Surface Facilities for Oil and Gas Handling

Prof. Abdus Samad

Department of Ocean Engineering

IIT Madras

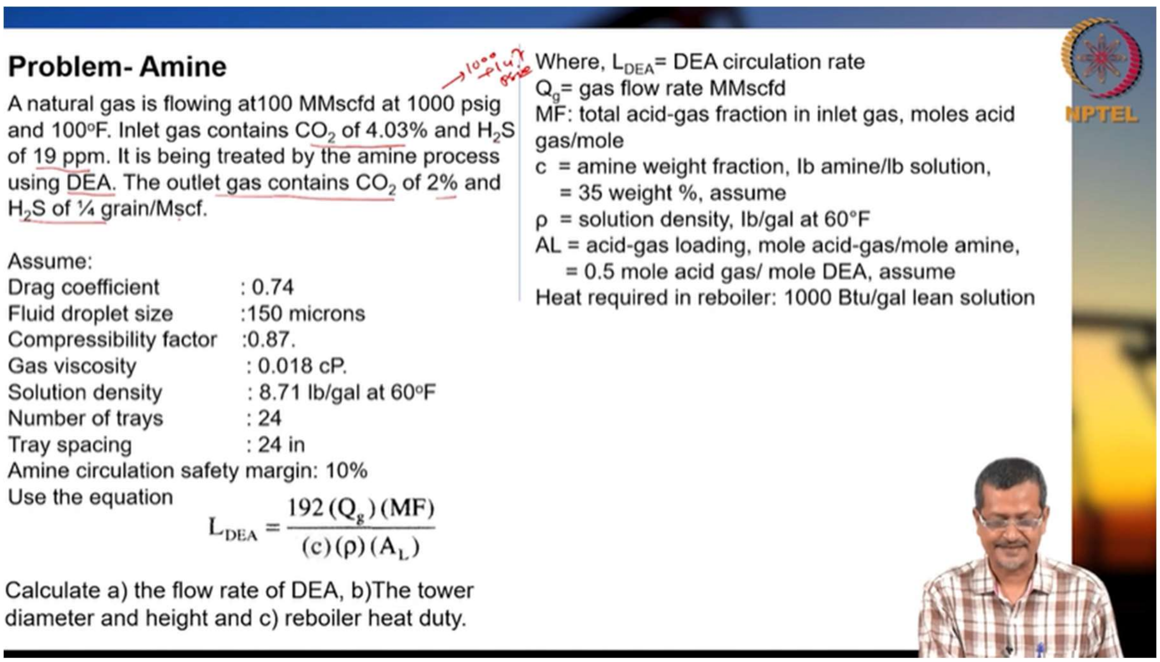
Amine System For Gas Sweetening-01

Good morning. Today I will start amine system for gas sweetening and we will do some calculation also ah, the volume calculation fluid calculation and we will ah, cover this amine separation part then we will start a gas dehydration part. If you have higher amount of water content or water vapor or water particle content so, you have to remove that one. So, first amine ah, removal ah, amine using amine you have to remove sour gas. So, sour gas implies H 2 S basically and CO 2 ok, but in certain gas only CO 2 there H 2 S is not there ok, H 2 S is not there only CO 2 there then this will be called as sweet gas ok. But if you have both H 2 S and CO 2 then it will be sour gas ok.

So, during amine process you have to remove sour gases and there are different methods to remove sour gases, but we have already seen that if we have iron sponge or other absorption method using that technique also we can remove sour gases. Sour means acidic gases acidic gases if you have then there will be certain issues such corrosion there will be hydrogen pitting and corrosion hydrogen pitting all these are problem and H 2 S if you have more than certain amount then again it will be a health hazard. You see if you have more than 500 or 700 ppm H 2 S in air then instant death possible, but if you have less than that maybe one very low amount is there maybe you can sense hydrogen sulfide H 2 S punch and gas will be there. If you have more than certain amount then actually a sense will go because it will be covering your breathing organs ok.

