Fundamentals of Food Process Engineering

Prof. Jayeeta Mitra
Department of Agricultural and Food Engineering
Indian Institute of Technology, Kharagpur

Lecture – 18
Evaporation and Concentration (Contd.)

Hello everyone, welcome to NPTEL online certification course on Fundamentals of Food Process Engineering. In the last class, we were discussing about the different types of evaporators. So, today we will continue the discussion on Evaporation and Concentration.

So, we have discussed in the last class about the multiple effect evaporators. Multiple effect evaporator is one way by that we can improve the efficiency of an evaporation system. And if we talk about improving the efficiency; so, generally efficiency we define by the output effect that we are getting divided by the input energy that we are giving to the system.

So, using multiple effect evaporator we can increase the vapour that is being evaporated from the system ah, where as we can utilize the same amount of steam that we can use in a single effect evaporator. So, that is one way to increase the steam economy that is steam needed to evaporate the, you know amount of vapour from the liquid that we are concentrating using the evaporation.

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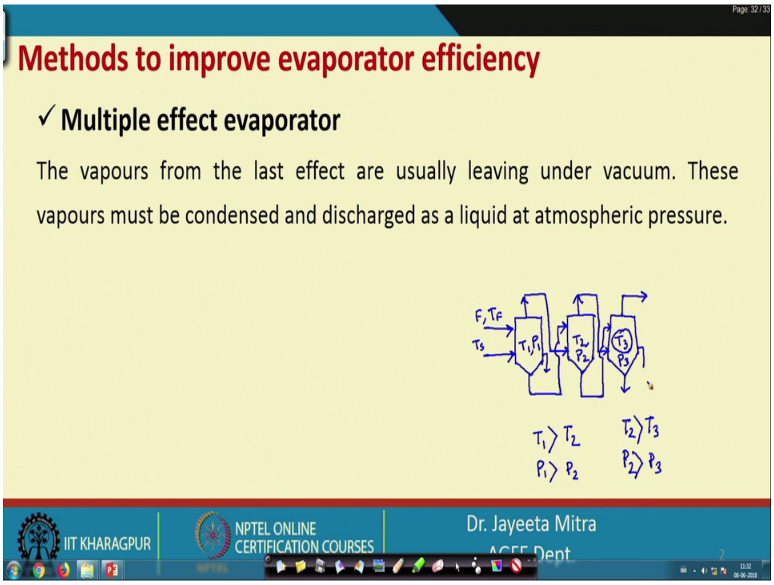

Methods to improve evaporator efficiency

✓ Multiple effect evaporator

The vapours from the last effect are usually leaving under vacuum. These vapours must be condensed and discharged as a liquid at atmospheric pressure.

$T_1 > T_2$ $P_1 > P_2$ $T_2 > T_3$ $P_2 > P_3$

So, today we will discuss the same thing that is the multiple effect evaporator and other mechanisms by which we can increase the efficiency. So, in the multiple effect evaporator if we just recapitulate that.

So, in multiple effect evaporator what we did is suppose this is the first effect and in series there is other 2 effect that is the second one and this is the third one right. So, steam enters into the first effect; let us say T S temperature and this steam is utilizing here to evaporate the liquid from the feed F that is entering at T F. And the temperature here in the first effect is T 1 in the second effect it is T 2 and third effect is T 3.

And the corresponding pressure prevailing in all these chambers are P 1, P 2 and P 3. Now the vapour produced from the first effect is going to enter into the second one and similarly the vapour produced from the second effect is going to introduce in the third one.

So, this vapour will be condensed here in the second effect and give the latent heat of condensation that is being utilized by the feed; that we use here which is the concentrated feed that is coming out from the first effect. And then similarly from the second effect the concentrate which will come will be utilized as the feed in the third effect right.

And finally, the vapour which is coming out from the third effect at the temperature of T 3 will be going to the condenser right. So, what will happen that if our first effect operates at atmospheric pressure; so, this vapour that is coming out at that atmospheric pressure and temperature will be again condensing here in the second effect.

So, temperature T 1 must be greater than T 2 right or pressure P 1 must be greater than the pressure P 2 in the second effect. Similarly the vapour which is coming out from the second effect will going to condense in the third one; so, T 2 will be greater than T 3 and the pressure P 2 will be greater than P 3. So, definitely the vapour that is coming out from the last effect will be ah you know this is coming at vacuum because P 1 which was our atmospheric pressure is higher than P 2, P 3.

So, except the first one the other 2 effect must be operate under vacuum; therefore, we can say that the vapour from the last effect are usually leaving under vacuum and these vapours must be condensed and discharge as a liquid at the atmospheric pressure right.

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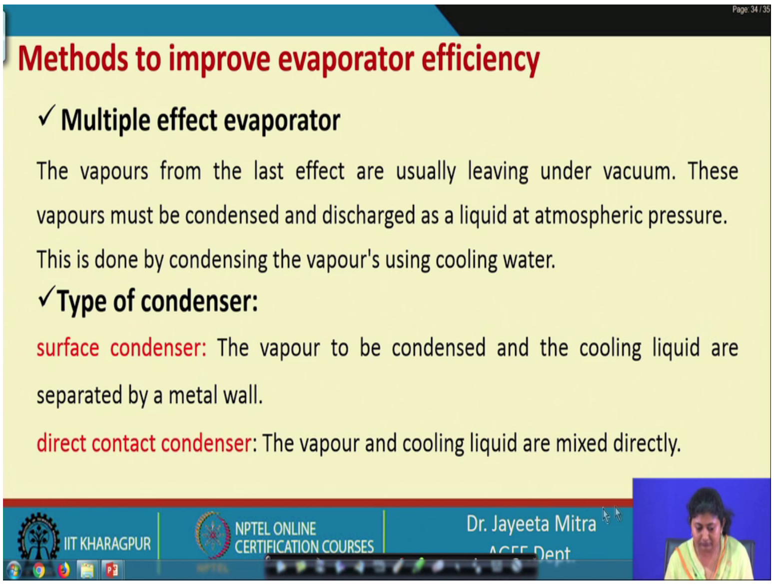

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Methods to improve evaporator efficiency

✓ **Multiple effect evaporator**

The vapours from the last effect are usually leaving under vacuum. These vapours must be condensed and discharged as a liquid at atmospheric pressure. This is done by condensing the vapour's using cooling water.

✓ **Type of condenser:**

surface condenser: The vapour to be condensed and the cooling liquid are separated by a metal wall.

direct contact condenser: The vapour and cooling liquid are mixed directly.

