Natural Gas Engineering
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Module No # 01
Lecture No # 02
Introduction to Natural Gas – II

Hello everyone and welcome to the class of natural gas engineering in today's lecture we are going to continue our discussion of introduction natural gas. So I name this topic as introduction to natural gas 2 before we go ahead with a plan of discussing the phase behavior.

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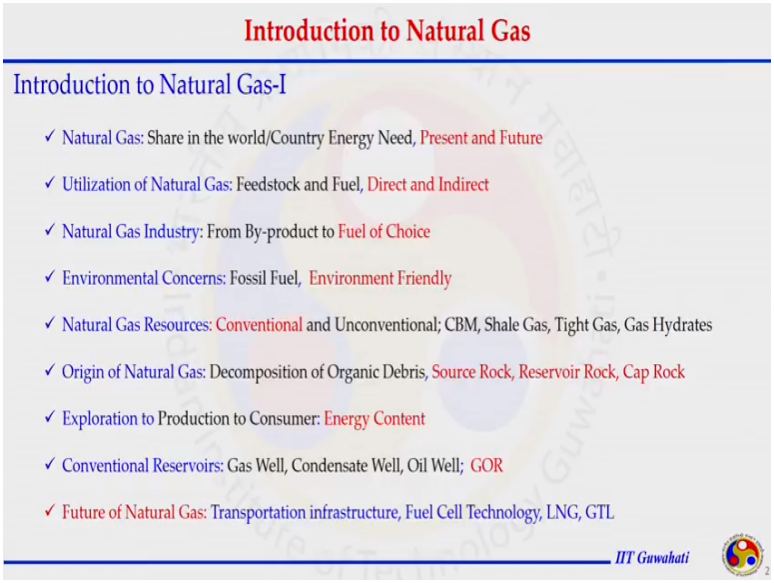

Let us summarize what we discuss in the last class introduction to natural gas 1 in that class we discuss several of aspects of natural gas engineering from its exploration to its business. We started with natural gas definition share in the world market. So natural gas as a hydro carbon source or a fossil energy source is going to play a major role in the meeting of world energy demand as well as for a particular country.

How the future can be predicted for the natural gas several reports are published those reports provide us the guide line based on certain models which particular component of energy is going to lead in the future and in which sector the major contribution will come we

discussed these aspects with respect to natural gas in the domain of fossil fuel energy or in a carbon constraint wall.

We also discuss the utilization of natural gas means from it is feed stock as well as fuel properties how this can contribute to several sector in the form of direct energy or in direct source of the energy like for electricity natural gas can be used as a fuel similar for fertilizer and petro chemical synthesis natural gas can be utilized. Another aspect we discuss about fuel cell technology where the natural gas can be used to produce the hydrogen that is the feed for the fuel cell.

Natural gas industry we discuss from its by productive field to choice. So we discuss natural gas engineering aspect as the people were not aware about it engineering aspects where people not aware about its characterize as of fuel. So long time back it was just a byproduct of other process like the coal mine and the wild exploration when the natural gas is being produce either it is using locally or before that it is being just flare to the atmosphere.

But over the time this becomes the choice of important as a fuel and people are researchers or countries are exploring not only the conventional natural gas but several unconventional sources also considering natural gas is having a good future as a fuel and feed stop for several materials. We discuss the environmental concern also that is within the fossil fuel comparison like oil and coal environmentally natural gas is more friendly it releases no particular matters it has less harm to the atmosphere compared to coal and oil.

That is why it is considered the most clean fossil fuel energy source to produce the energy we also discuss about the resources those could be conventional and unconventional resources. Conventional means the producing through this reservoir steam they upstream sector where sector several aspects are involved and the gas is being produced which is naturally stored in the reservoir domain.

Unconventional also the gas is naturally stored in those domain but the technology has not been advanced up to the level and coal bed methane, shell gas, tide gas, gas hydrate other forms are considered unconventional sources it is blamed there is a huge amount of the

unconventional energy resources are available at several places and if those can be exploited effectively there is a plenty of hydro carbon energy available is still on this planet.

After that we started understanding the origin of natural gas so the origin of natural actual gas is similar to what is the theory for the composition of organic matter that has been proposed for oil generation similar theory of (()) (05:07) to natural gas production where the organic material gone through the temperature and pressure history underneath the surface over a geological time scale where the organic material got converted into coal oil and final into gas phase.

To have the resources like the fluid, gas and oil and get in the reservoir domain there are three types of rock are required source rock from where the gas will be producing because of the organic composition reservoir rock means permeable rock which is allowing the fluid to flow from one place to another place and where they are getting big porous media or kind of bank formation from where it can be extracted in a significant quantity and cap rock.

If there is no cap rock in this reservoir rock then the gas or the oil because of its own energy because of pressure energy will come out to surface by its own so there is a there should be a cap rock that is holding this valuable reserve underneath and in a control manner can be exploited while we reach to that resource by drilling that process of reaching to this resources.

Especially like natural gas that is a found very depth like around 70000 feet mostly will find the natural and to reach that point it is very important how to find out the side where the drilling should be started it the business of natural gas process start from the exploration several advance technic have been developed and those techniques allows to predict very precisely the place where the well should be drilled to produce the natural gas.

After producing the natural gas to surface after finding the natural gas at a particular location where drilling is required then well completion process is there after well completion producing starts and 1 production is starting the gas is reaching to surface and surface facilities are required to refine this gas and take out the valuable compound and remaining methane gas can be sent to pipeline or to consumer uses.

