Lecture No. # 29

So, in the previous lecture, we took an example on multistage counter current extractor. Today, we will take one more example on this. And here, we will like to solve problem related to minimum amount of solvent required. So, in this case, if you recall, we have to look for del point, in fact del min point where the tie line coincides with the operating line. And the good thing about this new example which we will take into in today's lecture is the train of the tie lines. So, the earlier (no audio from 00:41 to 00:51) so, we have this multistage counter current extraction <mark>right</mark>. So, <mark>and</mark> let us take a system here pyridine, water, and chlorobenzene. So, we have pyridine in water which we want to remove using the solvent chlorobenzene.

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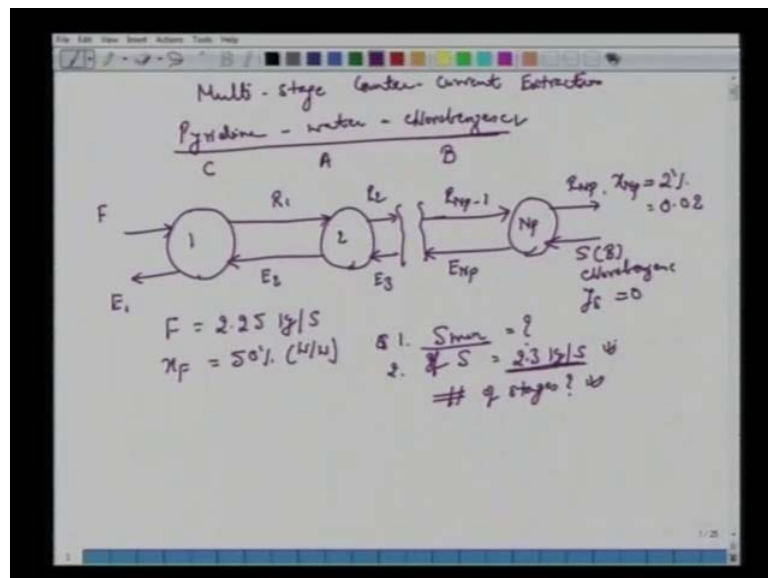
So, this pyridine would be C solute, water is a feed which we denote by A, and chlorobenzene is the solvent with B, and we have this multistage counter current extractions. So, let us draw couple of stages here 1, 2, and we say the last stage is N p. Then, we have this feed F this extracts from E 1, then we have this R 1, then this is E 2; you have R 2, and this E 3. So, the extract coming to this stage R N p minus 1, and we

have the extract from here E N p. R N p the treated raffinate, and we have the solvent S. So, this S or B this is chlorobenzene, and the problem statement says the feed is flow rate of the feed is 2.25 k g per second, and it contains pyridine also the water, and pyridine mixture contains pyridine say 50 percent weight by weight. And we have been asked to treat this feed using the solvent chlorobenzene, pure chlorobenzene. So, we have this y s 0, and this raffinate concentration treated feed is two percent. So, which is 0.02? The question asked one here is, what is the minimum amount of solvent required? And question two is, if the amount of solvent used is 2.3 k g per second, how many stages are required? In this case also it is possible that solvent required is say 1.5 or 1.2 times S min then how many stages are required. So, different questions can be framed here first, we are supposed to find out what is the minimum amount of solvent, and if we use 2.3 k g per second, which should be larger than S min. That is, what we are going to check here, then how many stages are required, and we have been given this thermodynamic data.

So, again some thermodynamic book or one of these textbooks prescribed textbook they give this; wherein this is also very common system pyridine, chlorobenzene, water, and here also we have pyridine, chlorobenzene, and water. So, now the data may be note down a few data here say 0, 99.95, 0.05 let us make 11.05, 88.28, 0.67.

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Now we have 18.95, 79.9, 1.15, and let us skip some of the data here let us note down 35.05, 61.0, 3.95, 40.6, 53.0, 6.40, and we have 49.0, 37.8, and 13.2 ok. So, looking at this data amount of chlorobenzene here is larger. So, you will expect that, this is extract phase, and this water. So, this is a chlorobenzene, this is s solvent or b, and we have

pyridine, which is C, and similar to this. We have some data here load 0.08, 99.92, 5.02, 0.16, 94.82, 11.05, 0.24, 88.71. Let us skip some of the data here 44.95, 4.18, 50.87. Then we have 53.2, 8.90, 37.9, and we have 49.0, 37.8, and 13.0. Now, look at, before you plot let us inspect here let us see that. So, this is also C here this is S this is A. So, essentially if this is your raffinate phase, and so this is x here or the solute. And we are using y now, look at the trend here x here is smaller than y. So, 11.055, 18.95, 11.05, But at higher concentrations you notice that now x is greater than y.

That means, you have the tie lines which will go like this for some part of the equilibrium phase, before it starts flipping in the opposite directions all right. So, this must alert us that del min we have to be careful whether the feed line which passes through this. We talk as, this way or the tie line which passes through this gives us del min all right. We did say that, in general tie line passing through the feed composition should give del min, but then that possibility where that some other del line if extended will will keep minimum amount of solvent required. So, this is one example very peculiar system or pyridine, chlorobenzene, water where you have this type of trend for some concentration range lower concentration range say y is greater than x. So, we have the tie lines downward in these directions. Then, we have x greater than y. So, the tie line in the opposite directions; unlike in the previous example where we had all the tie lines in one directions like this way or like this way all right.