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This condensation can be done by using the cooling water; now the type of condenser if we look into there is one surface condenser; that means, there is a heat exchange surface is provided ok; one side of which there is a steam and the other side there is a liquid. So, the vapour to be condensed and the cooling liquid are separated by a metal wall. The other method is direct contact condenser that is where the vapour and the cooling liquid are mixed directly.

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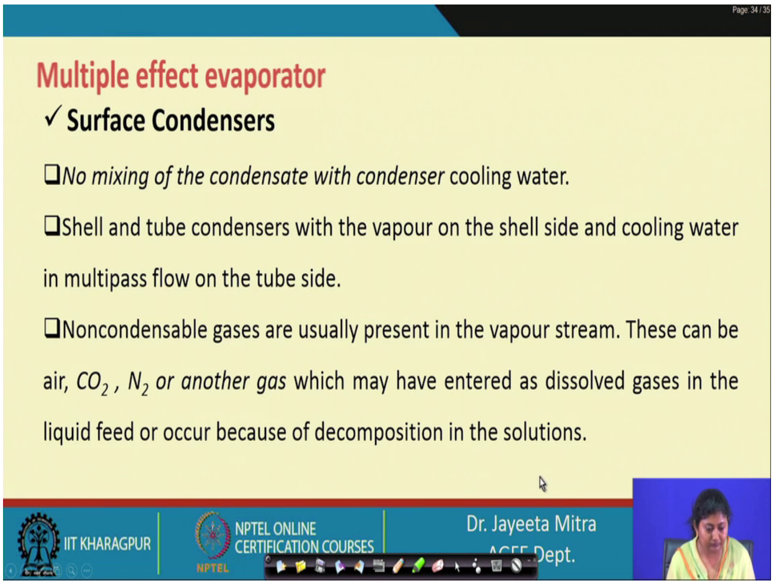

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Multiple effect evaporator

✓ **Surface Condensers**

❑ *No mixing of the condensate with condenser* cooling water.

❑ Shell and tube condensers with the vapour on the shell side and cooling water in multipass flow on the tube side.

❑ Noncondensable gases are usually present in the vapour stream. These can be air, CO_2, N_2 *or another gas* which may have entered as dissolved gases in the liquid feed or occur because of decomposition in the solutions.

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So, coming to first the surface condensers; here no mixing of the condensate with condenser cooling water is done because there is a heat exchange surface. So, across which the heat is being transferred; so, no mixing of the condensate with the condenser cooling water is done here.

Shell and tube condensers with the vapour on the shell side and the cooling water in multipass flow on the tube side so, that is one case we will discuss in detail the heat exchangers in the ah other chapters. So also with the vapour; there are some non condensable gases usually present ok. So, this can be air or carbon dioxide, nitrogen or another gas which may have entered as dissolved gases in the liquid feed or occur because of the decomposition in the solution.

So, these has to be removed from that vapour.

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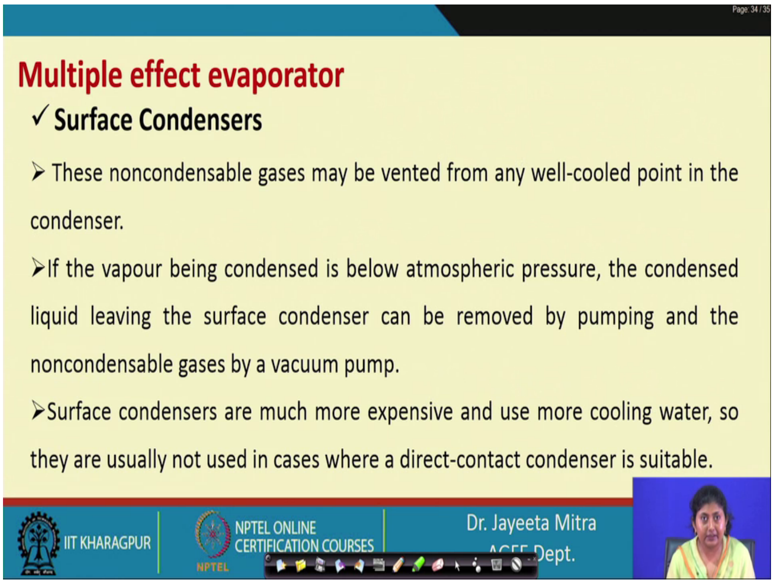

Multiple effect evaporator

✓ **Surface Condensers**

- These noncondensable gases may be vented from any well-cooled point in the condenser.
- If the vapour being condensed is below atmospheric pressure, the condensed liquid leaving the surface condenser can be removed by pumping and the noncondensable gases by a vacuum pump.
- Surface condensers are much more expensive and use more cooling water, so they are usually not used in cases where a direct-contact condenser is suitable.

So, these noncondensable gases may be vented from any well cooled point in the condenser. And if the vapour being condensed is below atmospheric pressure as the case may be when the last effect is operated under vacuum; the condensed liquid leaving the surface condenser can be removed by pumping and the noncondensable gases by a vacuum pump right.

So, because from the from the low pressure to the high pressure we need to take them out the condensed liquid that is that is why we need to pump them ok. Then surface condensers are much more expensive and use more cooling water. So, they are usually not used in cases where a direct contact condenser is suitable.

That means, since we are using a proper define geometry that is the tubes inside the shells, where the steam is in and we need to define all those geometry length of tube, the thickness everything and designing of this and fabrication is a cost involving affair. So, where the direct contact condenses can be use there we avoid any kind of surface condensers.

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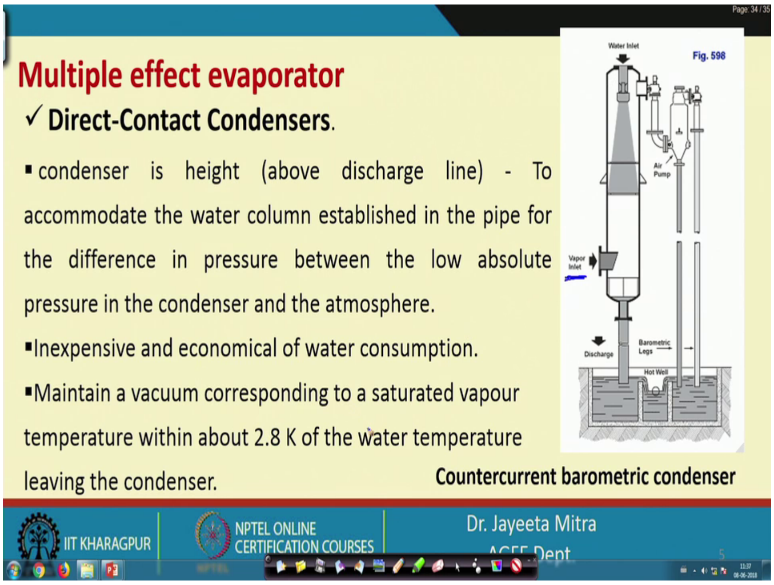

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Multiple effect evaporator

✓ Direct-Contact Condensers.