Some impurities those needs to be separated out also when we talk about supplying the natural gas to consumer it is not only measured in terms of volume but in terms of energy contain the gas being supplied to consumer carrying it is measured in terms of BTU sometimes in therm also the energy supplied to consumer is accounted conventional resources we discuss about how to classify the gas reservoir in a based on the gas oil ratio gas well, condensate well and oil well are the major classification based on the gas to oil ratio under the producing condition.

Future of the natural gas it is discuss in terms of transportation or the facilities or infrastructure can be developed where the natural gas can be utilize at a place of interest from the place of production effectively from the best technology or the infrastructure can be developed it may have a bright future in terms of hydro carbon energy resources other technology like fuel cell technology uses of natural gas in the form of LNG or converting this natural gas to liquid.

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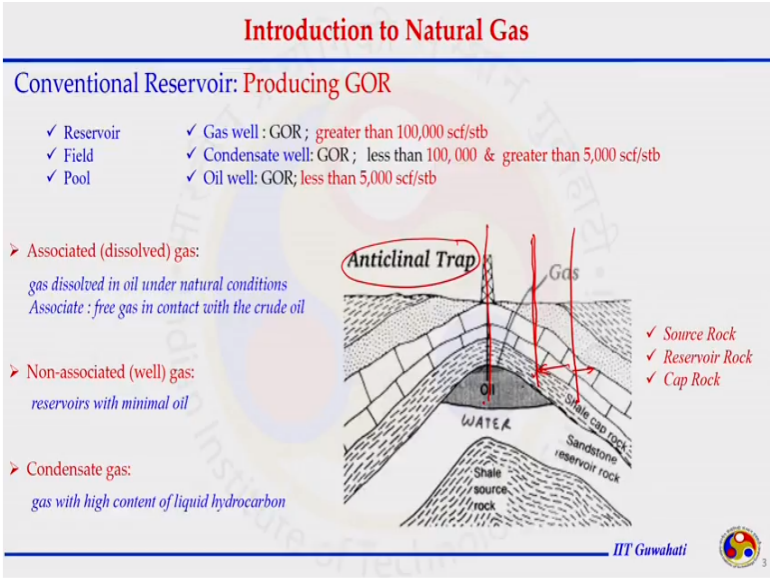

Before we go to phase diagram let us discuss the conventional resources one more time that I said based on the producing GOR we can classify gas well condensate well and oil well. Reservoir field and pool concept was discussed the reservoir is the particular domain if where the possibilities are hydro carbon resources or in our case the gas resources are high where we can drill the well and get the gas out.

This one type of the anticlinal trap could be several type of formation underneath those allowed the fluid this gas, oil and water to be trapped and recovered by drilling the well up to the location. Sometimes it may happens the value is not at a particular location like in this is going like this it is not going hit properly or may be little bit far away and it seen to be make ahh this should stop drilling also tried horizontal direction.

Those are several aspect those related to the exploration and well completion process we are not going to discuss those in detail but what we discuss about with respect to the natural gas. The gas can be produced with the oil when the well is producing oil it is a natural gas it is associated with that well and that could be form of dissolve gas.

So gas is dissolved in the when oil coming to surface because of the pressure difference gas is coming out of the oil phase or it is just a free gas kind of cap rock for formation is there when the oil is producing and after the gas is also producing because of that gas was available freely in that reservoir domain. Non associate gas that not carrying the liquid or carrying the liquid in very small amount that we called as non-associate gas, well gas, dry gas are the example of non-associate gas, condensate gas, gas with high content of high liquid hydro carbon.

So when we are having a gas which is carrying higher hydro carbon like C7+ and which it is being produced to the surface those because of the pressure difference these are getting separated out in the form of natural gas liquid and we are having the condensate gas type of the reservoir. This is the topic which we are going to cover in today's lecture in terms of the phase diagram.

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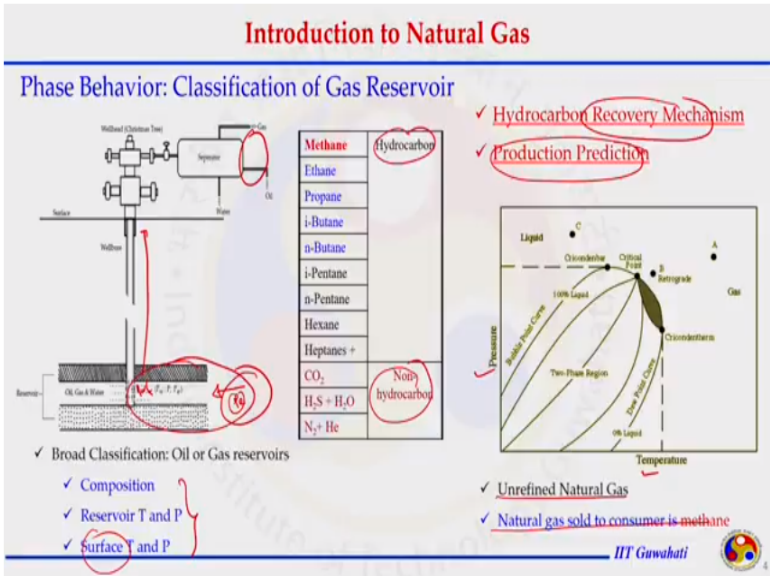

So before we go to phase diagram let us understand why phase diagram is recalled phase behavior understanding of the fluid when it is export to different conditions especially in our case different temperature and pressure condition how the fluid will behave can be accomplished under the thermo dynamic domain and how this particular fluid will go to gas phase or liquid phase can be accomplished with the help of phase behavior study.

And based on that behavior we can classify the reservoir not only the gas reservoir but as well as gas and oil reservoir can be classified based on the phase diagram. This is very important because this phase behavior allow us to understand when the pressure is changing. For example here in the production system where the reservoir pressure is PE the gas is travelling from PE to PWF. Assumption it is under isothermal condition and when the gas mixture the hydro carbon mixture the natural gas is the mixture of hydrocarbon and non-hydro carbon gases when this gas is passing from different pressure zone on it will behave differently.