So, let us come back to this problem here again. So, again based on these data one one has to plot. So, let us again let us see that again we use this rectangular system. So, we here we have 0, B hundred percent. So, essentially we are plotting percentage amount of solvent. So, instead of triangular diagram now, we have plotting this using these rectangular coordinates. So, with x, and y here, and we have percentage amount of solvent. Now again, we do not have to plot all the concentration maximum may be we have sixty here C is 60 percent. So, here we have x, and y, and if you plot, then this phase diagram will be will look like this, and somewhere, here let us say this is 50.
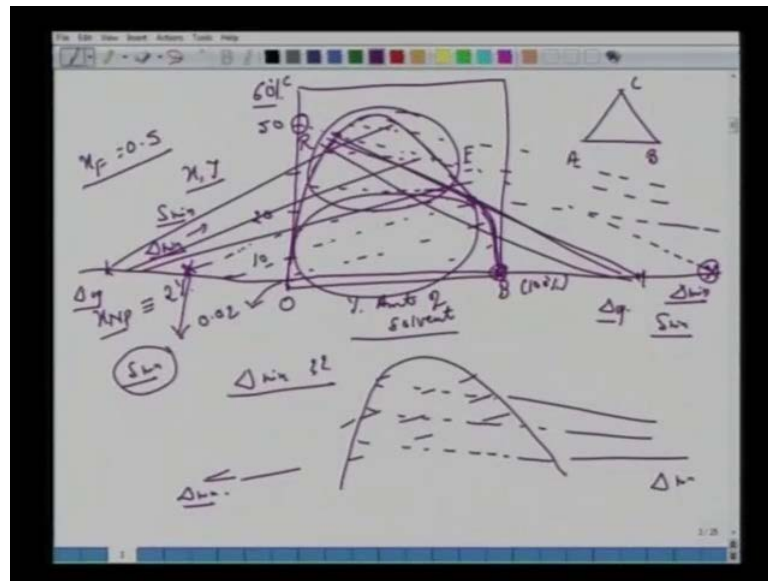
So, again when we have the equilibrium diagram like 0, 10 say 20, 30 etcetera, and we are writing C here; that means, this is a mole fraction of C in x or y phase. So, we have this raffinate phase, and we will have this extract phase, and the tie lines which will be which will be coming appearing here. Again, you should make a note that the tie line will like this y. You have the situation like this, and then it is going to flip like this right. So, one has to be careful this is extract here, this is a raffinate. We have tie lines going in both the directions in for some concentration, it is like slope downward, and here the slope is upward ok. So, that. So, again instead of working on this rectangular coordinates sorry triangular coordinate system on graph. We are representing on this rectangular coordinate system with the percentage amount of solvent given here comparing between 0 to 100 percent, and we are plotting solute concentration in raffinate phase, and the extract phase x, and y ok.

So, the first question ask here was what is the minimum amount of solvent required. That means, we are looking for del min now, all we have to do is find that tie line which if you extend through this feed feed concentrations. So, here the concentration of feed was solute was 0.5 all right. So, find these concentrations. So, this will be in some iterations you look for a tie line which if you extend then it intersects at 0.5, and if you do this you have tie line say extend like this. Now, here again if you go we have 0 percent solvent, and R N p, and corresponding to this x N p. So, here we have this 2 percent. So, point 0 2. So, 10 percent is 0.1 may be somewhere here you have qualitative this 2 percent not 0.02. So, we connect this line and with this extend this gives us or should give us del min

ok. If any other tie line if we try to extent you can see that this will go beyond this like this, there is also a possibility now look at this these two tie lines or some tie lines in the lower concentrations for raffinate, that when you extend. So, when you extend like this here, and extend this line. This will also intersect somewhere here, and this may give you del min corresponding to which we have this S min here.

So, now in principle we can have two scenarios. Now I can recall previous examples we had the equilibrium curve, and most of the tie, all the tie lines they were in one directions. So, in this case if you extend you have the del min this way. If the tie lines are like this monotonically decreasing in one direction you extend through the feed you have this del min left handed side. Here, there are some tie lines on the lower concentrations, and some on the higher concentrations, where the slopes are different. So, in principle one has to calculate what is the minimum amount of del min S min required for here, and what is the S min required from here right. Any of these, two will give you S min you have to compare the two, and find out which is the minimum amount maximum of the two. So, that when we take the larger amount of this we are in the safer side. Now suppose, you work suppose you work on this, and you calculate S min, and now you take 1.5 times here. In that case suppose, the del operating comes to this side now as long as del operating is here, and all your operating line. They fall in this directions, then you are in the safe side no circumstances that any of the operating line will be coinciding this.

