Chemical Reaction Engineering II
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Lecture - 39
Non-ideal Reactors: Multiparameter models

Good morning. So, will discussed or we continue your discussion on non ideal reactors models and we looking at multi parameter model or a 2 parameter model.

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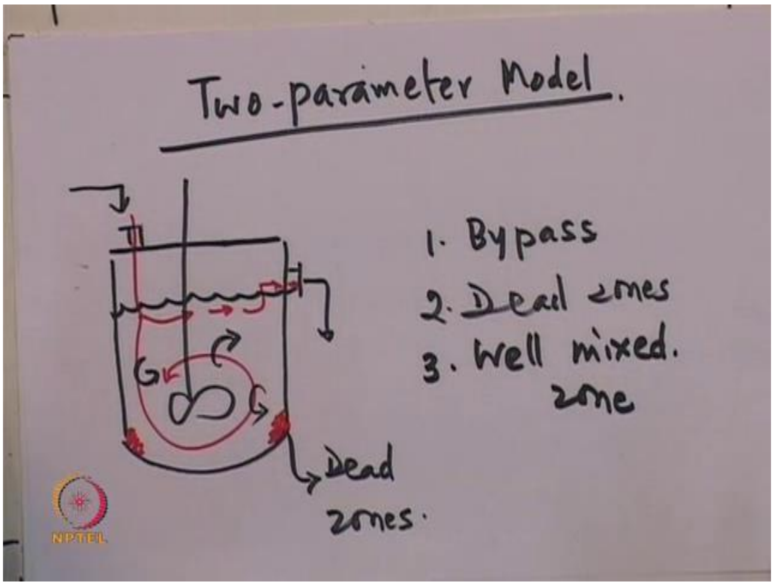

So, in the last lecture we just started our discussion on this off course, like depending on geometry will have different kind of model is not a it is not like will have just 1 equation which will have 2 parameters and that is applicable to any react a system. So, I will just give 1 example right now and then will see how it varies from reactor do reactor. And will have the 2 parameter model applicable to different react a system, but then the equations would change accordingly.

So, what we are looking at is the formulation for a 2 parameter model fine. So, we looking at it normal CSTR, and now will look at geometrical CSTR. So, it is like this and you have a nozzle here and you have a nozzle here. And this is stirrer and you have a feed coming in and there is the overflow that is happening and then there is a product that is coming out. Now, you will have nice mixing inside because of intense hesitation right, but there is a possibility that you will have certain pockets in the reactor; which are away from the stirrer or impeller. And they may act like stagnant pockets or dead zones or relatively dead zones.

There is another possibility, that you will have a feed coming in and part of it will go and mix here or get in inside a core. But, then there is a possibility that part of it will bypass and go along with the outgoing stream. So, apart from dead zones you will have another notability coming in picture which is called as bypass. So, there are 3 possibilities that you have a bypass, then you have dead zones and off course, you will have a the main core or well mixed zone right.

And all are known is this, that well mixed zone is something similar to a CSTR whereas, these 2 things I do not know how be in corporate them so far at least, how do in corporate them in the actual reactor model, but then if I known a something called as bypass is the possibility of bypass. There is a possibility of dead zones in that case, i should in corporate than and 1 parameter for this and 1 parameter for this we will have 2 parameters as simple as it become a 2 parameter model.

So, this is applicable to a stirrer reactor and I get talking about if you have some system there also you may have multi parameters not necessarily 2. But bypass and dead zones are normally observed in many reactors and there is always someone parameter associated with 1 of these effects. S

o, in general a reactor let or reactor model that considers bypass and dead zones can be considered as a 2 parameter model for a mixed reactor or back mix reactor or a stirred reactor. I am not calling it has CSTR now, because CSTR is a deal reactor that we always say what is the stirred reactor, stirred tank in which you may see bypass and dead pockets. I get going to look at some other situations, as well where you have will come across 2 parameter model or multi parameter models this is 1 example.

Now, will tried elaborate this further, try and give a mathematical treatment to it and tried conversion impossible. Now, first of all how do you know that there is a possibility bypass, how do you know that there is a possibility of dead zone who will tell you, again the tracer experiment. See that is the importance of tracer experiment, is such a useful technique that tells you the health of the reactor; health in the sense what kind of flow patterns are there inside, what is happening inside a stomach.