Not only within the phrase difference in the reservoir domain but from PWF to PHF similar at this surface facilities when it is going to meet the separator it will behave differently. So with respect to what is in the reservoir domain? And what are the conditions at the separator if we understand how the fluid, oil or gas is going to behave when it is travelling from reservoir to separator.

Over the time the reservoir phrase will also decline when the pressure is changing within the reservoir how the fluid that is reserved in that domain that could not be recovered up to that point then the pressure drop in the reservoir how it is going to behave will allow us the understanding of fluid phase behavior allow us to provide or adopt the appropriate mechanism for this hydro carbon recovery mechanism.

So the hydro carbon recovery mechanism can be chosen based on the understanding of how the fluid is behaving in a different temperature pressure zone and the phase behavior mostly understood by pressure and temperature behavior PT behavior we call it. Broadly classification of oil and gas reservoir.

So particular reservoir is producing the oil or gas depend on three primary parameters what are the composition of that fluid which is being produced what are the reservoir temperature and pressure condition and when the fluid is brought to surface what are the temperature and pressure condition at the surface we call it like a surface means at the first place the separator when the fluid is meeting the separator at what temperature and pressure condition it is going to be.

So these three things composition reservoir temperature pressure and surface temperature pressure decide broadly classification of the reservoir fluid broadly we can classify reservoir while reservoir and gas reservoir we will discuss later on in terms of natural gas the unrefined natural gas that is here in the reservoir travels all the way to surface and before it goes to consumer it is just a methane.

The composition are also changing and within the reservoir also we will see at the end of the class we will see when the fluid is being produced from the reservoir it is assumed like it is producing the constant composition and the composition of the gas will remain constant throughout the production but if it is a different type of reservoir where phase separation is happening the composition will also get change and when the composition are changing everything designed based on composition will get effected.

Another application of phase behavior and where the phase behavior is going to help us is production prediction. So we can predict the production if we understand well how the fluid

or the gas which is being produced is going to behave in future when the pressure will decline in the reservoir.

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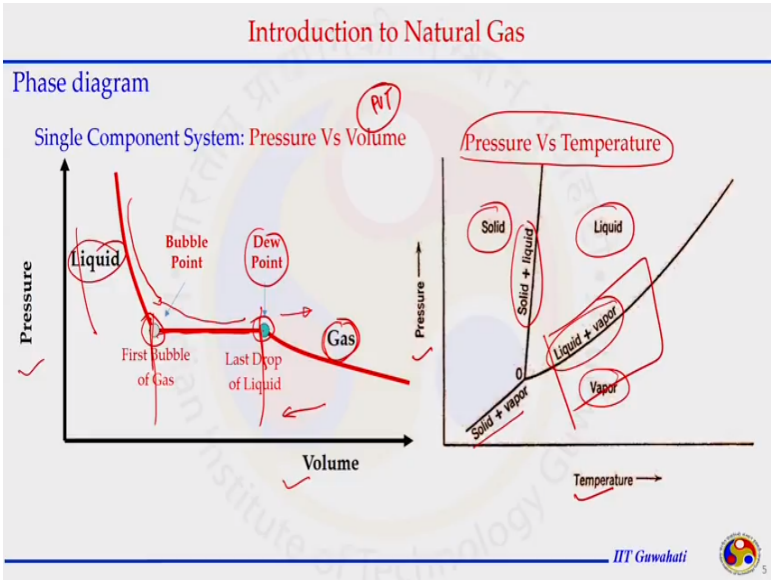

So before we start understanding the complex behavior of our complex system that is natural gas a mixture of hydro carbon and no-hydro carbon gases let us understand the thermo dynamic or the phase behavior of a single component any component which is present in a system and we are going to understand its behavior under different temperature, pressure and volume then we call the PVT behavior how it is going to be.

In a today diagram we always choose two parameters for example here pressure versus volume for any component it says how we are going to achieve bubble point and dew point. Bubble point means first bubble of gas appears and dew point last drop of liquid beyond this due point we are having the gas and on the other side before bubble point is reached we are having the liquid.

So if we see here for example we are having this pressure liquid is there and when we reducing the pressure what are going to say first the bubble and then a constant line and then we are going to hit the dew point when there in this case only volume will change not the pressure and once we reach the dew point we are having the last drop of liquid is appearing here is the first bubble of gas and head the last drop of liquid after that we are having the gas.

In this region in between in this region of bubble point and dew point we are having the mixture which is an equilibrium generally we understand PT behavior we choose the PT behavior instead of the PV behavior and where we can say with respect to pressure and temperature how a particular single component is going to behave when it is having these soiled and vapor reason liquid and proper reason solid and liquid reason it will be in the solid form only when it will be in the form of liquid form only when will be the vapor form only our interest with respect to natural gases in this region when we are having the liquid and vapor.

So let us understand that what we discussed when we are changing the pressure or the volume either we are reducing the volume or reducing the pressure or the increase in the volume or increase in the pressure or any combination of pressure and volume we can change the phase of the component it can go from liquid to vapor, vapor to liquid or condition where it is adjusting equilibrium it means gas and both gas and vapor and liquid phases are adjusting.