- condenser is height (above discharge line) - To accommodate the water column established in the pipe for the difference in pressure between the low absolute pressure in the condenser and the atmosphere.
- Inexpensive and economical of water consumption.
- Maintain a vacuum corresponding to a saturated vapour temperature within about 2.8 K of the water temperature leaving the condenser.

Countercurrent barometric condenser

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So, direct contact condensers; now we will look into direct contact condenser one example is countercurrent barometric condenser right. So, what happened here; the vapours which is coming from the evaporator effect that is first coming into the condenser the barometric condenser ok.

And then that is being cool by condense by the water which is falling on or getting directly mixed with the vapour. So, this kind of condenser generally the condenser is kept over a long distance from the discharge and because to accommodate the water column that is established in the pipe for differences in pressure between the low absolute pressure in the condenser and the atmosphere right.

So, because of atmospheric pressure it try to maintain a liquid column inside the; you know the direct barometric condenser. So, that is why we need to keep it keep the condenser at specific height above the discharge level and these are very inexpensive and economical in terms of water consumption.

So, here maintain a high vacuum corresponding to a saturated vapour temperature within about 2.8 Kelvin of water temperature leaving the condenser ok.

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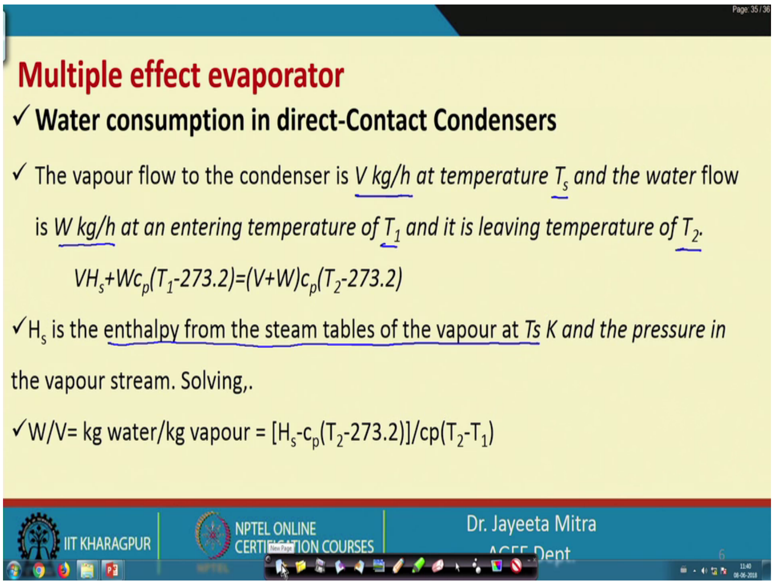

Multiple effect evaporator

- ✓ **Water consumption in direct-Contact Condensers**
- ✓ The vapour flow to the condenser is *V kg/h at temperature* T_s *and the water* flow is *W kg/h at an entering temperature of* T_1 *and it is leaving temperature of* T_2.

$$VH_s+Wc_p(T_1-273.2)=(V+W)c_p(T_2-273.2)$$

- ✓ H_s is the enthalpy from the steam tables of the vapour at *Ts K and the pressure in* the vapour stream. Solving,.
- ✓ W/V= kg water/kg vapour = $[H_s-c_p(T_2-273.2)]/cp(T_2-T_1)$

So, now water consumption in the direct contact condensers; so, how we can calculate the total water consumption in case of a direct barometric condenser? So, the vapour flow to the condenser if we assume that that is V kg per hour ok; V kg per hour, in this rate the vapour flow is coming to the condenser at a temperature of T S.

And the water flow is W kg per hour at an entering temperature of T 1 and this water leaves at a temperature of T 2 ok. So, then what will happen that the heat which will be given by the V kg per hour vapour will be taken by W kg per hour water and the temperature of this will increase from T 1 to T 2. So, making a heat balance; we can write V into capital H S which is the enthalpy from the steam table of the vapour at T S Kelvin.

So, V into capital H S plus W that is the mass flow rate of liquid water into C p specific heat into T 1 minus 273.2, that is equal to V plus W into c p; T 2 minus 273.2 ok. So, W by V that is kg of water divided by kg of vapour is coming as capital H; suffix S minus c p, T 2 minus 273.2 divided by c p into T 2 minus T 1. So, from this we can calculate the water consumption per kg of vapour needed in the direct barometric condenser.

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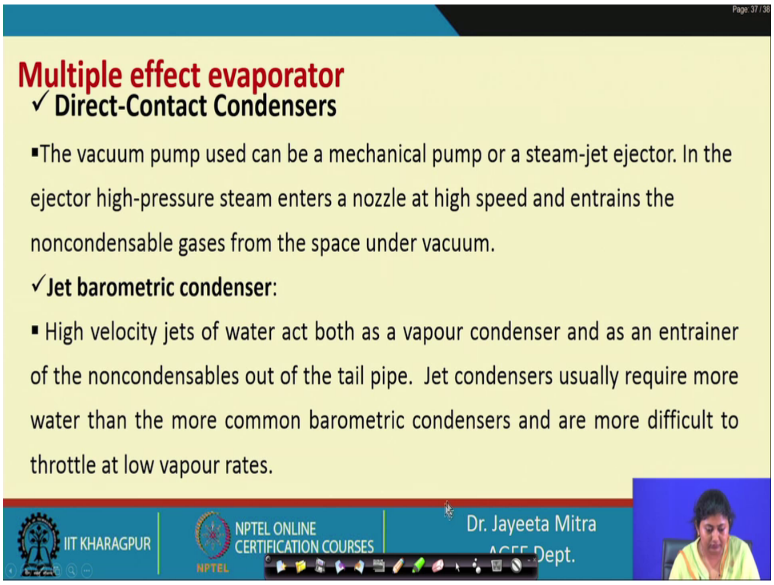

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Multiple effect evaporator

✓ **Direct-Contact Condensers**

- The vacuum pump used can be a mechanical pump or a steam-jet ejector. In the ejector high-pressure steam enters a nozzle at high speed and entrains the noncondensable gases from the space under vacuum.

✓ **Jet barometric condenser:**

- High velocity jets of water act both as a vapour condenser and as an entrainer of the noncondensables out of the tail pipe. Jet condensers usually require more water than the more common barometric condensers and are more difficult to throttle at low vapour rates.