Similarly, if you work on this del min, and you get S min here, and if you have the take 1.5 times larger than this. Then you have del operating falling here. So, depending upon the amount of solvent which you use? Now, you can have the operating line going in this direction as well. So, this is the example where one has to be do some introspections look at in what directions we have this feed concentration. In our problem example it says that find the minimum amount of solvent required. So, what we do here again to find this minimum amount of solvent say we (( )) redraw this equilibrium phase diagram. So, we here we have 0.6 or 60 percent and feed is say 0.5 or 50 percent here, and the phase diagram looks something like this, we have the raffinate which is 2 percent. So, this is say 0.5, 0.4, 0.3, 0.21, very small concentration here, let us say 0.02. So, this corresponds to R N p for which we have this x N p as 0.02 this is feed F given as and for this.
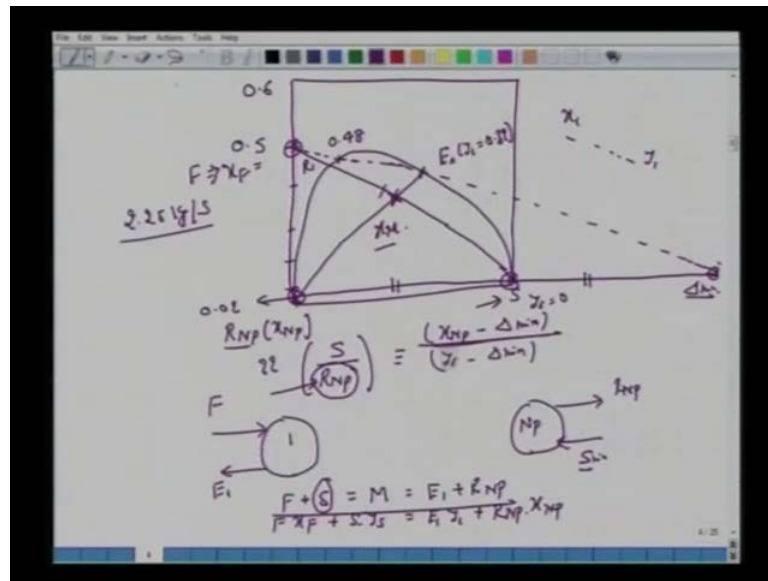
We have x F as 0.5 here amount of F is given to us 2.25 k g per second all right solvent is pure here. So, y S is 0, now if you connect these two lines x N p, and S; we have this straight line going in this directions. Now, in this case to find the del min we find the tie line let us say which if you extend meets this feed concentrations. So, as an exercise some trial, and error, take this tie line. You will see that this intersects at 0.48 compositions, and when you extend here say it meets here which is del min here all right. So, to find the minimum amount of s min corresponding to this del min like in the previous example we did this s over R N p. So, the ratios of solvent to this raffinate phase will be equal to x N p dash del min all right.

Over for R N p we have s for del min. So, we can measure on these two segments length of the segments, but please notice we do not know the amount of R N p all right. So, unlike in the previous examples where we knew the amount of raffinate here all right. So, here although we can measure the segment numerator, and denominator, on the right side of the equations we do not know R N p. That means, we should make use of those quantities let us say F here. Now, if we take 0 point the tie line which passes through this, and through this here. This will intersect at E 1 all right. So, here we have extract, and here we have raffinate this tie line, which go through this is let us say we have y 1 which you notice that this is 0.39 ok.

Now, how do we get this minimum amount of solvent let us see the schematics we have the first, and we have the last. So, we can make overall species balance or material balance here. So, we have F plus S min in this case equals to R N p plus we have this

extract E 1 <mark>ok</mark>. So, knowing this F, and <mark>and</mark> S min so, we connect this if. So, we are essentially, we are writing in the equations that F plus S equals M, and we have E 1 plus R N p. So, we know the amount of feed here. So, based on this F, and S <mark>right.</mark> So, you have x M, we can find out x M, how do you find out x M here, because the amount of solvent S is also not known to us, but remember this is a tie line; which goes through E 1. If you connect this E 1 with this you will get here this point as x n. Another words, we are writing the mixing rule here F x F plus S into y S of course, y S is 0 here equal to E 1 into y 1 plus R N p into x N p..

So, we know these compositions <mark>we know these compositions</mark> we know the coordinates composition here as well we do not <mark>we do not</mark> know the amount of S nor, we know the amount of R N p, but we know the amount of f here <mark>ok</mark>. So, since we know this coordinate, and we know this coordinate E 1 with that is the tie line an equilibrium tie line. Here, we have this y 1, and with this x 1 we can mark this point we can connect this get x M take this x M, and connect with this S solvent here, to again apply this mixing rule here. So, first connect like this then connect like this. Now, we can find out what is the amount of solvent required. So, we are writing again F plus S min equals E 1 min plus R N p, and here if you look at, and x M. You should be able to obtain this number as 0.3.Tthat means, now we can apply a tie rule say this location was F here for x F, and here we have S solvent which is y S equal to 0. You connect this <mark>this</mark> point here we got this x M as 0.3.

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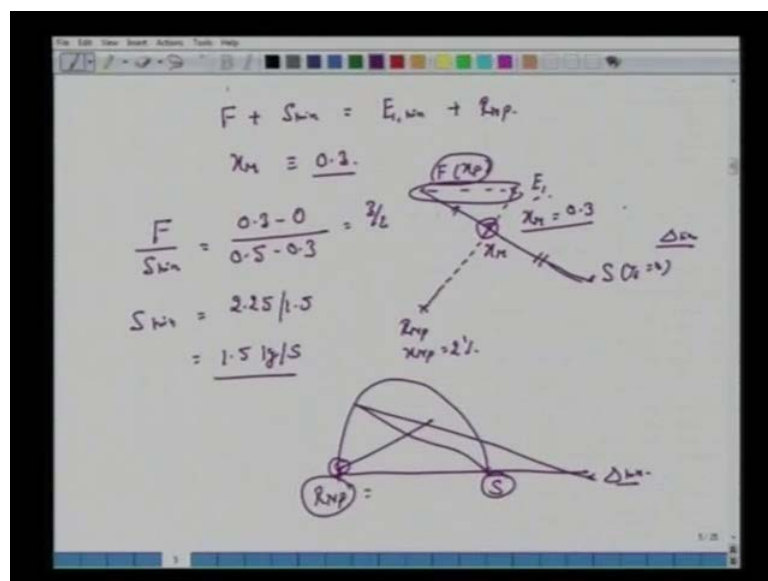
So, all we have done we connected this tie line again as E 1, and if you extend this line here, and connect this with this R N p, you have x N p as 2 percent. So, first state of del point now, we are obtaining through this x M mixing point here 0.3. So, x M is 0.3. Then now, we can write down F over S min so, F over S min is 0.3 minus 0 so, this segment over 0.5 minus 0.3. So, 0.5 is here minus point 3 here. So, this segment, and then this will be equal to from here, we can calculate S min f is 2.25 divided by 1.5. So, this number is 3 by 2 (3/2=1.5), we have 1.5 k g per second. So, the idea was how did you get this instead of working on this del min point all right; we have calculated S min based on this mixing rule.