Then after certain time if you have more than certain amount then your it will be affecting your brain also it will be senseless actually. So, if it is crossing up to say gradually crossing up to more than 700 500 700 then instant death possible ok. Because there is breathing organs will be covered using cough and lungs will not work brain will not work finally, it will be dead ok. So, if you have hydrogen sulfide in your gas you have to remove small amount is that this is there still you have to remove and you have higher amount then that can be disaster ok. So, how to separate amine? So, you had one contactor column or reboiler column I will say straight line actually.

So, contactor column or this is called absorber column absorber column. So, what happens you give sour gas sour gas mixed with your actual natural gas ok. So, sour gas entries here then lean gas should be going out lean gas or sweet gas we do not say lean gas or the sweet gas ok. Sweet gas will be going from top and what happens lean mixture of amine solution mixture you inject from top and there will be several trays ok this is called amine trays ok. So, you create lots of bubbles and when sour gas is moving up it will be mixed up with lean amine mixture lean amine mixture will be rich amine mixture rich amine mixture means it is having more H 2 S ok.



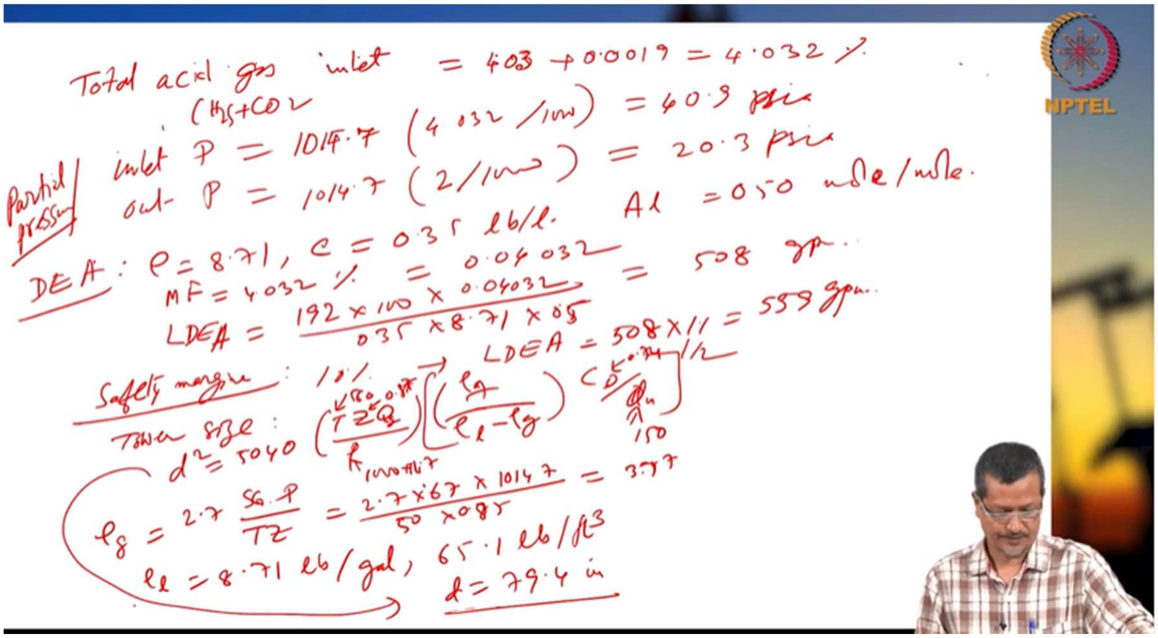
H 2 S will be in reacting with lean mixture of amine and then it will go out from the bottom ok. So, this is rich mixture of amine rich mixture of amine ok. So, this rich mixture you got that is having lots of H 2 S CO 2 ok because it is reacted. Now every time you cannot buy from market and you cannot use you have to reuse this this rich mixture as a lean mixture how to do it then you have to heat here using high temperature you give temperature here ok. So, re boiler or regenerator column will be there.