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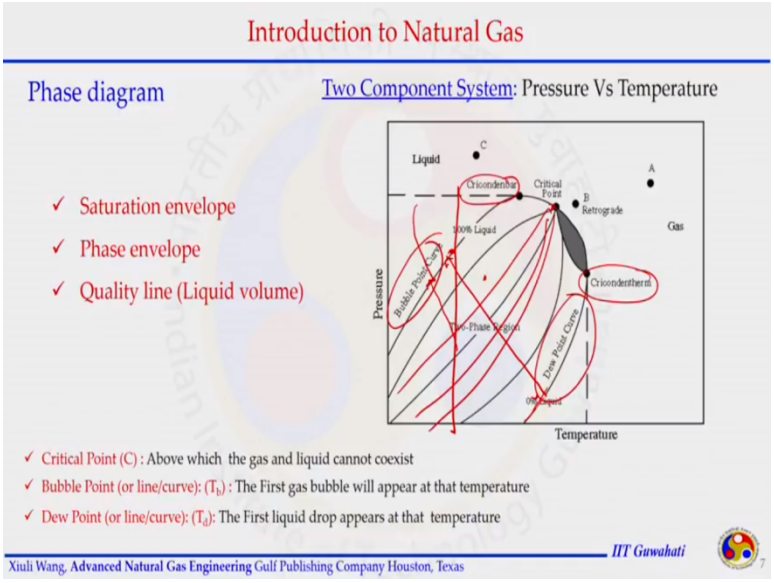

So for a single component again with respect to pressure and temperature we can see how fluid behaves when we are having temperature and pressure when the fluid is exposed single component fluid is exposed to different temperature and pressure history so we are having this line that is the called the vapor pressure line on one side of line we are having just a liquid phase on the other side we are having vapor phase and the point where on this line where the both liquid phase and vapor phase or the adjusting together.

And from this point when liquid is going to convert into vapor because of changes in condition this line will called the bubble point curve and by any mean vapor going to change into liquid line will call the dew point curve and the points C here is the critical point above phase the gas and liquid cannot adjust together at this point on the temperature scale is called the critical temperature and on the pressure scale is called the PC.

Bubble point curve when we are having this bubble point curve changing liquid to vapor phase and that can be done for example we are going in this direction from pressure to volume pressure to temperature if we are increasing the temperature at a constant pressure we are going to get the phase change from liquid to vapor and similar when we are reducing the temperature the fluid is passing this line or vapor curve line it will change from gas to liquid.

So that can be accomplished we can change the phase of a single component system just by changing temperature and pressure and this phenomena is just represented by 1 line that is called the vapor pressure line which accounts for both bubble point line as well as dew point line and the fluid characterize by a single point C that says beyond this point there is no changes where the gas and liquid can changes if we extent this further and say for 2 component system.

We are having the two component system here if we are having the two component system here I had shown the diagram for multicomponent system as in there are only two component system what exactly happens the vapor pressure line it is not a single line or the bubble point and dew point they get separated and one side you will be having he bubble point curve and other side we will be having the dew point curve.

And in between bubble point and dew point curve there is kind of a reason we called as saturation envelope or the phase envelope where both liquid and gas phase where are adjusting there are there will be several lines we called them the quality lines those represent the amount of liquid in terms of volume when we are at a particular location within this envelope we can draw the quality line and can say how much percent the component mixture is in the liquid phase and how much is in the gas phase.

The point critical point will be here and that above the gas an liquid cannot adjust together and the definition will be the same for this system also two more point comes here that is the Cricando bar and cricando therm that we are going to discuss separately so for a two component system the vapor lines just to spread it and becomes kind of an envelope where we can draw several lines of for the representation the volume.

Bubble point curve the first bubbles so when we are changing the condition similar thing will happen when the liquid is reaching this point the first gas bubble will appear and when we are going down inside of this for example we are going on this straight line let us say at a constant temperature at isothermal condition we hate this point when we are having the first gas bubble will appear in further we going in the amount of the gas phase is increasing.

Similar from this point when we are reaching the dew point the last liquid drop will appear and after that further reduction is happening we are in the beyond the below the dew point curve line we are having only the gas phase.

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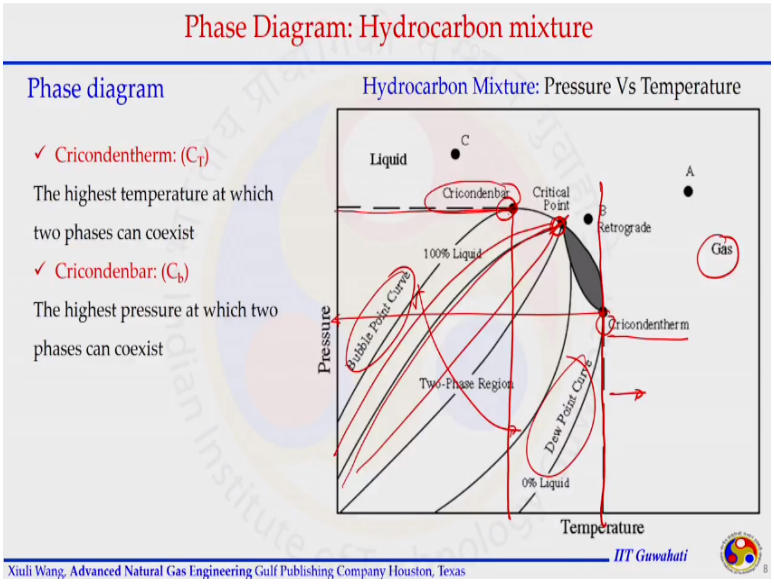

When it comes to hydro carbon mixture it represent different unique system we will discuss that thing for a pressure and temperature when the hydro carbon mixture is exposed we get two terms that is Cricondenbar and Cricondentherm and both are different then the critical point if you see the critical point here. So the Cricondentherm simply says the highest temperature at which the two phases can adjust here so this is Cricondentherm.