In the previous example recall, we located this del min all right, but in that problem you could not find out S, because the earlier example we knew this amount of R N p raffinate, but in this case R N p is not given to us. So, essentially we rely on this again mixing rule, we have the tie line which intersects equilibrium phase at E 1 connect this E 1 to R N p to obtain this x M. And then, we can apply again lever rule here between F, and S, to obtain this 1.5 k g per seconds. Now, the second part of the question is actual S is given to us 2.3 k g per second all right. So, the S min is you calculate it is 1.5 k g per second, and now we have s as 2.3 k g per seconds. So, now, let us see where the location of this del operating is so, go back to the same equilibrium phase diagram. We have this 0.5 here, and now S min is 1.5 k g per seconds, and typically we are we calculated del min, and then we find out del operational, it is given that it is 1.2 or 1.5 times times del minimum.

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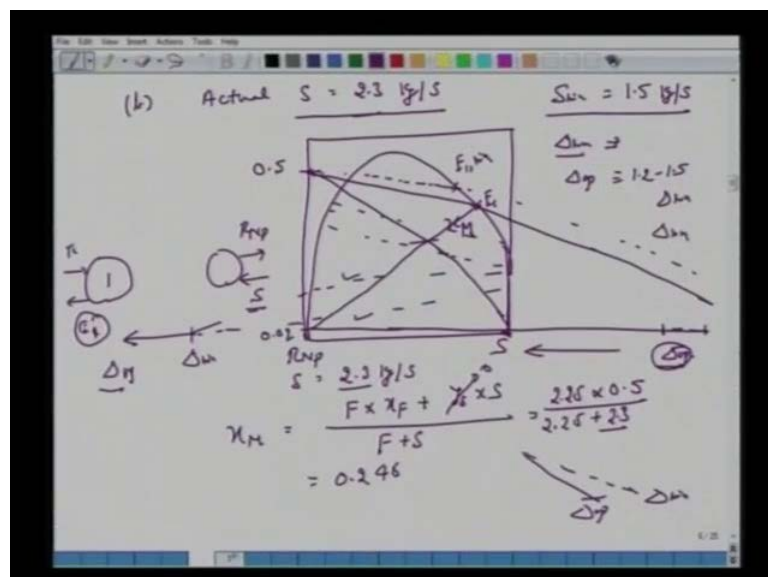
But in this case now 2.3 k g per second per solvent is given to us. So, again this feed is given to us this is 2 percent 0.02. We have the pure solvent extend this since the amount of solvent is given to us, we can locate this del point del operating point <mark>ok</mark>. So, this is example anyone can write actual S is 2.3 k g per second. We are adding with the feed here F connect to this S. So, we can get x M as F into x F plus y s into amount of s, y s is of course 0 F plus s. So, we have 2.25 into 0.5 plus 2.25 plus 2.3. So, that is the amount of solvent given to us if you calculate we have 0.246. So, <mark>we now</mark> we have x M slightly lower here. Now, what is the idea of this x M? Once, we connect with this 0.02 to x 1. Now we have E 1 criteria notice this corresponding into E 1 min.

Now, we have the extract concentration which is smaller why because we have taken larger amount of the solvent. So, it is a multistage feed getting in here, raffinate getting out here, you have the solvent getting in here, and we have E 1 leaving from the stage one. So, when we take the lager amount of S? The concentration of solute in this extract phase is a smaller. So, this had corresponding to our del min <mark>all right</mark>, and now we chose working operating S larger than this 2.3 k g. So, when you extend this line? Here, now you will see that this will intersects much ahead of so, if we extend this <mark>this</mark> is the del min, and if we extend this you will see that this intersects del operating, and here you have this del min.

So, this is downward here, now the question is in this condition is there any possibility of certain tie lines coinciding with this. Now look at, the tie lines which we said earlier at the all this tie lines they are like this. And then, they change the slope after a while in the opposite directions. So, as long as we are here on the right hand side and del operating was towards this R N p <mark>all right</mark>. Then none of these tie lines is going to <mark>going to</mark> coincide with the operating lines <mark>right</mark>, and if we extend these tie lines, they are on the left hand side. So, there is no problem with any of those situations then we require infinite number of stages when the tie line coincides with the operating line <mark>all right</mark> had that del operating been in our left hand side. Then of course, then we would have to calculate del min based on these two tie lines, and then take some amount of solvent larger than this.

So, again let us recall <mark>recall</mark> our discussions that location of the del, this moves when you take the larger amount of solvent in this directions till the line connecting this F, and E

becomes parallel to this. So, that means, we have reached minus infinity you take more amount of solvent. Then the del points come on the right hand side plus del take more amount of solvent, then you have del moving in this directions. So, all the tie lines which are in this directions this will give you one del min. You take large amount of solvent; you are here all the tie lines which are in this direction. That will give you one del min you take large amount of solvent you have del operating <mark>ok</mark>.

