Surface Facilities for Oil and Gas Handling

Prof. Abdus Samad

Department of Ocean Engineering

IIT Madras

Acid Gas Treating

Good morning. Today we will start the acid gas heating system and how it is getting treated and what are the chemicals used, how the process is happening, we will discuss in this lecture. We do some solving some problem also. Previous lecture we have seen that gas whatever you are getting from oil well, condensate well or gas well, it will be having mixture of H2S, CO2, water, carbon dioxide, CO2 carbon dioxide, some other component also. So, one of the most important component is acidic gas. So, acidic gas includes H2S and CO2.

So, in certain well bore if only CO2 is there, there is no H2S. So, it will be also considered as a sweet gas. Only CO2 will be considered as sweet gas, but this is sour gas. Why sour gas? Sour means acid, acid is sour.

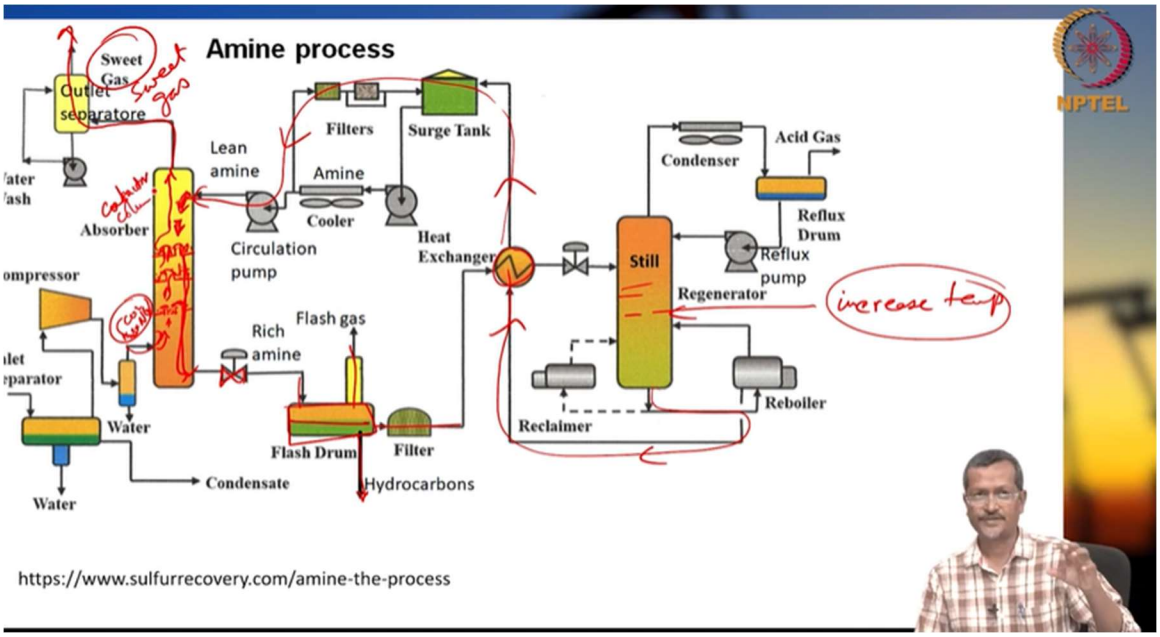
So, H2S will be reacting with water and it will create H2SO4, H2SO3. Similarly carbon dioxide, it will be producing H2CO3 or carbonic acid. So, these acids are important because this will create corrosion and some cases hydrogen pitting if H2S is there hydrogen pitting, hydrogen pitting, pitting will be there. So, metal surface will be small, small pitting or rupture will be created. So, that will be creating next problem.

So, it will be reducing heating value, reduce heating value. So, sales value, heating value reduce means sales value also reduce, reduce sales value, sales value. And another thing is that H2S is lethal, it is very much dangerous. So, if oil and gas system is having lots of H2S, so that can be dangerous also for human life and it will be reducing your life for your metallic part, it will be creating hydrogen pitting, it is not giving any heating value, honestly you are creating trouble, pipeline and other machinery will be eroded, corroded. So you have to avoid this one.

So, you have to separate, if you are not separating then problem will be persisting. Carbon dioxide will be creating corrosion also but it may not have this lethal value but if carbon dioxide is having certain more than certain amount then maybe lethal but normally H2S is called lethal gas. So, 0.13%, 0.13 ppm if H2S is there in a gas by volume, by volume, so this gas will create smell, pungent smell.

If we have 4.6 ppm, so smell noticeable, so 0.13% is small smell maybe there, may not be there but some smell may come but 4.6 is there but strong smell you can get, so noticeable, if we have more than 200 ppm, so in that case you have smell fatigue, so you will not get smell actually, smell fatigue will come, okay, so no smell. If you have more than 500 ppm, so in that case no smell, breathing issue will be coming from 700, more than 700 to 1000, so death, okay, so more than 500 is there, so breathing issue and death can be coming, 700 to 1000 then immediate death possible, so these are the 1000, these are the most dangerous thing actually, if you have more H2S, so you have to remove it.