Beyond this point if the temperature is higher than this we are having only the gas phase does not matter what pressure is there similar on a Cricondenbar point where we are having this point beyond that we are having only and only the liquid does not matter what temperature it is. Corresponding to this Cricondenbar we are having Cricondenbar temperature and similarly with respect to Cricondentherm temperature we are having Cricondentherm pressure also that will help to characterize the system.

So this is critical point we are seeing several quality line those are getting merge to critical line and when they are merging at the critical point it means they are reaching to a critical point and the bubble point curve and dew point curve they are separated again we are having the envelope here as for the two component system or multi-component system also the envelope will be there quality line again will repellent the percent of the liquid phase of that mixture when we are exposing the material to different temperature and pressure history.

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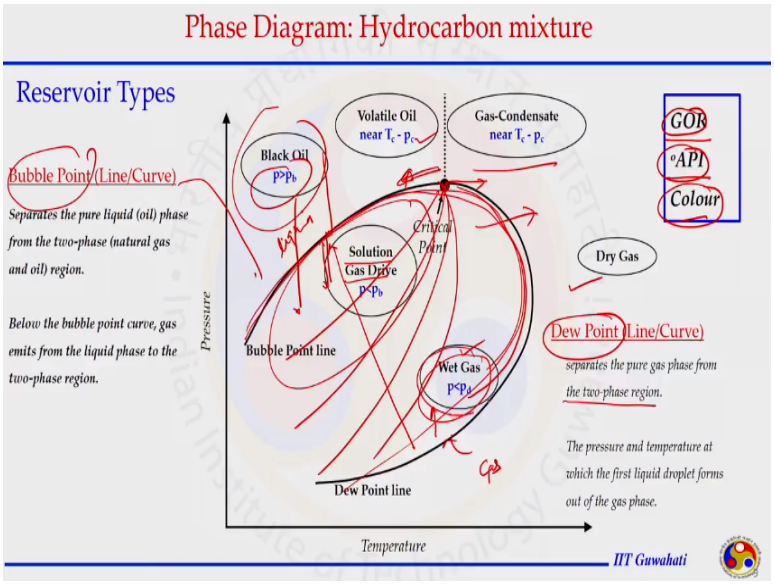

Other aspect of that can be understood for example the bubble point curve for the hydro carbon mixture that says it separate the pure liquid here we are having the liquid from the two phase reason that is about two phase reason from here to here below the bubble point curve. So when we are reducing the pressure reaching to this bubble point curve and when we are further reducing it here the first bubble of the gas will appear and when we are going further

the phase will go to two phase reason or the liquid will go to two phase reason where both liquid and gas will be adjusting together.

Similar for the dew point curve from here we are entering into the two phase reason and in that two phase reason we are having the condition where the gas will get converted into liquid. So here we are having just gas and here we are having the liquid if we understand this for the hydrocarbon mixture that I said if we know the composition we can draw this phase diagram. This phase diagram the shape of this phase diagram depends on the composition if the composition are changing the shape of envelope will get change.

And there are very different shape we will see in coming slide when the system is producing different type of the hydro carbon mixture. But this is just a representation that says we are having the bubble point dew both bubble point and dew point or going emerging at the critical point by doing this there is envelope got created within that envelope we are having the both gas phase and liquid phase can be classified just based on this understanding what type of reservoir it is.

If we see this is one of the example we are having some specific reservoir fluid composition with the help of performing the experiment we could establish this the bubble point curve and dew point curve what different temperature and pressure history we got this envelope inside this envelope we got this several quality lines. Now if we see this is the critical point if the reservoir temperature and pressure on this point or especially reservoir temperate on this part we are having the oil reservoir.

So it means when the reservoir temperature is below the critical temperature of a hydro-carbon mixture we are expecting it is a oil reservoir and which it is higher than that we are having the gas reservoir. Oil reservoir also further classified in several segment like black oil, volatile oil condense means near critical point oil similar on the other side the gas reservoir are also classified as gas condensate reservoir, dry gas reservoir, bad gas reservoir and that depends on where the reservoir temperature and pressure are falling on that envelope and the based on this chart we can say at the temperature and pressure condition the fluid will behave like this type of reservoir fluid.

For example we are having this black oil if P is always greater than bubble point pressure it will always remain in the liquid phase and we are just having the black oil in this region. When it is going down the phase will get change we are more interested in natural gas class on this right hand side when we are having this gas reservoir domain and in that case we can see this is a critical point from here we are having the gas.

The gas reservoir and this is a dew point curve if we are understanding this in detail we can classify that as a dry gas, wet gas or gas condensate and the gas to oil ratio the degree API and color of the fluid which is being produced sometimes like example in condensate reservoir we are going to produce the liquid also. So the color degree API and gas to oil ratio can tell us this type of reservoir it is in the domain of natural gas.

It is condensate it is well or it is wet gas or it is a dry gas reservoir we will discuss this one by one so we understand now the dew point and the dew point is here and bubble point curve is there on this side and within this envelope we are having the solutions gas drive say if reservoir temperature, pressure condition are falling in the near to bubble point curve we can say the solution gas drive reservoir it is there.

We are having the gas that is dissolved in the oil and that is kind of the driving force for the oil to be flow from this reservoir to surface and when we are closed to this dew point curve we are having the wet gas it means some of the component of the gas phase got converted into liquid phase but still it is measured in the gas phase and we are having the reservoir of a wet gas type.