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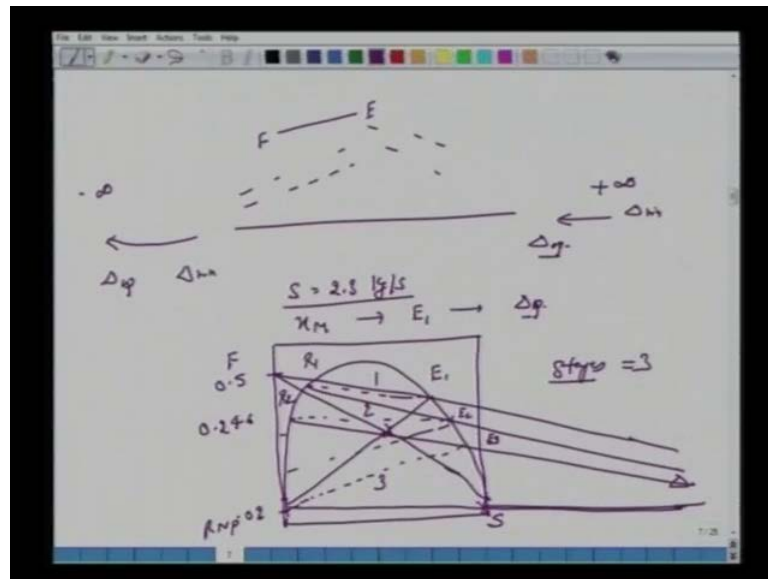
So, in this example now we have seen that type of systems where we have both <mark>both</mark> types of tie lines slope downward in this direction, and slope downward in this directions. Now, coming back to the questions now the for this actual S equal to 2.3 k g per second how many stages are required. So, once we locate x M from x M we locate the location of E 1. Then we locate del operating; once you have del operating you can construct the <mark>the</mark> stages to find out how many stages are required. So, for the last time they can be draw this curve equilibrium curve like this you had F 0.5, and then here you have 2 percent 0.02. This is pure solvent what we did since the amount of solvent was given to us. We connected F with S, we got this x M 0.246, and then when you connect this R N p with this or x N p with this we have E 1.

So, now if you extend difference points you get your operating del, then we start making the tie lines say E 1 get the tie lines way downwards. So, you get R 1 first stage connect with this del, and then you have E 2, you find the tie lines slightly they will start becoming flatter R 2 connect to this you have E 3 <mark>ok</mark>. And when the E 3 you will see now the tie lines have become exactly like this, and this will go below R N p. So, we have

stage 1, stage 2, stage 3, notice this what we are saying that this peculiar system certain tie lines at a larger concentrations or smaller concentration of raffinate. They are downward, and then the smaller concentration of expert now you have a in this tie lines which are upward ok.

So, one has to do some introspection here, the number of stages is greater than 2 or it is 3. So, it has gone below this R N p equal to 0.022 percent ok. So, that was the example on multistage countercurrent extractions where now we try to find out how many stages are required, and what is the minimum amount of solvent required. So, it is a very peculiar example; where we have two types of tie lines, and in which case del min can fall on the left hand side, del min can fall on the right hand side one has to calculate the worst case this example: S operating was of course, given to us. So, we were on the right hand side, and we ensured that 2.3 greater than 1.6. Now, we do not have that type of situations those tie lines which where slope downward. They fell on the left hand side of the equilibrium phase ok. So, similarly we we now we take one more example of this multistage counter current extractions before we conclude on this unit operation on extractions. So, let us take one more examples slightly different from the previous two here ok. So, here this problem reads that again in this case also we will do qualitatively; you can do the exercise at your home, and see whether you getting the similar results. So, we have 50 percent solutions of solute C in solvent A is extracted with a second solvent B all right.

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So, re read the problem all we are saying that we had you know one solutions which is C plus A, and we bring in contact with the second solvent B here. So, A still it is turning a system we have A plus B plus C. C is the solute, A is our feed that becomes raffinate phase, and this B is solvent, that gives us extract all right. It is given its given that the weight of B is 25 percent that of the feed. So, B by F or A it is given here as 0.25. So, now, it is the weight of B all it means even the flow rate will be in the same ratios. So, S by F may be. So, this is solvent B that we have been using the previous nomenclature S s by F is essentially 0.25.

So, k g per second, and here we have also k g per second. So, all the we says the amount of weight of B the w 8 of b is 25 percent that of the feed. Essentially, this has the same meaning S by f is 0.25, and the question ask here is determine the number of stages ok. Determine the number of stages and the weight, and concentration w 8 and concentration of the first, extract if the final raffinate has fifteen percent of solute C. So, essentially this is x N p is 0.15, and then we can find the determine the other quantities here all right. Here notice that, the solvent amount of S is not given, not the amount of feed, but the ratios is given all it means if we choose the feed has 1 k g per second as a basis 1 k g per hour, S is 0.25 k g per hour.