So, you see this picture I have taken from one website, hnhu.org, so very small amount is there, then you can get order but if you have like 100, 200 around, so in that case like eye, itching, all these things will come, irritants will come up to 250, then 250, 500 you can see these people are going die and more than 750 dead, okay, so you have to remove hydrogen sulphide, so distinct rotten egg order will be coming, if you have very low amount but severe irritation will come, if you have 20 to 100, severe eye irritation and cough and other thing will be coming, if you have 100 to 50 but if you have more than 750, death within moment to many is due to respiratory paralysis, okay. So, basically it will be attacked to respiratory system and it will be attacked to your brain also, so that way death will occur. So, gas sweetening process, solid bed absorption process, iron spawn, so now you see, you have seen this gas H2S especially, it is having very much dangerous, okay, dangerous property. Now, how to remove it? So, there are several ways to remove, the solid bed absorption process like iron spawn, Fafatreat, some company name is there, zinc oxide is there, chemical solvent, amine, potassium carbonate, potassium carbonate, physical solvent like shell sulfenol, these are actually company brand name, so that is why this shell name is there, select shell is the company name actually, we will see later details of these.



So, solid bed conversion, so clause process, look at process, they will be converting directly H2S into sulphur and hydrogen, so in that way they will be removing. Sulfide scavenger, distillation can be done, gas penetration will be done, well because our time limited is there in lecture, so I cannot discuss in everything but a few things we will discuss in this lecture. So, solid bed absorption, so this iron sponge, okay, so what is this? This process applied to the hydrogen concentration low, 300 ppm, low hydrogen concentration is there, H2S, so in that case you can use iron sponge, okay. Operating a low or moderate pressure, 50 to 500 psig pressure, okay, within this pressure and within this H2S range, normally iron sponge can be used, okay. So, this is not removed by this process, CO2 not removed, removed in iron sponge process, okay, not removed.

Reaction requires slight alkaline solution, slight alkaline solution required to react H2S and iron. So equation is that Fe2O3 2 plus 6 H2O equals to Fe2O S3 plus 6 H2O, okay, so some water already there and 6 H2S, okay, hydrogen sulphide you take, it become water actually. So ferric oxide impregnated on wood chips which produce solid bed with a large ferric oxide area, okay, so you create a sponge with wood with ferric oxide, okay, so the surface area will be increasing, so on the surface, once you get larger surface area, pass your gas, so gas will be absorbing your H2S and it will be creating sweet gas, okay. So now you got Fe2S3, okay, now you have to recover again, otherwise again you have to supply Fe2O3 again and again, so how to recover it? So you have to increase temperature, okay, so then what you do in this case to recover, recover, recovery, recovery, so how do

you recover? Fe2O3, Fe2S3 plus 3O2 2Fe2O3 plus 6S and S plus O2SO2, okay, so this reaction will be occurring during recovery process. Now this is exothermic process, this is equal to exothermic, this is exothermic, thermic, exothermic means heat generates, when reaction will be occurring it will produce lots of lots of heat, so when lots of heats are there and if you are not controlling the reaction then there will be fire, so you have to control the supply of oxygen and control the temperature so that there will be disastrous things should not happen, okay.

Tray must be removed after 10 cycles because this after reaction Fe2S3 we are getting continuously and when you are getting continuously Fe2S3 the tray 1, sulphur cake will be deposited on this system, okay, because your product is sulphur, right, so the sulphur cake when it is deposited so your gas will not be interacting with Fe2O3 again or ferric oxide and gas will not be touching because sulphur will be coating these things. So, you have to remove these things after 10 cycle of operation you have to remove, again you have to clean, again you have to put new type of Fe2O3 that sponge then your system performance will be increasing. Now, similar way you got zinc oxide reaction, so ZnO plus H2Os you get ZnS plus H2, okay, this is also similar sort of reaction like iron sponge, okay. So, at high temperature more than 250 degree centigrade, 250 degree Fahrenheit, 250 degree Fahrenheit the reaction will be occurring, so it will be high temperature will be required for this one. Now, another one is sponge, iron sponge reaction and will be amine reaction, so what is amine? Amine is nitrogen containing organic compound, so there will be 3 type of amine, primary, secondary and tertiary amine.

So, primary let us see what reaction happens when you are using amine with to remove your H2S, okay, the amine can be categorized as primary, secondary and tertiary, okay. So, primary will be more active, more active, so reaction will be quicker and less active will be this one, secondary, the further lower will be this one, okay. So, most active primary, then secondary, then tertiary one, okay. So, amine is a organic compound, okay, okay. So, primary amine will be acting quickly or reacting quickly with CO2 and H2S, okay.

So, what is the reaction? Reaction is like this, 2RnH2 plus H2S, so this is low temperature, low temperature, what is happening RnH3 whole 2S, so this high temperature reaction will be opposite, high temperature reaction will be opposite. So, if you increase temperature, again you will get original amine, okay. So, 2RnH3 or nH3 plus H2S, again high temperature, this low temperature, low temperature, high temperature, okay. So, reaction will be like 2RnH3HS, another reaction 2RnH2 plus CO2, low temperature, high temperature, okay RnHCOONH3R. So, this, this reaction actually for monoethyl,

monoethanolamine or MEA, monoethanolamine, okay MEA, so this is called primary amine, this is primary, okay, this reaction for this one.