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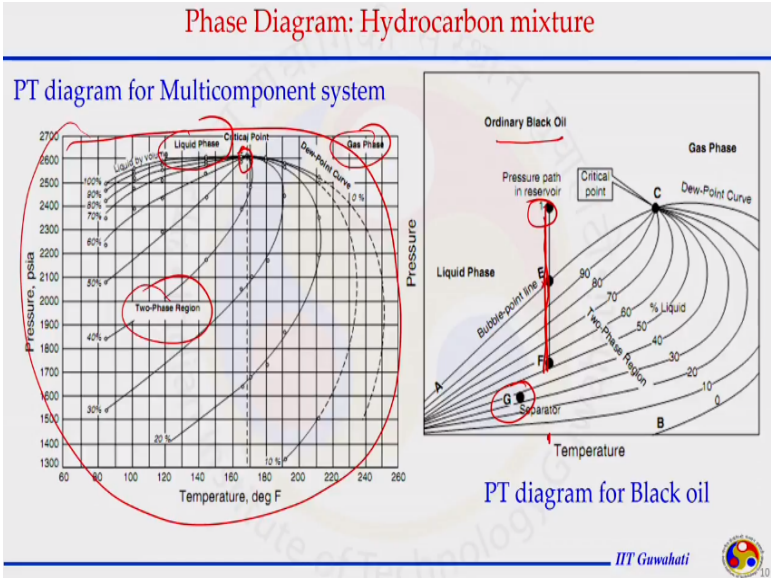

Here I had shown some diagram for like how a typical PT behavior should be further we see the PT diagram for a multicomponent system it is just a representation where it is the envelope make any shape depend on the composition. So here the liquid phase is just here when we are having more than 2000 PSI and the gas phase is here when we are having more than significant temperature between this we are having the quality line two phase reason where the percent of liquid and gas is changing.

Critical point may be somewhere here if we see for particular component for example the ordinary break oil we see the shape can change. Because the composition of the oil which is produced as the black oil where is from C82 300 and more than that is 100, 1000 components are there if we do the PBT or PT phase behavior study for the ordinary black oil we will see like the shape of the envelope will be shape different.

And this is a pressure path line in the reservoir so when we are in the reservoir domain we are at one point when we are going to produce the oil will also travel from different path region or over the time when the reservoir pressure is changing the pressure the fluid is going to experience may be different considering the isothermal condition we will see the oil will hit this bubble point and then we are having the two phase reason and at the separator when this the black oil is going to reach the separator what about the amount smaller or large amount dissolved in the oil phase will come out automatically.

So we will be having the two phase production even the reservoir is just a black oil reservoir.

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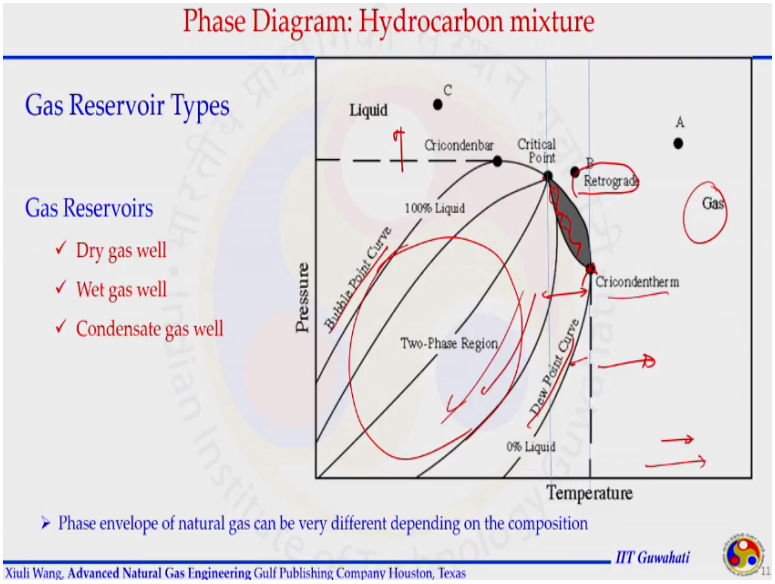

Now focus is on gas type reservoir so we are having three types broadly classified three types of reservoir dry gas, wet gas and condensate reservoir. There is another near critical point reservoir or sometimes the condensate reservoir is also called as a retrograde condensate reservoir. Let us classify in just three broadly part dry gas, wet gas and condensate reservoir.

The same diagram is here that we discussed here now we can extend our study further what we can say this is a bubble pint curve this is dew point curve both emerging to critical point and you see there is a reason between the critical point and cricondentherm the reason is called the condensate reason or the retrograde reason and this is always covered by stated reason. This is very unique phenomena that is exhibit by the hydro carbon mixture only we will discuss little later.

So I think the understanding is very clear based on this diagram we can say if the temperature is too high and that happen when we go underneath around 17000 feet or more than that the temperature is such high mostly we get the gas reservoir. So if the reservoir is at very high temperature beyond the cricondentherm we are going to get only the gas reservoir under the reservoir condition.

Again the gas will travel from that high temperature high pressure reservoir reason to surface it will be facing different temperate and pressure zones. So we have to specify the condition that condition says under the reservoir condition beyond the cricondenterm the gas is always in the gaseous phase and we can say this is in the dry phase. We will discuss again the dry phase when we come down here between the critical and criconden we are having the condensate and when we are with this envelope somewhere or near the dew point curve we are having the wet gas reservoir.

So the phase envelope for natural gas can be very different depending on the composition we are changing the composition the phase will we get change. For envelope which represent how the mixture hydro carbon mixture is going to change when we are having the different pressure and temperature exposure will get different shape.