So, I am not drawing separately all these items. So, there will be I will show separate picture or several figure regenerator ok. So, using regenerator you are producing lean mixture of amine lean mixture of amine means low amount of H 2 S and CO 2 ok almost negligible. So, that again you put in contactor column separate separate or absorb your sour gases ok and so I was absorbed pure gas or sweet gas you take from top rich mixture you are getting you heat here you give heat ok. So, when heating so that can that compound be broken and your lean mixture will be passing through contactor column again and if you have H 2 S that H 2 S part or sour part again you put through another separation system.

So, from there you guess sour gas ok. So, in that case you have to add heat actually at cold temperature it will be absorbing ok. So, that amine contactor column will have a temperature lower ok at lower temperature will be absorbing at higher temperature it will be releasing H 2 S fine. So, amine absorber normally it will have 20 to 24 trays ok there will be trays ok. So, in tray the amine solution will be there when it will be bubbling up from bottom it will be mix up ok.

When mixing up is happening it will be releasing all this H 2 S and pure sweet gas will be going out from your system. Flash drum retention time around 2 3 minutes ok. So, there will be flash drum here ok, in 2 3 minutes retention will be there if any hydrocarbon is there in the gas. So, the hydrocarbon will be settling ok H H c H c this is rich mixture ok. So, rich mixture going out it will be going through flash drum where extra hydrocarbon will be moving out from the system and gas will be going to reboiler section ok.

Amine reboiler section will go. So, reboiler section what will do? Boiler the term says boiling right. So, you need heat there. So, you are heating the amine stripper which drives off the acid gas. So, acid gas you are removing ok.



Reboiler temperature in a stripper operating at 10 psig can be assumed to be 245 degree Fahrenheit 20 percent amine and 250 degree Fahrenheit for 35 degree amine ok. So, dimethyl amine like this. Amine stripper heat to reverse chemical reaction with C O 2 and H 2 S ok. So, whatever contactor column reaction was there here you are doing just reverse reaction ok. This stream acts as a stripping gas or removes acid gases.

Overheat overhead stripper and reflux accumulation. So, these components also will be there. So, reach and lean mixture heat exchanger will be there. Now, you have I will draw here on the top ok. You have contactor column you are getting ah rich mixture it will be going to flash chamber ok.

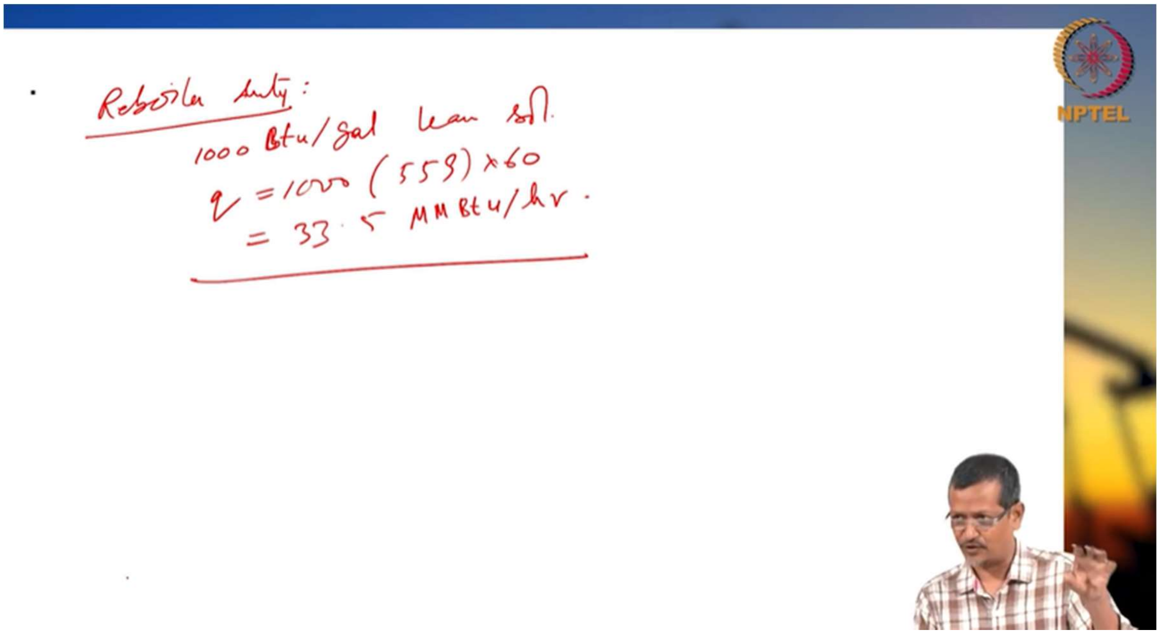
Flash flash chamber then it will go to reboiler section ok. So, this temperature is lower right this temperature is low here and after reboiler when it is going out ah after releasing all this H 2 S the amine part. So, it will have higher temperature ok. So, temperature high it is having lower temperature. So, what you do you do some you use one heat exchanger here.