So, this problem feed is given although the ratio was given, but we can always make base a choose a basis of feed 1 k g per second per hour to obtain the amount of solvent which is 0.25 k g per hour. So, there is solvent amount is already given to us essentially, we will look for del, and not del min, because here the s is already given to us. So, this type of problem all it means, again if you do all kinds of balance where instead of 1 k g per hour. If you choose hundred k g per hour the solution will be in the same S will be come to 25 k g per hour we will get the same number of stages now what you got in earlier cases ok. So, let us draw this equilibrium diagram, we have a B, we have C, and let us draw this phase, which will go like this, and say this is 10 here, this is 90 here, and we have say let say 40, and then let say this is 60 here ok. So, in this case raffinate phase concentration is given as 15 percent. So, if this is 90, 10 increasing this direction; that means, somewhere here this is we have to read this 85 ok.
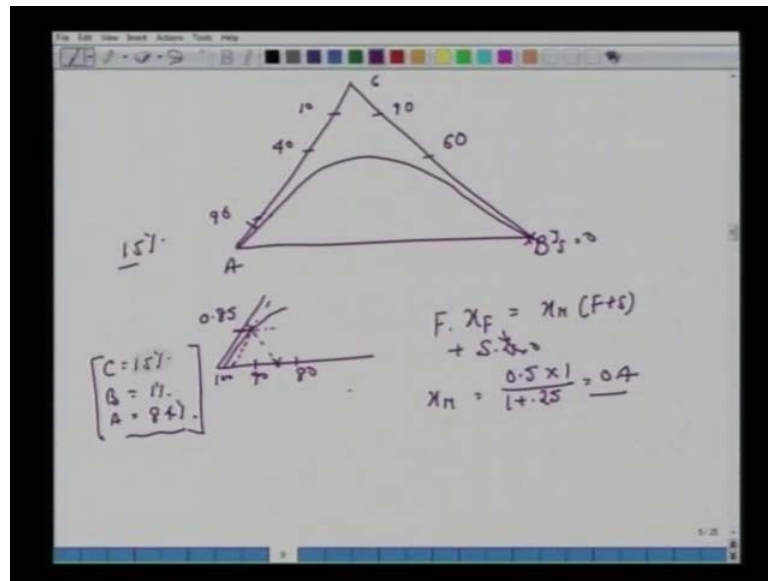
So, if you extent if you expand this or we are saying that let us say this is 0.85 then read like this. So, just on this equilibrium phase you will have the line like this. So, this is 0.15 is a solute S is 15 percent, and how much is B, and how much is A. So, to obtain this B, again you look for the line which parallel to this this is a B here parallel to this. We should be able to read a very small quantity here as 1 percent on this. So, b is 1 percent, and how much is amount of A, you will have to draw a parallel line this which will correspond to this on this is scale of A a to B here which will be around 84 percent.

So, this hundred percent here then you will have 90 then this is 80 all right. So, in this case you have to read this as 84 percent, 80, 90, and 100. So, just an example sometimes or you have expanded, and re read very carefully, what this amount of C is… So, again going back to this problem we apply this mixing rule F x F equal to x M F plus S amount of solvent S here or y S is 0. So, you have F x F plus S into y S, but this is 0 here. So, we can get x M as 0.5 into 1 k g over 1 plus 0.25 equal to 0.4. So, mark this x M, we know the amount of the solvent here all right. So, all of this curve again, we can mark on this. So, equilibrium phase diagram goes like this connect this F wherever it is 50 percent with the solvent B get your x M, x M point here we know this R n x N p connect this to obtain E 1, then you can find out. Now, I can when you read this E 1 as a you can see that this x is 58 percent all right. So, this would be very close to 60. So, the quantity increases like 100 this is 10 here.
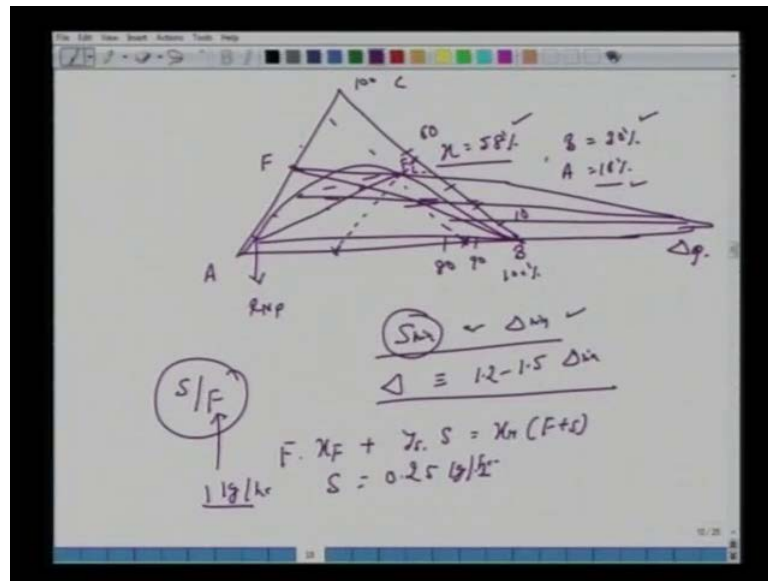
So, this is C 10, 20, 30, 40, 50, 60. So, if we read x equal to 0.5. So, what you will do you will take this to find the amount of solvent you will read like this that will be x.5 into how much is the amount of B you have draw a parallel line like this, and here you will read amount of B as 30 percent. So, this b is 30 percent how much is amount of a. So, you will have to look at parallel line which goes like this from here A is 16 percent all right. So, all this numbers when the report this is hundred percent then they will be 90 then they will be 80 all right. So, as is hundred percent here, and in this direction a decreases. So, as is 16 percent corresponding to this point b is 30 percent corresponding to parallel to this what we have read from here or we can read from here as well ok

So, x 58 percent B 30 percent, A is 16 percent, once we have locate all 1, 2, 3, 4 points now we can find this del l right operating line, and one can construct obtaining this del l del operating. Then, we can find the number of stages connecting with this; connecting with this connecting with this here notice that there is no need for S min or del min. Generally, we have said that del we need to know it is 1.2 to 1.5 times del min corresponding to this S min or del min corresponding to this S min or S. So, in this case the amount of solvent was given, because the ratio of S to S was given to us although the absolute value of F was not given. We choose this basis of F, why because again you back to this fixing rule we will have been the same ratios y S into S equal to x M F plus S all right. So, you just make a choose basis of 1 k g per hour per which S is a 0.25 k g per hour, and then you can do this calculation here all right.