Now, if we have secondary amine, dimethyl, now if I have secondary amine, di, diethanolamine, so DEA, secondary, so in that case, reaction like this 2R2nH plus H2S, again high temperature, low temperature, this is low temperature, this is high temperature, so R2nH2, R2nH2 whole 2S, R2nH2S plus H2S, again low temperature, high temperature, reaction like this 2R2nH2HS, R2nH plus CO2, low temperature, high temperature, R2nCOONH2R2. So, there will be some other type of amine also, but we are not going to further details, just you remember these things, it will be okay for your basic study on how to treat amine and the chemical reaction. So, you see this amine process, amine process will have one contactor column or absorber column, so this will have trays actually, trays will have like this okay, so lean amine will be falling down from here and your gas will be going here, so this is having H2S plus NG okay, natural gas plus H2S plus CO2, all this mixture will be there, so you are injecting and it will be passing through this tray, these are called tray okay. So, this is filled with amine, this will be amine okay and when fluid is going, it will be going through this, maybe another tray will be there, so several steps of trays will be there okay, so one tray, two tray filled with amine solution, when it is going through this, it will get lots of bubbles okay, so the bubbles will be going and you are taking your gas here. And lean amine will be falling down from here okay, you see I am making bigger arrows for lean amine and it will be creating layers here, it will be creating some layer okay and reach amine, amine will be some holes will be there, so amine will be coming down, down, down, down and it will be reaching here okay, so this is amine, then it will be going through reach amine channel to flash drum, hydrocarbon you separate, flash gas you separate and reach amine, you move with filter, heat exchanger, then steel, steel actually this is also one contactor type column, there you increase temperature, so what is happening, increase temperature here, temperature.

If you see the previous slide, where I said if you increase temperature, reverse reaction will be happening, so here you increase temperature, you create reverse reaction, you separate H2S and amine and amine part you put again back to your system okay, so amine part will come here, it will go through this, heat exchanger here, here, here, here, here, here okay, this is amine line okay, actually amine going through this. So, different process will be there, heat exchanger will be there, you will have surge tank, you have pump, you have cooling system, because at cold temperature you are sending there, so cold temperature, amine and your acidic gas will be reacting, then you got that amine acid-based gas free, acid free gas and you are taking out to sweet gas, here you can see sweet

gas okay. And the rich gas with amine plus your H2S mixed or reacted that gas will be coming and it will be going to regenerator or reboiler section, where you separate again amine and acidic gas, amine again you put into your contactor column or absorber or contactor column you say, contactor column, contactor okay. So, there acid will be absorbed, gas separated, acid mixed with amine is separate in regenerator okay, so there you increase temperature, separate amine again you put there, so the cycle will be going on. Hot potassium carbonate process, so this is another process other than amine process, here potassium carbonate is used to separate H2S.

So, how this work, so H2O plus CO2 plus K2CO3, so high temperature, high carbon dioxide pressure is there, so it will produce 2KHCO3, so potassium bicarbonate and if reduce temperature, reverse thing will happen, low CO2 okay and K2CO3 plus H2S, it will create KHS plus KHCO3, this is high H2S, low H2S okay, H2S alone cannot be removed unless there is a sufficient amount of carbon dioxide okay, so carbon dioxide is must okay in this process, so carbon dioxide is there, so that sufficient amount of H2S can be removed. So process is like this, you see this sour gas is coming okay, sour gas is coming and you are putting into your absorber column okay, there will be any again contactor column type thing, this is absorber column and the gas is coming like this, it is going to stripper channel, again pumping, cooler, mixing up okay and from here whatever gas you got here like H2S free gas, so that one you are taking, you are sending to sweet gas, here heat exchanger is there, so those sour gas inlet and sweet gas is not mixing, so this is only heat transfer, so different pipes are there, so only heat is getting transferred, fluid is not mixing up okay. So, this is rich mixture is going through this bottom, rich mixture is going to stripper or there K2CO3 and H2S that mix whatever reaction happened that is getting separated, so separated fluid again you are entering from the top after cooling okay, so this way this K2 potassium carbonate reaction is happening and the whole flow process is like this, direct conversion of hydrogen sulphide to S, so this is a clause process, CLAUSS process okay. In that case what is happening H2S plus 3 by 2 O2, so SO2 plus H2O, SO2 plus 2 H2S, 3S plus 2 H2O, so this first process is called thermal stage, second stage is called thermal and catalytic stage, thermal and catalytic okay. So first stage you are reacting and you are creating sulphur dioxide and water, second stage the sulphur dioxide and H2S together reacting and the second stage sulphur dioxide and H2S is reacting and it is producing your sulphur and H2O, so directly you are producing actually sulfur okay.

Thank you very much, next lecture we will try to solve some problem, we will see some

mathematical calculation and sizing of this amine process and sponge process system and we will see what are the different calculations, thank you very much.