Now the vacuum pump that is used can be mechanical pump or steam jet ejector. In the ejector high pressure steam enters a nozzle at high speed and entrains the non condensable gases from the space under vacuum; jet barometric condenser that is another type of condenser that is being used, where high velocity jets of water at both as vapour condenser and as an entrainer of the non condensable gases out of the tail pipe.

So, jet condensers usually require more water than more common barometric condensers and are more difficult to throttle at low vapour rates.

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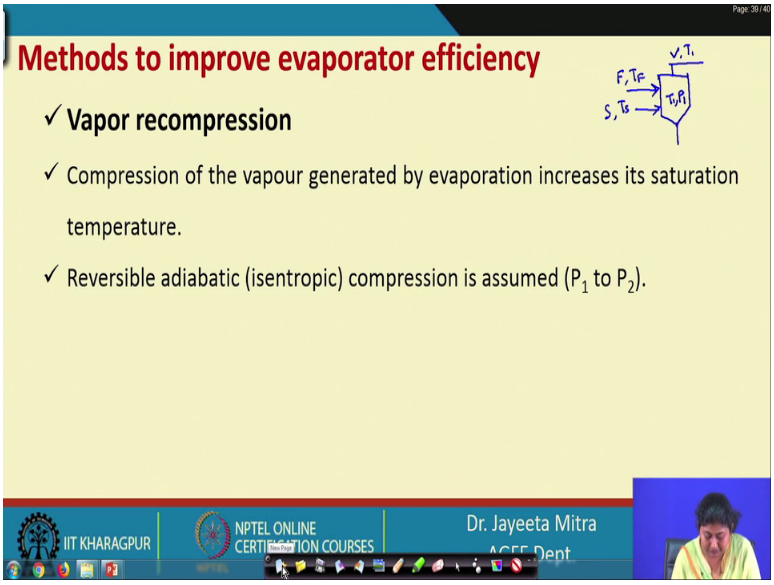

Methods to improve evaporator efficiency

- ✓ Vapor recompression
  - ✓ Compression of the vapour generated by evaporation increases its saturation temperature.
  - ✓ Reversible adiabatic (isentropic) compression is assumed (P_1 to P_2).

So, another way of improving the evaporator efficiency is the vapor recompression. So; that means, we are somehow increasing the pressure of the vapour that is coming out of the effects of the evaporator ok; so compression, so compression of the vapour generated by evaporation increases its saturation temperature, so the vapour that is if we want to draw this.

So, if we take a single effect evaporator as well this is steam entering at T S temperature and this is feed at T F and here it is T 1 temperature, P 1 pressure and the vapour V which is coming out at T 1. Now if the vapour is being compressed; that means, we are increasing the pressure from P 1 to P 2. So, this is kind of a reversible adiabatic compression ok; so reversible. So, there is no change in the entropy and again adiabatic; so entropy is constant in this case; so isentropic compression is assumed and the compressed vapour is introduced to the steam side of the same evaporator.

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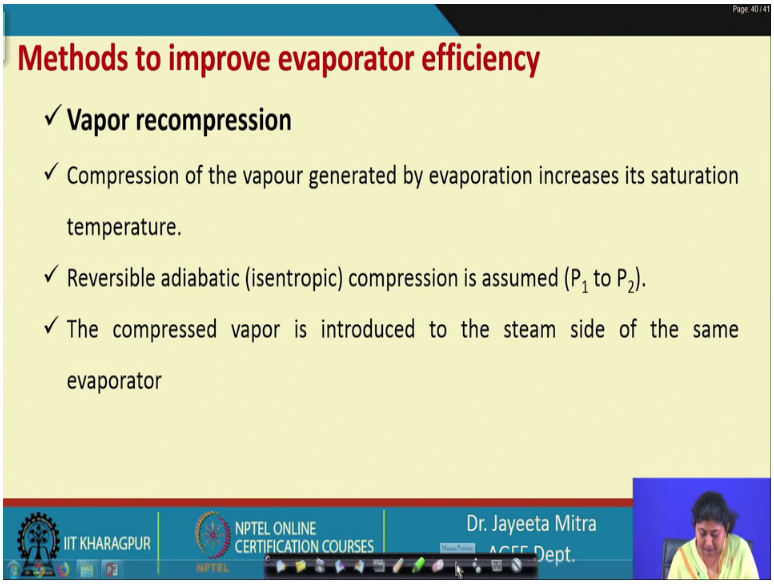

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Methods to improve evaporator efficiency

- ✓ **Vapor recompression**
- ✓ Compression of the vapour generated by evaporation increases its saturation temperature.
- ✓ Reversible adiabatic (isentropic) compression is assumed (P_1 to P_2).
- ✓ The compressed vapor is introduced to the steam side of the same evaporator

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So here we are not going to increase the you know different effect, but within a same effect, we just recompress the vapour that is coming out of the effect and then we are reusing it in the steam side section of the evaporator.

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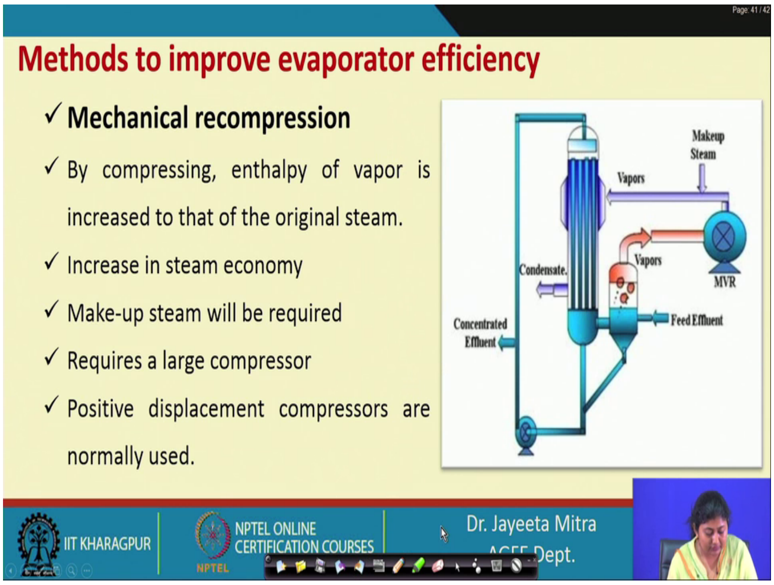

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Methods to improve evaporator efficiency

- ✓ **Mechanical recompression**
- ✓ By compressing, enthalpy of vapor is increased to that of the original steam.
- ✓ Increase in steam economy
- ✓ Make-up steam will be required
- ✓ Requires a large compressor
- ✓ Positive displacement compressors are normally used.