So, these are the examples we have chosen on counter current extractions. They are several examples given in the textbook for tray (( )) as well is the book by (( )). You can go through them, and try to solve all this thermodynamic properties. This equilibrium solve solubility data, they may be given the textbook or you have to look for certain other thermodynamic hand hand book here; hand book there to find out on this extract, and raffinate phase, what are the concentration x, and y, and then depending upon type of problem either you can decide to work on equilateral graph or you can you will like to work on this coordinate system cartesian coordinate system or rectangular systems. In that case, also you have to need similar data except that; if you modified little bit to find out how does the x y mole fractions in of the solute in the raffinate, and the extract phase vary with the amount percentage fraction of solvent ok.

So, these are the 4, 5 examples we have chosen in this unit operation extractions there is one more a small thing we will like to discuss here qualitatively just like in case of distillation column we had that reflux. It is also possible that in case of extraction you also have reflux ok. So, generally typically in the industrially, it is very difficult to maintain this reflux unlike in discussion column it is very compulsory. So, in case of distillation also if you do some little, but more go through this text book you are something called open system. In which case or we have say feed, and solvent you know one end we do not have re boiler.

So, all the time we have the steam how even the top we have a condenser, and then we have a reflux. So, similar to that situations where you have the open system. So, called open system in distillation column we can also have a reflux. So, in other words whatever extract comes out from two phase consist of A plus B plus C. You try to take out the solvent or take out separate, and separate solute from the solvent, and send back your reflux, at one end ok. So, we will like to spend time here, and see ah qualitatively you know how we can address this type of problem. So, what we are trying to say here is that we have continuous counter current extraction with reflux all right. So, essentially we can have a feed say feed stage F where feed enters like this, and then let say we have a (()) here, and we have N p last number N p stage, and we have the solvent which enters here raffinate is treated as R N p.
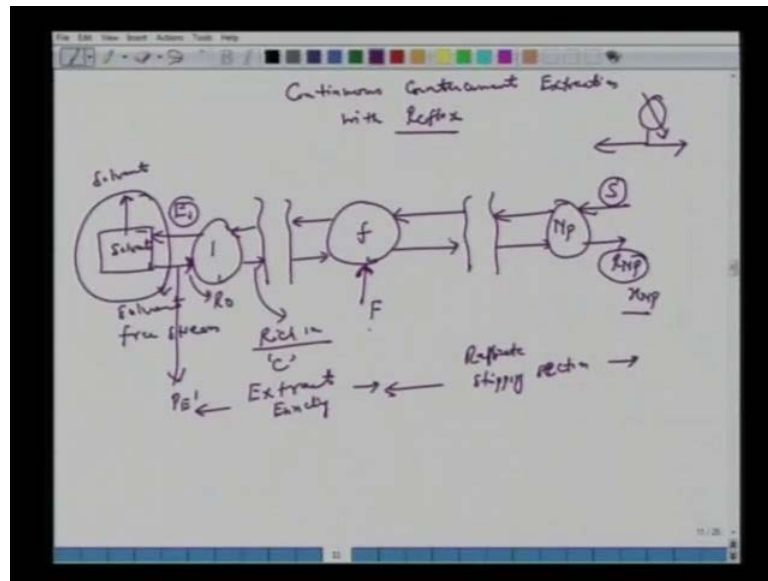
So, feed is making an entry somewhere just like in case of discussion column we have let us taken a break here then we have another stage. So, let us say this is first stage E 1 we have extract E 1 ok. Now, all we are saying that take this extract, and separate the solute. So, you have this this E 1 solvent separator here take this solvent and send back. So, this is your solvent here, and this stream is solvent free stream. So, essentially you are trying to recover the solvent, here and send back like this. So, you have certain amount of reflux you can withdraw the product let us say p, and you can have this raffinate as R 0 reflux, which goes back in this directions ok. So, this is what we have situations very similar to the discussion column where we had the condenser, and the top column we had the reflux going back to the discussion column. In this case, also with this solvent which comes here; we have solvent separator. We take back recover the solvent, and the solvent free stream is sent back to the first column. In this case, what we will have that this stream will be rich in solute or in C. So, this x N is actually your extract enriching section. And this side you have raffinate or strip raffinate stripping sections. So, given this feed again, we are treating back we are treating this to raffinate section C or at B here. Here what is the advantage that amount of solvent required is smaller or for the given amount of S here the product, we can have x N p much smaller than what we had in the previous case. So, in this case also the way you will have the treatment, it is very similar to what we had in case of discussion column.