What this heat exchanger will do heat exchanger will increase the temperature coming the fluid coming from your contactor column is going to boiler section it will take some heat and whatever heat is there in the exit fluid from reboiler temperature higher. So, temperature that temperature will go down because in contactor column I told ah CTU R ok. In contactor column it will be low temperature reaction ok. So, you have to reduce temperature. So, if after reboiler if temperature is very high that you are not putting into your contactor column you have to reduce temperature.'

But again if you are wasting that heat you can use any contactor you can waste also or you can use that heat to increase temperature of the inlet fluid of reboiler ok. So, you can reuse the heat. So, you are increasing system efficiency ok. One way reboiler whatever temperature high temperature is there you are reducing. So, you got some extra heat extra heat you are giving to inlet fluid.

So, that reboiler fluid fuel cost will be reduced fine ok. So, amine cooler now after heat exchanger you put one cooler also ok. Why because still some higher temperature is there you reduce temperature. So, that reaction will be proper in in contactor column ok or absorber reaction will be proper if you reduce temperature. So, before putting into contactor column or ah absorber column you are using cooler to reduce temperature.

So, that temperature that heat whatever removing that you may not use, but before that cooler you are using that heat that is even you are exchanging heat ok. From rich mixture from lean mixture you are taking heat you are giving to rich mixture then you are putting into boiler and lean mixture with lower temperature it will go to cooler section cooler will be reducing further temperature then you are putting into your ah absorber section ok. So, amine cooler will be fin fan small simple fan cooler lower amine temperature before entering to absorber ok. Lean amine temperature should be 10 degree higher than the sour gas entering the absorber ok. So, temperature have to reduce before entering into your contactor column or absorber column .



So, here you can see the detailed pictureI said like one absorber system is there ok. You can see this one I am drawing using my red pen . So, these are trays ok this is one tray. So, many trays will be there they have shown one tray and this is rich mixture ok. And entering from pump you see lean this is lean mixture ok.

So, rich mixture coming out it is going to flash chamber or flash tank extra hydrocarbon if it is there you are taking out that hydrocarbon hydrocarbon is large longer chain hydrocarbon. So, you are not selling that one with gas you may sell separately ok. So, that long chain hydrocarbon you are collecting here ok. So, that is not our purpose at this moment our purpose is to remove H 2 S and CO 2 basically. So, that flash tank fluid is coming to some filter then heat exchanger section it is heat exchanger section I told that heat will be exchanged with lean and rich mixture.

And this still this will be producing yourlean amine ok, lean amine is being produced ok. How it is producing you increase temperature and do the reverse reaction ok. So, you are producing lean amine. So, lean amine exiting here you see from bottom it is going to heat exchanger and it is going to this going to booster pump. So, everywhere pressure drop will be there.

So, every time you need one pump to increase pressure. So, that fluid will be flowing with certain whatever required pressure then again you are passing through one filter then amine cooler is here ok. You are reducing amine temperature again you pump you put into your absorber section ok. Some other systems I am not showing here because other system supporting system actually for example, that inlets our gas is there. So, there will be some inlet separator.