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So, the vapour recompression can be of 2 types one is the mechanical vapour recompression, another is the thermal vapour recompression. So, mechanical vapour recompression; so, if we look into this diagram. So, this is a single effect evaporator where steam is entering from ok; steam is entering from this section and that is condensing condensed liquid is coming out from this side.

The feed which is you know sending to the entering to the evaporated from this bottom and then it is evaporated in a here ok. And all the vapour that is being separated is going to this mechanical vapour recompression device and then it is compressing the steam increasing its pressure. And then adding some makeup steam to it and that steam is the again utilizing you know that that is being utilized for the evaporation process.

So, here we are getting a higher efficiency with single effect only, but by the application of vapor recompression. So, the enthalpy of the vapor is increased to that of the original steam ok. So, in this process the steam economy is increased; that means, using 1 kg of steam, we can increase higher amount of water evaporation that we can get; so, that is how that is how steam economy is increased. Make up steam will be required and this requires a large compressor generally positive displacement compressors are used.

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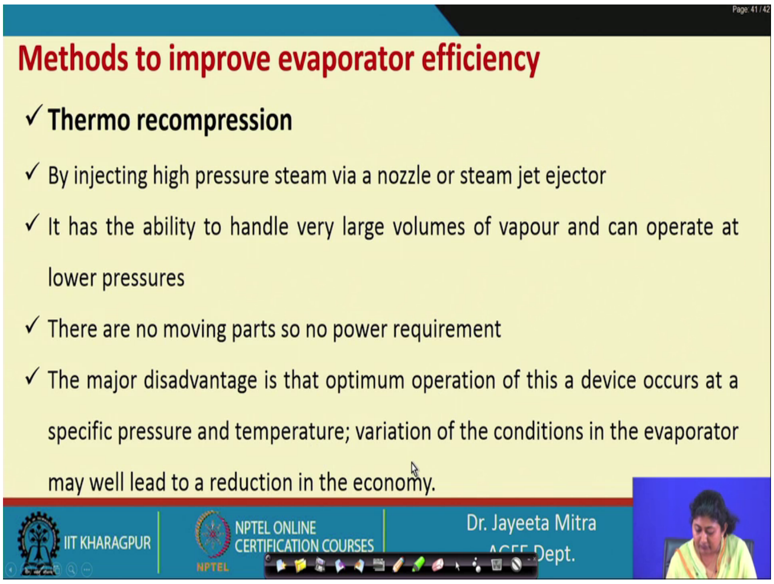

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Methods to improve evaporator efficiency

- ✓ **Thermo recompression**
- ✓ By injecting high pressure steam via a nozzle or steam jet ejector
- ✓ It has the ability to handle very large volumes of vapour and can operate at lower pressures
- ✓ There are no moving parts so no power requirement
- ✓ The major disadvantage is that optimum operation of this a device occurs at a specific pressure and temperature; variation of the conditions in the evaporator may well lead to a reduction in the economy.

So, another method is the thermal recompression here by injecting high pressure steam via a nozzle or steam jet ejector.

We increase the you know pressure of it, it has the ability to handle very large volume of vapour and can operate at lower pressure. So, there are no moving part as it needed for mechanical vapour recompression; so no power requirement is needed. The major disadvantage is that optimum operation of this device occurs at a specific pressure and temperature.

That means, if there is any kind of variation in the condition that is the steam the amount of steam that is being generated or any variation in the pressure and temperature of that if happens, then it cannot perform ok. So, variation of condition in the evaporator may well lead to reduction in the economy; so that is about the thermo recompression.

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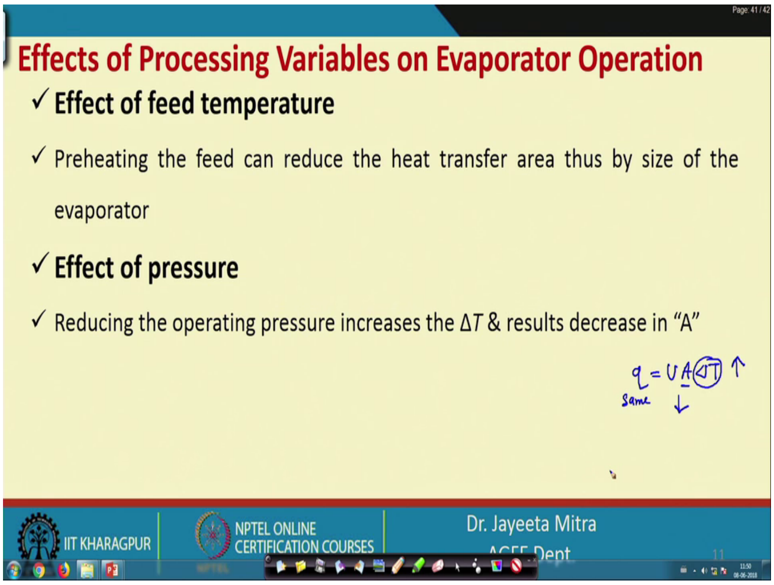

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Effects of Processing Variables on Evaporator Operation

- ✓ **Effect of feed temperature**
- ✓ Preheating the feed can reduce the heat transfer area thus by size of the evaporator
- ✓ **Effect of pressure**
- ✓ Reducing the operating pressure increases the ΔT & results decrease in "A"

$$\underset{\text{Same}}{q} = U\underset{\downarrow}{\underline{A}}\boxed{\Delta T}\uparrow$$

Now, next we will see the effects of processing variables on evaporator operation; first is the effect of feed temperature. Now how the feed temperature is going to effect because we generally try to increase the efficiency of an evaporator.

So, feed temperature if well below the operating temperature of the evaporator; then what happened we need to heat the feed to the boiling temperature. So, we need more heat and more you know heat transfer area is required. So, to minimize the extra heat needed to increase the you know sensible temperature sensible heat of the feed, we can preheat the feed and then we try to enter it you know near the temperature that is prevailing inside the effect of the evaporator so, that can be done.

So, one point is preheating the feed that can reduce the heat transfer area and size of the evaporator. Next is effect of pressure; so this is also very clear by now that corresponding to the pressure corresponding to the pressure the saturation temperature; we can see from the steam table and that that is the temperature that is being present or that is the boiling temperature of the liquid in the evaporator.

Now by any means if the pressure is changed; so the saturation temperature or boiling temperature will also change. So, reducing the operating pressure increases the delta T; that means, if the pressure is reduced or the vacuum is being generated inside. So, delta T will increase and results in decrease in area because a overall heat transfer q; that is equal to overall heat transfer coefficient into area into temperature difference right q that is equal to UA delta T. So, if somehow this delta T is increasing; that means, A will decrease to get the same heat transfer effect right.