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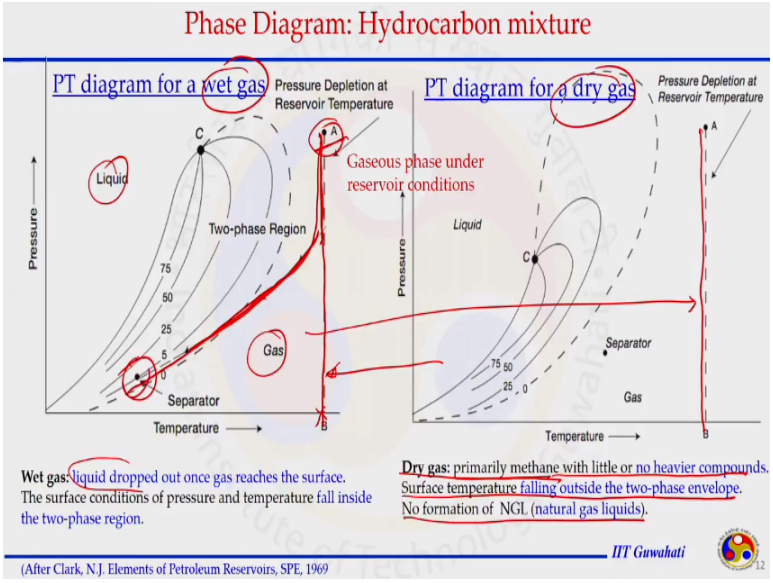

Let see here for a wet gas we are having the PT diagram where this here is the liquid here is the gas and when we are going to get the wet gas reservoir let us see we are starting here. The reservoir pressure temperature is at point A we know at point A this is just a gas because it is beyond cricondentherm temperature and beyond cricondentherm temperature we are supposed to get the gas reservoir.

Now the pressure will change because the production is happening and when the production will happen over the time the reservoir pressure will depleted and when we assume there is no

change in the temperature that is not going to be the case. But let us assume the reservoir is under isothermal condition when we are reducing the pressure what we will see we are going to go like this and that is happen if we see here in the dry gas reservoir we started producing here.

We are saying this is no change in the temperature only pressure is reduce in such a manner that the pressure or the line that is drawn for changes in the pressure is by any mean not going to envelope it is not going to the envelope side temperature is not changing just it is going like this we are going to have only the dry gas reservoir. So the dry gas reservoir primary condense with methane this happens because the composition of the gas or the product or in such a manner they had created such envelope where the reduction in the pressure at a constant temperature is not going inside the two phase envelope it just getting produce like this.

And the composition of primary methane with little or no heavier compounds present then we will be some compound present but not in a significant quantity. Mostly dry gas reservoir produce at the small amount of the water surface temperature falling out at the two phase envelope so that I said the even the surface pressure temperature condition are falling outside the envelope there is no mean the gas is getting gas is going to cross the dew point curve and becoming two phase system.

No formation of NGL when it is not crossing the dew point curve when it is not formation and the liquid substance it has no natural gas liquid present in it. While what happens in the case of wet gas reservoir when we are going down now pressure is changing we are going down pressure is changing because of depression is happening because fluid is travelling from reservoir pressure to wellbore pressure.

Now it travel to surface temperature may get also changes when the temperature is changing the path line reservoir or the pressure or path line will shift like this. And when it is shifting crossing the dew point curve reaching the two phase reason it is going to limit the liquid out of the gas and we are going to have the liquid drops out once gas reaches the surface.

The surface condition when we said here for example the separator where the temperature and pressure are which in the envelope it means the gas will go to liquid phase and we are going to get the two phase system and that gas produce under rare condition is called the wet gas and the reservoir is called wet gas reservoir it becomes very important when we want to run the gas well under the wet gas condition or under the dry gas condition that can be controlled by precisely understanding the phase behavior we will discuss later on how it can be useful and how it can be a drawback.

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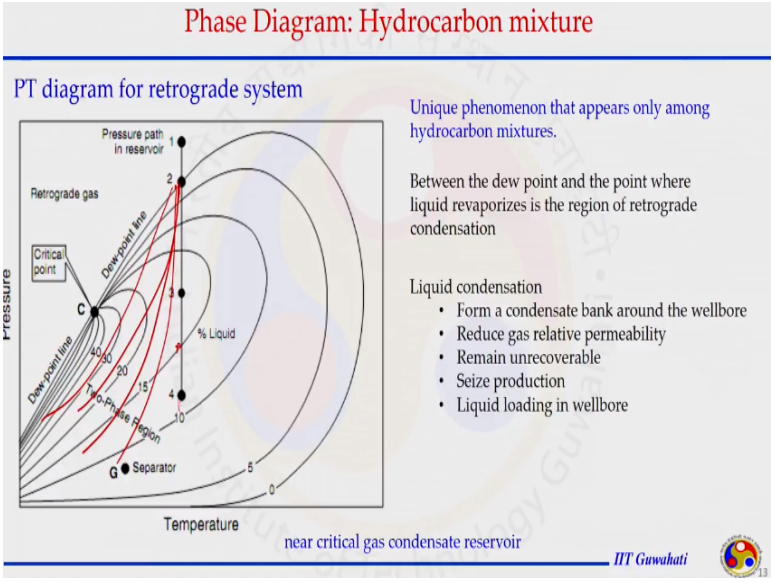

In the next when we talk about the retrograde reason in retrograde reason what happens between the critical point and cricondentherm there are several quality lines and when the fluid or reservoir condition or between these critical temperature and cricondentherm temperature when pressure is reduce at a constant temperature it goes through the two phase region and intersect several quality lines when it happens or retrograde kind of behavior occurs when we reduce the pressure the gas is going to hit the dew point curve it should go to liquid part now when we further reduce it goes to vapor part.

See here like from here it is going to 15% liquid now it is going to 10% liquid some of the liquid got re-vaporized. And this is a unique phenomenon that happens only in the case of the hydro carbon mixture and because of this retrograde nature this kind of reservoir are also

called condensate reservoir because they produce liquid and some time they also called as the retro grade condensate reservoir.