So, I am not showing I am not discussing now at that point. So, my main focus is absorber and steel orthat reboiler section where you are separating H 2 S and amine ok. And what about sour gas you are getting sour gas or acid gas here ok. It is coming through this reflux condenser and it is going like this ok. So, then you can remember the loop it is coming from contactor column flash chamber then heat exchanger then reboiler section then again heat exchanger because heat exchanger will be common one common area is going to pump then again further cooling again contactor column.

So, this circle cycle fluid flow cycle you should remember ok. So, based on that I can give some question also how this fluid will be flowing from where to where and you see this lean rich mixture is coming off a bottom entering from top. So, those things also you should remember. So, actually you should draw this picture and you should remember how this flow is fluid is flowing from one point to another point ok. And here one more point is there sweet gas.

So, sweet gas is here sweet. Sweet gas implies there is no H 2 S and no carbon dioxide. Now, before we go for one calculationwe should go through the formula LMEA ok. See this formula is taken from your book Arnold and Morris ok, volume 2 ok. So, one chapter is there on gas sweetening process.

So, you can see this formula. So, LMEA equals 1 1 2 q g m f divided by c rho a l. So, what are the terms? So, LMEA is the M e A circulation rate ok. Q g is gas flow rate and q g for unit is M m s c f M m s c f d also will be there per day M e A circulation rate g p m ok. And m f is your total acid gas fraction in inlet gas total acid gas fraction in inlet gas inlet gas moles acid how many moles? Acid divided by moles inlet gas ok.

And c c is amine weight fraction ok ah. This is L B pound amine amine pound amine divided by pound solution ok. So, weight fraction rho rho is solution density density. This unit is L B pound per gallon at 60 degree Fahrenheit and a L a L is given a L is acid gas loading acid gas loading. So, this is mole acid gas mole acid gas divided by mole amine ok. So, this is LDA L M LDA formula is like this only the 192 this sum constant term is changing ok other terms are all same.

And ok. So, ignore this two equation now later if we use we will explain. And vertical separator gas constant formula. So, this formula actually you have seen for your separator design ok. D min square 5040 d z cube g divided by p rho g rho L minus rho g c d d m power half ok. So, this formula is given in volume 1 of the same book Arnold and Morris volume 1 ok.

So, this derivation and some problem also I think we have solved in previous lectures. So, you can go through this for this formula ok. So, problem for amine treating using for gas sweetening process you see the problem a natural gas flowing 100 mm h c f at 1000 psig. So, psig is given.

So, psia if you want to convert. So, 1000 divided by 14.7 then it will be psia ok absolute. Inlet gas contains carbon dioxide 4.03 percent H 2 S or hydrogen sulphide 19 ppm you see this two different way we have give I have given. So, you have to convert actually you have to make single type this it is being treated by amine process using DEA dimethyl amine.

The outlet gas contains carbon dioxide of 2 percent NH 2 S 1 by 4 grains per m s here ok. So, I will explain that one what is grain? Grain unit. So, grain unit is of mass like 1 grain grain equals 64.

8 milligram. So, 1 gram equals 15.4 sorry 15.4 grains ok. So, many people can use grains also. So, that is why I have given grains term. So, that you should be familiar with the term this is unit of mass ok. So, because to solve this problem you have to assume certain value.

So, I have given that value many cases you have to reiterate and you have to calculate. For example, you have to calculate C D drag force Reynolds number. So, instead of going through that route I have given just drag coefficient you can use this one ok. Fluid droplet size 150 micron compressible factor 0.

87 again you can get from table chart or table ok. Gas viscosity also you can get from chart 0.018, but I have given just to simplify this things. Solution density I have given number of trays 24. So, normally 20 or 24 trays will be using will be using.

So, I have given ok use 24. So, that I will get unique answer from everyone. Tray spacing a spacing 24 inch. So, one tray two tray in between space will be 24 inch or 2 feet. Amine circulation safety margin say this safety margin is like this.