So, therefore reducing the operating pressure increases the delta T and results in decrease of the heat transfer area.

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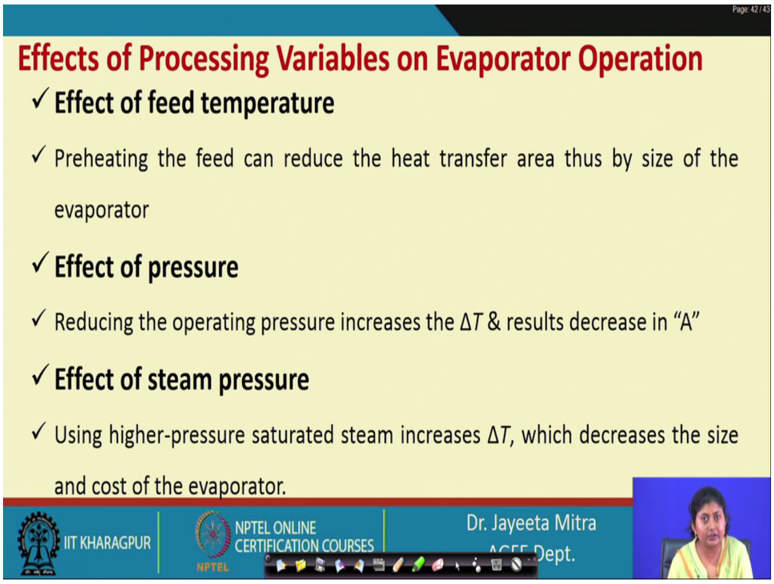

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Effects of Processing Variables on Evaporator Operation

- ✓ Effect of feed temperature
- ✓ Preheating the feed can reduce the heat transfer area thus by size of the evaporator
- ✓ Effect of pressure
- ✓ Reducing the operating pressure increases the ΔT & results decrease in "A"
- ✓ Effect of steam pressure
- ✓ Using higher-pressure saturated steam increases ΔT, which decreases the size and cost of the evaporator.

Then effect of steam pressure; so using higher pressure saturated steam increases the delta T right; which decreases the size and cost of the evaporator. Definitely, because if delta T increases again by increasing the; pressure of the saturated steam then we are getting a higher heat transfer by ah having a lower surface area. So, thereby we can design smaller evaporator; smaller size of evaporator for the same heat transfer rate and the cost will be reduced.

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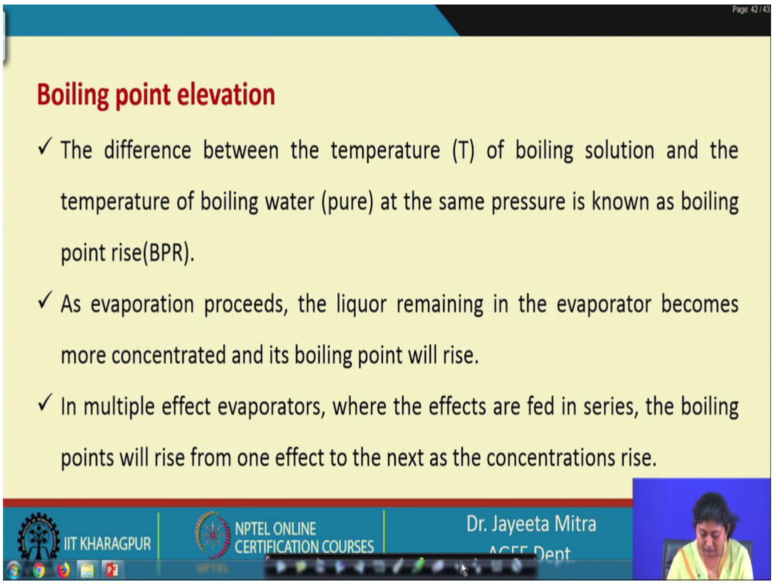

Boiling point elevation

- ✓ The difference between the temperature (T) of boiling solution and the temperature of boiling water (pure) at the same pressure is known as boiling point rise(BPR).
- ✓ As evaporation proceeds, the liquor remaining in the evaporator becomes more concentrated and its boiling point will rise.
- ✓ In multiple effect evaporators, where the effects are fed in series, the boiling points will rise from one effect to the next as the concentrations rise.

The next thing we will going to cover is boiling point elevation. So, this is an important phenomena because there are a difference in the boiling point of a solution corresponding to the pure water. The difference between the temperature of boiling solution and the temperature of pure water, boiling of the pure water at the same pressure is known as the boiling point rise or sometime boiling point elevation.

So, as evaporation proceeds what happened that the liquid sample liquid that we have taken for evaporation becoming concentrated more and more and this will cause rise in the boiling point, in the evaporated. So, in multiple effect evaporator whether effects are fed in series; so, the boiling point will rise from one effect to the next as the concentration rises. So, based on the concentration the boiling point elevation happened; so as the concentration increases, boiling point elevation will also increase.

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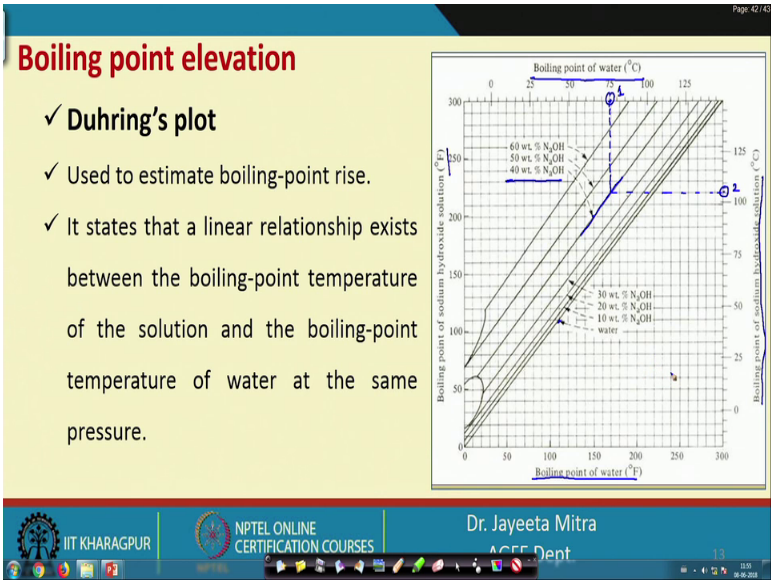

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Boiling point elevation

- ✓ **Duhring's plot**
- ✓ Used to estimate boiling-point rise.
- ✓ It states that a linear relationship exists between the boiling-point temperature of the solution and the boiling-point temperature of water at the same pressure.

