to find out the number of ideal stages in the rectification section.

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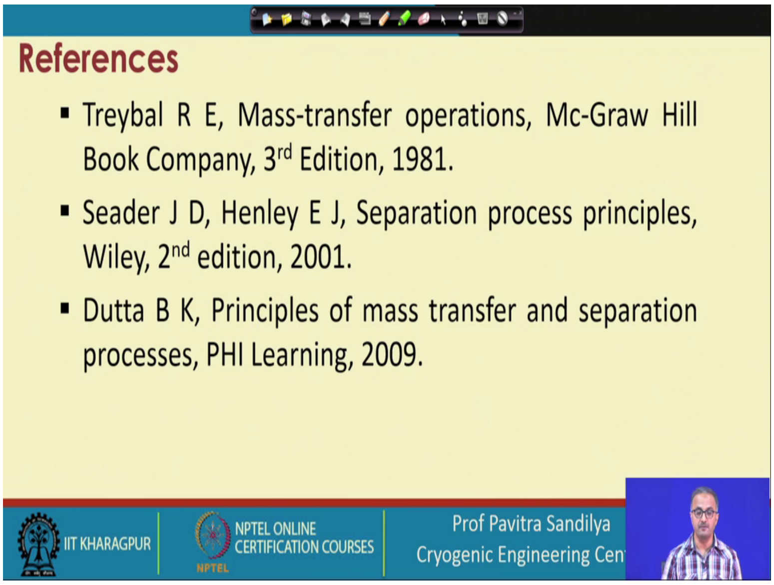

And you can find more detail about this from these reference books.

Thank you.