So, if we need 100 litre amine. So, it will be 10 percent safety margin is 110 litre you have to use ok. So, some loss and other thing you are considering. So, from calculation if we get 100 then you have to say you have to buy 110 ok. Use this equation.

So, already I told this equation 192 Q g M f C rho L. So, you have to calculate the flow rate d e a the tau diameter height and reboiler heat duty ok. And the terms also explain here I already told you that L d a d e a circulation rate Q g gas flow rate M f total acid gas fraction, amine weight fraction, rho solution density, a L acid gas loading ok. So, this some values will be given for example, C value 0 35 percent is given here ok. If it is not given actually you have to go through other chart and table from there if you want, but for problem purpose normally I will give.

So, that everyone should get unique answer. If I give chart or something then there will be issue then I have to give chart also ok just I made simplified. Now, how to solve it? Yeah for this problem total acid acid gas inlet, acid gas inlet equals 4.03 carbon dioxide already given and H 2 is given 0.19 ppm .

19 ppm if you convert into percentage it will be coming like 0.0019. So, total 4.032

percent ok total acid gas inlet. So, carbon dioxide and H 2 S, H 2 S plus CO 2 ok. So, CO 2 exit this then inlet partial pressure for acid gas it will be like this 1 1 1 0 1 5 because 1000 plus 14.

7 or you can write 14.7 ok. 2 divided by inlet acid partial pressure equals inlet acid partial pressure equals 4.032 divided by 1000. So, it is becoming40.9 psi ok and outlet partial pressure of acid 1014.

7 and exit acid is 2 percent 2 divided by 1000 it is coming20.3 psi ok. This partial pressure DEA calculation DEA ok anything wrong fine just wait DEA calculation formula given ok. So, for DEA calculation rho given 8.71 ok solution density of DEA C given 0.

35 lb per lb, Al given 0.50 mole per mole ok. So, you have to remove the formula. So, formula whatever definition is there based on the data is given direct formula actually m f equals 4.

032 percent. So, it is coming 0.04032 ah. So, LDEA LDEA equals 192 into 100 into 0.

04032 divided by 0.35 into 8.71 into 0.5 ok. So, this is giving 508 g p m ok. Now, safety margin safety margin. So, safety margin for DEA 10 percent is given.

So, now, LDEA equals 508 into 10 percent. So, 1.1 multiplication. So, it is coming 559 g p m ok. Now, tower size, tower size formula D square equals 5040 formula you have seen already T z q g divided by p rho g by rho L minus rho g C D by D d m square d m this is not here this is here or half ok. So, C D value given here 0.

74 d m value 150 given T value is given 560 100 plus 460 z is 0.85 then z is 0.87 I think and p 1000 plus 14.7 and rho L rho g rho g equals 2.

7 s g into p by T z ok. From there if we put data 2.7 into 6 7 into 1014.7 divided by T 560 into 0.

87. So, this is giving 3.77 ok and rho L is giving 8.71 L B per gallon or 65.1 L B per cubic feet ok. So, finally, D is coming 79.4 inch ok. So, you put all this rho L rho g value then finally, D will be calculated as this.

Now, reboiler duty reboiler duty. So, using 1000 B T u B British B capital B T u per gallon lean solution. So, Q or heat transfer will be 1000 into 559 we got this that much of m i required 559 and 60 minutes per hour you have to calculate.

So, into 60. So, it is giving 33.5 m m B T u per hour ok. So, reboiler heat duty how much heat will be required for in reboiler ok. So, some heat you can recover some heat you can not recover. So, if you assume that we are recovering some amount then again you have to do more calculation ok. So, for simplification thus you should get idea this much of heat will be required and this amine will be flowing to your reabsorbable it will come again reboiler again it will go to absorber.

So, the circulation go on ok some extra acid whatever you are producing. So, that acid will get separated and you can reuse or you can dispose ok.