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Now, there is a chart which is called Duhring's plot which can give us an idea that how the pure water boiling point and the solution boiling point varies and we have seen that they have a linear relation ok. So, if we see the Duhring's plot; it looks like the boiling point of water either in degree Fahrenheit or boiling point of water in degree Celsius and also with that we have the boiling point of sodium hydroxide solution both in degree Celsius and degree Fahrenheit.

So, we have pure water the bottom curve and then 10 percent Na OH, 20 percent, 30 percent then 40, 50; up to 60 percent ok. So, from this we can get an idea that the boiling point elevation because of the dissolve NaOH into the liquid water varies from the boiling point of pure water linearly and we can calculate them from this chart. For example, let us say the boiling point of pure water is boiling point of pure water at certain condition is 75 degree Celsius.

Now if we want to calculate the boiling point of 40 weight percent NaOH in the similar condition. So, this curve which is which is corresponding the 40 weight percent NaOH and the boiling point of water which is showing 75 degree Celsius. So, we will look for the intersection of that and then we will find the point which is the boiling point of the 40 weight percent NaOH solution. And the difference between this point and these points this is 1.1 and 0.2. So, boiling point between these 2 will give us the boiling point rise or boiling point elevation ok.

So, at a particular temperature; at a particular pressure the relationship between the pure water and dissolved material in that will generally follow the linear relation.

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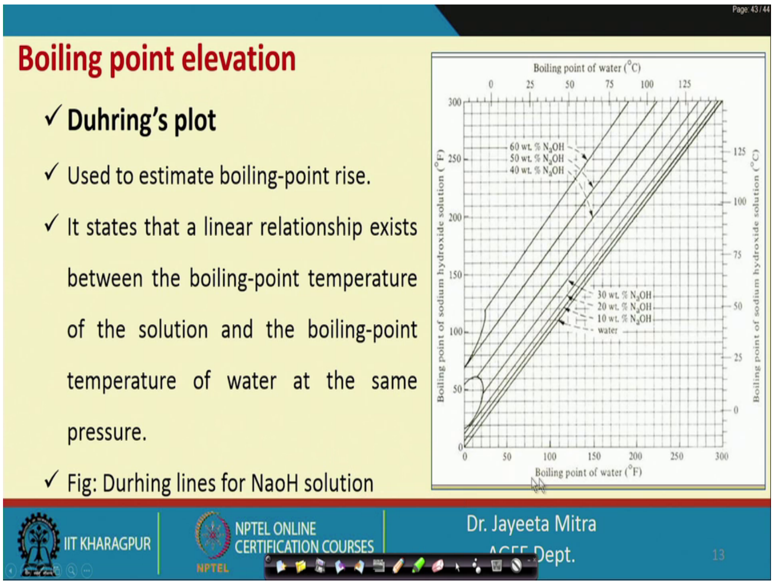

Boiling point elevation

- ✓ **Duhring's plot**
- ✓ Used to estimate boiling-point rise.
- ✓ It states that a linear relationship exists between the boiling-point temperature of the solution and the boiling-point temperature of water at the same pressure.
- ✓ Fig: Durhing lines for NaoH solution

So Durhing line is for NaOH solution and for other we can also calculate it.

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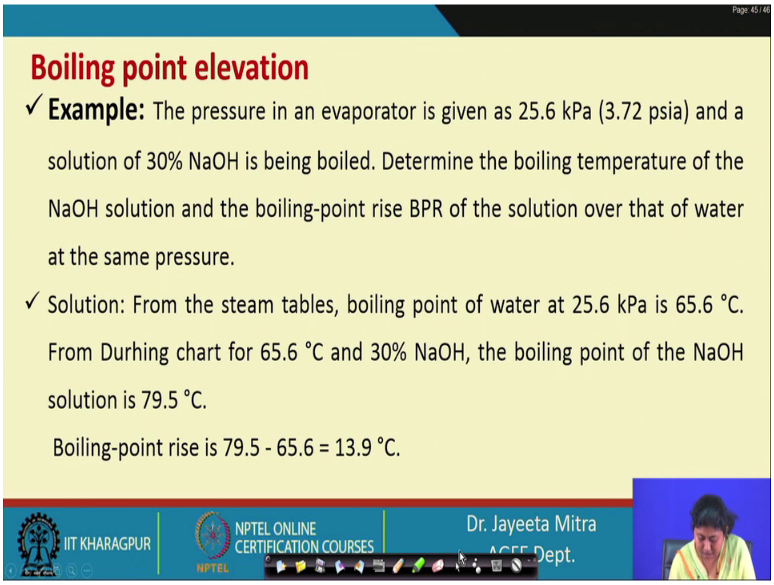

Boiling point elevation

- ✓ **Example:** The pressure in an evaporator is given as 25.6 kPa (3.72 psia) and a solution of 30% NaOH is being boiled. Determine the boiling temperature of the NaOH solution and the boiling-point rise BPR of the solution over that of water at the same pressure.
- ✓ Solution: From the steam tables, boiling point of water at 25.6 kPa is 65.6 °C. From Durhing chart for 65.6 °C and 30% NaOH, the boiling point of the NaOH solution is 79.5 °C.

  Boiling-point rise is 79.5 - 65.6 = 13.9 °C.

So, here will solve an example that the pressure in an evaporator is given as 25.6 kilo Pascal or 3.72 psia and a solution of 30 percent NaOH is being boiled. Determine the boiling temperature of the NaOH solution and the boiling point rise of the solution over that of water at the same temperature ok. So, what is given here? The pressure; the pressure in the evaporator that is given and solution of 30 percent NaOH is given.

So, what we can do is first corresponding to 25.6 kilo Pascal what will be the saturation pressure of pure water; saturation temperature of pure water that we can find and later on we can read from the Durhing plot that for 30 percent NaOH and the boiling point of pure water corresponding to this much pressure what is the boiling point of the solution ok?.

So, we have seen that from the steam table 65.6 degree Celsius that is the saturation temperature or boiling point at boiling point of pure water at this pressure. From the Durhing chart; 65.6 degree Celsius and 30 percent NaOH, boiling point of the NaOH solution is coming around 79.5 ok. Now, those who are not familiar with steam table; I think I have here want to show you.