Because not only they are producing the liquid at the surface that happens in case of wet gas reservoir also we are going to get the liquid on the surface condensate on the surface in case of wet gas reservoir but in this case of reservoir in the retrograde kind of reservoir we are going to get very complex system where the liquid will further get re-vaporized when it is going to hit the low pressure region and becomes very complexes term.

If we are not going to have a good understanding about the phase behavior we are not understanding when the gas is going to liquid when liquid is going to gas when we are changing just a pressure and when we are changing just a pressure and imagine when we are going to change both temperature together the line may go very differently depend on temperature and pressure as we did for the wet gas reservoir.

When wet gas reservoir the pressure was declining isothermally when we said temperature is also changing the quality line or the pressure path line just change at enter in the two phase region and across the quality lines. Between the dew point and the dew point if you are liquid re-vaporize in the reason of retrograde condensation that is on by the (()) (41:13) part.

Liquid condensation form the condensate around the wellbore so what exactly happening from the reservoir high pressure the food is travelling to wellbore but now it is going to hit the low the pressure reason because the flow is happening because of pressure drop down. Pressure drop down there then only the flow will happen and because of this pressure changes because the pressure is changing assumption isothermal condition.

We are going to get some of the gas getting converted into liquid and when there is liquid is getting converted near the wellbore reason it is going to form near a oil bank near the wellbore region and when the oil got accumulated near the wellbore region it is reduce the effect the permeability for gas passes when gas is not able to pass it means it is reducing the recovery of the gases or other way it is ceasing the production is not happening at the desire rate because the effective permeability for the gas got reduce a bank of oil got formed near the wellbore region.

Another problem comes in the liquid loading when this liquid just goes through the wellbore and the gases coming it is not having enough energy to carry over these liquid started getting accumulated all the reservoirs is a dry gas reservoir but when it goes through surface facilities a production facilities in between it pass through the several temperature pressure zone and similar happen in the wellbore.

Within this wellbore liquid got accumulated and the gas just not having enough energy to carry over this liquid under that cases several action should be taken like injecting the gas or setting the well for sometimes then it get (()) (43:01) or some other means should be adopted to reduce the liquid loading that conversion from gas to liquid may be useful also.

Because the reservoir those are having such kind of behavior those can produce liquid while they are classified as a gas reservoir liquid is having more value than the gas so if we are not able to take out that liquid which got converted near the well bore region for example we are lose the quality material inside the reservoirs we want that liquid is getting produced to the surface but the sometimes we do not want the production is getting ceased that is why it is always a challenging task when we deal with natural gas production system.

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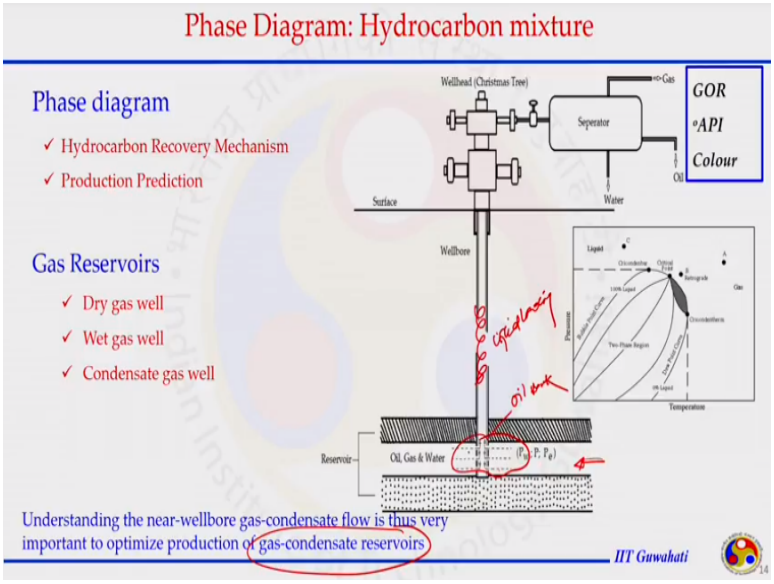

So in summary phase diagrams study allow us to understand the hydro carbon recovery mechanism those should be adopted to have the better production prediction as well as

having the profit running the well under the profit condition gas reservoir we understood dry gas reservoir, wet gas reservoir, condensate gas reservoir how to produce the reserve from the reservoir which is initially beyond the cricondentherm temperature which is completely a gas reservoir how it can go to wet reservoir and how it can go to condensate gas well reservoir.

And when it is condensate gas well reservoir how effectively it should be produced so we are not losing the valuable product inside the reservoir similar we are not going to cease the production also. Understating the near well bore gas condensate flow is that very complicated and important to optimize production of gas condensate reservoir so the gas condensate reservoir is one of the complex domain of natural gas production.

Here we can see like natural gas is being produced here this is the reason where the liquid loading may happen here is the region when the oil well may get from here. Based on the understanding several action can be taken to account or to understand the effected production mechanism that can be adopted. With this I think our natural gas introduction chapter ends and we are going to discuss some of the technique those will be recalled when we are going to understand several aspects of natural gas production processing and transportation.

For example in the previous when the natural gas is getting produced from this region to PWF from PWF to PHF we set up the mathematically equation sometimes the mathematical equation or most of the time of mathematical equation are complex in nature because the fluid properties will get change based in the local temperature and pressure condition.

As the fluid or gas is being produced it is going to face different temperature and pressure condition and because of that properties will get change when the properties it getting change parameter those are depend on the properties will also not be constant with this I would like to thank you for watching the video we will meet in the next week thank you very much for watching the video