Now, if you recall in in case of discussion column we looked for two difference points del d, and del w. So, essentially you have (( )) methods where you plotted H v, and plot H

l, and here you had x y, and then you look for one reflux here as del d, and then at the bottom you had del w all <mark>right</mark>. So, just qualitatively if you want to address this extraction with reflux one follows a similar approach here or notice this, what we are plotting here is x y. So, essentially this is your B over A plus B in two phases all <mark>right.</mark>

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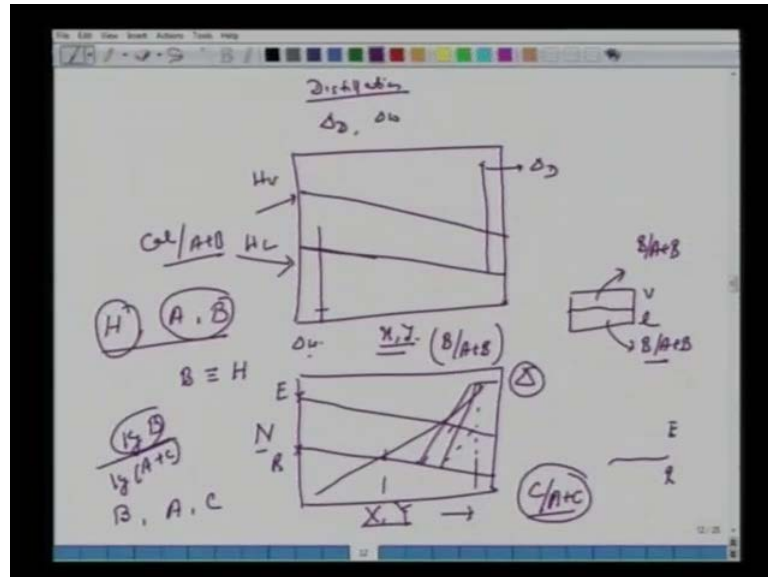
So, in case of distillation say you have liquid vapor phase and you have the liquid phase. So, you have B let us say more volatile A plus B and then here we have B over A plus B top product, and the bottom product, and what you plot here is a calorie per mole of A plus B; whether this is H v and this H l <mark>ok</mark>. Now, notice that one way of coordinating this, if we try to make an analogy we can also work on the system like n versus x, and y capital x and y. So, what is capital x, and y, in case of extractions we are saying that C over A plus C.

So, here also we have two phases similar to vapor, and liquid, we have extract phase, and we have raffinate phase. So, we are plotting here C over A plus C just like here, we are plotting here B over A plus C, and N is k g of B per k g of A plus C. So, look at this we have three quantities here; enthalpy H, and we have A, and B. One can make an analogy we have B, and we have A and C. So, H energy enthalpy this represents enthalpy of streams liquid phase, and the vapor phase A, and B, the calorie over A plus B. Similarly, we can from the same equilibrium diagram we can also plot n versus x y; x y is C over A plus C. So, no solvent here. So, it is a solvent free C over A plus C, and here we can plot how much amount of solvent is required B over A plus C in two phases; if you do this you will see that you will get the similar plot like this.

So, make what B we have is equivalent to what H we have a scalar quantity enthalpy in two phases here we have vapor, and liquid here we have extract, and the raffinate two phases here we have x, and y, which is B over A plus B, here we have C over A plus C. So, we have the similar situations, and qualitatively one can show that you will have the same treatment, you will look for this del depending up on what was the reflux ratios in case of extractions. From the reflux ratios, again get this F connected here, and one can find out again tie line connect with this another tie line connect with this, etcetera. So, this extraction with reflux, it is quite and common, it is not that very popular here. It is very difficult to maintain reflux ratios or a constant reflux ratio in extraction system. Mind you every stage in extraction consist of two small units: One is a mixture, and one is a settler all right.

So, to have a cascades of such type of units where you have a mixture, and the settler. And then, you want to separate at the end the solvent, and for send back your solute or solvent free solute back to this cascades of stages, industrially it is very difficult to do this to maintain this pyridine here. But nonetheless from the qualitative point of view, we can have similar very similar situations analogous to what we had in case of discussion column with open system. In which case we have one reflux at the top, and the bottom we have this open system no reflux.

So, pure stream comes out from some other plant, some other units. So, here also we can have a feed in the extraction trains of cascades, feed enters somewhere here, and you take out this extract make it solvent free put in one separated, and sent back solvent free solute or the streams in the opposite directions. And how do we do the treatment, again we make an analogy, we plotted two ways of equilibrium phase diagram: One was A, B, C on a triangular that is a most common. Then we said that well since A plus B plus C is always 100, it is one mole fractions.

Then instead of working on this equilateral phase diagram; we can also work on rectangular phase diagram. In this case, we in that case we plotted x y versus percentage of the amount of solvent or percentage fraction of fraction of solvent in in the two streams. The third way is also plotting n versus capital X, and Y. So, what is capital X, and Y? Solvent free C over A plus C, and what is n that is k g B per k g of A plus C. So, we have A plus C plus B not distributed in different ways, we are plotting n versus x, and y, and if you do this you will get a very similar curve like what we had in case of (( )) methods for discussion column.

There we have enthalpy H over A plus B, and here we had B over A plus B. So, we make an analogy, we have the scalar quality enthalpy replaced by the amount of solvent. You will get the same stories here; again you look for the del point fine, and then connect the operating line, and connect this tie lines to find how many stages are required, when you have this extraction with reflux. Of course, extraction with reflux will give less number less amount of stages, we have large driving force, if you fix the amount of solvent or if you fix the number of stages, we can have large impurities. So, this is the discussions we are closing today our discussion on this unit operation del extractions, when we meet next time, we will take up a new topic that is on adsorptions. So, so far we have done adsorption, we started with adsorptions, then we had distillations, then we completed extractions. Now, we will take up the next unit operation which is absorptions.