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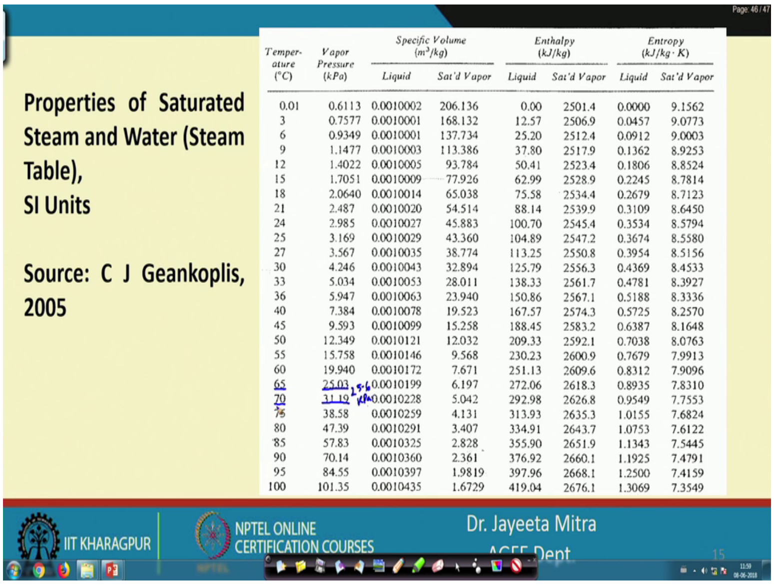

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Properties of Saturated Steam and Water (Steam Table), SI Units

Source: C J Geankoplis, 2005

Temperature (°C)	Vapor Pressure (kPa)	Specific Volume (m³/kg)		Enthalpy (kJ/kg)		Entropy (kJ/kg · K)	
		Liquid	Sat'd Vapor	Liquid	Sat'd Vapor	Liquid	Sat'd Vapor
0.01	0.6113	0.0010002	206.136	0.00	2501.4	0.0000	9.1562
3	0.7577	0.0010001	168.132	12.57	2506.9	0.0457	9.0773
6	0.9349	0.0010001	137.734	25.20	2512.4	0.0912	9.0003
9	1.1477	0.0010003	113.386	37.80	2517.9	0.1362	8.9253
12	1.4022	0.0010005	93.784	50.41	2523.4	0.1806	8.8524
15	1.7051	0.0010009	77.926	62.99	2528.9	0.2245	8.7814
18	2.0640	0.0010014	65.038	75.58	2534.4	0.2679	8.7123
21	2.487	0.0010020	54.514	88.14	2539.9	0.3109	8.6450
24	2.985	0.0010027	45.883	100.70	2545.4	0.3534	8.5794
25	3.169	0.0010029	43.360	104.89	2547.2	0.3674	8.5580
27	3.567	0.0010035	38.774	113.25	2550.8	0.3954	8.5156
30	4.246	0.0010043	32.894	125.79	2556.3	0.4369	8.4533
33	5.034	0.0010053	28.011	138.33	2561.7	0.4781	8.3927
36	5.947	0.0010063	23.940	150.86	2567.1	0.5188	8.3336
40	7.384	0.0010078	19.523	167.57	2574.3	0.5725	8.2570
45	9.593	0.0010099	15.258	188.45	2583.2	0.6387	8.1648
50	12.349	0.0010121	12.032	209.33	2592.1	0.7038	8.0763
55	15.758	0.0010146	9.568	230.23	2600.9	0.7679	7.9913
60	19.940	0.0010172	7.671	251.13	2609.6	0.8312	7.9096
65	25.03 25.6 kPa	0.0010199	6.197	272.06	2618.3	0.8935	7.8310
70	31.19	0.0010228	5.042	292.98	2626.8	0.9549	7.7553
75	38.58	0.0010259	4.131	313.93	2635.3	1.0155	7.6824
80	47.39	0.0010291	3.407	334.91	2643.7	1.0753	7.6122
85	57.83	0.0010325	2.828	355.90	2651.9	1.1343	7.5445
90	70.14	0.0010360	2.361	376.92	2660.1	1.1925	7.4791
95	84.55	0.0010397	1.9819	397.96	2668.1	1.2500	7.4159
100	101.35	0.0010435	1.6729	419.04	2676.1	1.3069	7.3549

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Dr. Jayeeta Mitra

AGFE Dept

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So, this is the properties of saturated steam and water that is called steam table; this is in SI unit, you can get in other unit as well. So, this is available in most of the unit operation or food engineering book index appendix section. So, here we need to find the vapour pressure that is been given something between these two 25.03.

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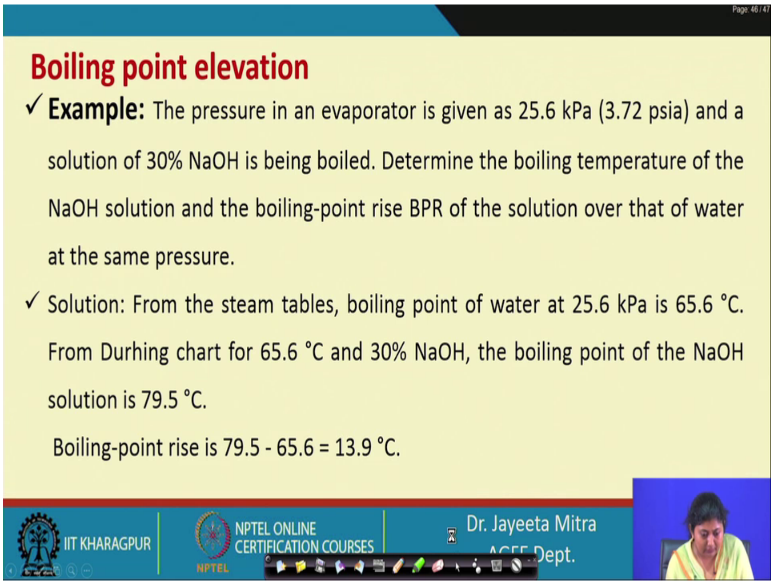

Boiling point elevation

- ✓ **Example:** The pressure in an evaporator is given as 25.6 kPa (3.72 psia) and a solution of 30% NaOH is being boiled. Determine the boiling temperature of the NaOH solution and the boiling-point rise BPR of the solution over that of water at the same pressure.
- ✓ Solution: From the steam tables, boiling point of water at 25.6 kPa is 65.6 °C. From Durhing chart for 65.6 °C and 30% NaOH, the boiling point of the NaOH solution is 79.5 °C.

  Boiling-point rise is 79.5 - 65.6 = 13.9 °C.

And I think the next one is; so, here 25.6 kilo Pascal ok; 25.6 kilo Pascal. So, 25.03; the temperature is 65 25.03, the boiling point will be 65 and 31.19; so, boiling point in 70. So, in between these 2 we need to interpolate for 25.6 kilo Pascal and that is coming around the temperature that we have measured ok.

So, so that is 65.6 and from the Durhing chart; we have read 79.5 for the solution of 30 percent NaOH; so, 79.5 minus 65.6 that will be the boiling point elevation ok. So, we will stop here and we will continue in the next class.

Thank you.