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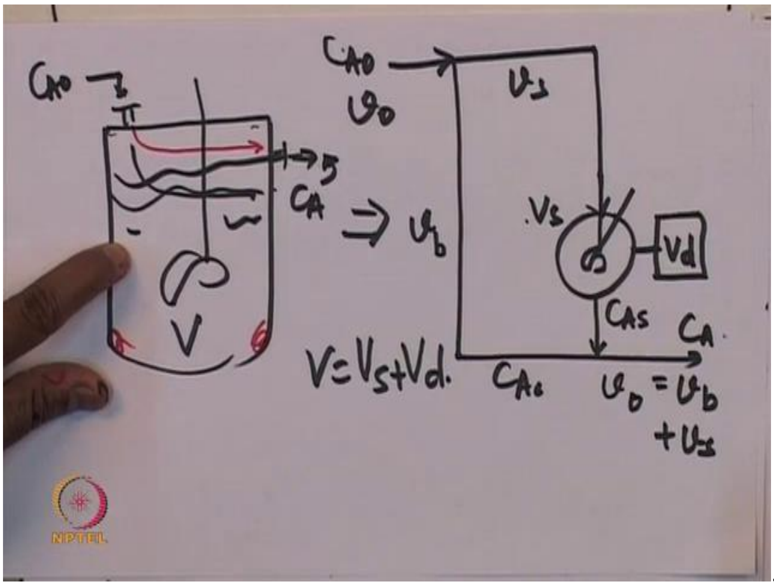

So, I made tree this particular reactor this is my real reactor equivalent to something like this see bypass means, it is not spending time in the reactor at all they would just it is going out. So, bypass is directly going out that means, not spending time in the reactor; whereas, some part is remaining here dead zones which is not seeing turbulence at all. So, I can look at this particular reactor as a set or network like this.

So, there is an that is coming in part of it is going to is CSTR part of it is bypassing and how were we present the dead zone? There is a dead zone here. So, some volume is that nothing is going inside, nothing is coming out of it is there. So, from outside I will look at a big reactor, but part of it is dead means, the actual active volume is much less or relatively less.

So, Vd is something that an need to subtract from the total volumes. So, Vd plus this I may call this is Vs. So, Vs plus Vd is V, so V is equal to Vs plus Vd right. Now, this is my inlet concentration is CA0 I get giving now mathematical treatment to this particular system flow rate v0 part of it is going here vs and part is going here bypass vb I get just calling it has vb.

Now, what is coming out or what is there inside is CAs a, this is CA0 same CA0 nothing happening, where is because the reaction something is happening here CAs is different from CA0 right Vd I do not have to very much about only volume voice they have problem there. So, v0 here the total volumetric flow rate I get assuming would be consensus liquid phase reaction which is nothing, but vb plus vs right and this is CA the result and concentration, so ultimately I get going to look at CA.

So this is nothing, but CA here; this is CA right and this is CA0. So CA0 coming out this CA here again coming out is CA this is CA0 what happens inside is have just formulated in network. So, this is how I get going to look at this particular reactor; this reactor for me is this as per as the modeling is concerned. Now, it becomes very easy for me to write on the equations for this. Because, every part of this particular network I get well aware of how to right equation for it, how to give mathematical treatment to it.

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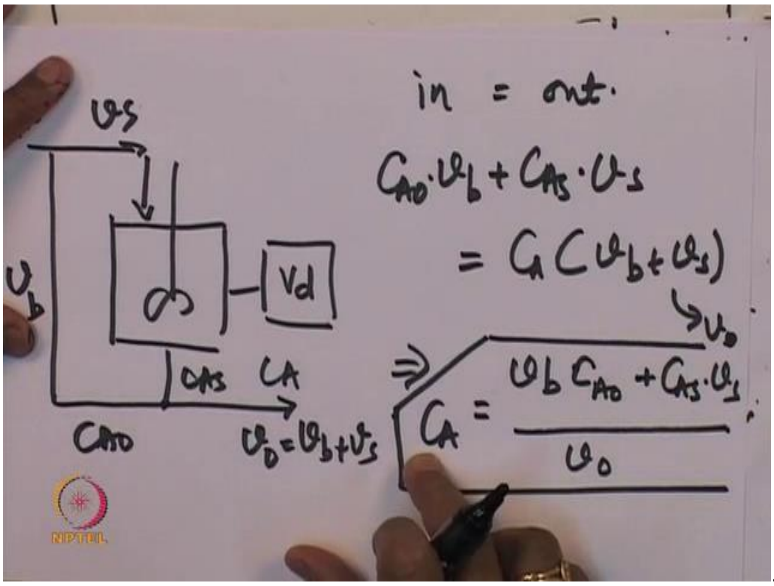

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So let us do that, let me draw it again because I will always need to refer it again and again while righting equations spend some time for in this CA CA0 right vb vs CAs CA0 v0 is equal to vb plus vs alright now. So, coming in is equal to out so let me write, whatever is coming in and I may take a balance at this particular point at this point at this point whatever coming in is CA0 into vb vb into CA0 plus CAs into vs is equal to CA into vb plus vs or nothing, but v0.

So, let us go ahead CA is equal to that means; CA is equal to vb CA0 vb CA0 plus CAs vs divided by v0. That is outlet concentration I get interested in outlet concentration. So, in this I will know inlet concentration, I know the flow rate, what I do not know is what is vb or what is vs? Once I know vb I can get vs because vs is nothing, but v0 minus vb. I do not know, what is CAs these 2 are known and these 3 are to you found what once I get these I can get a value of CA and that is nothing but my conversion as simple as that. So, fine let us go ahead let us assume, now let retain the same figure and then keep writing equations.

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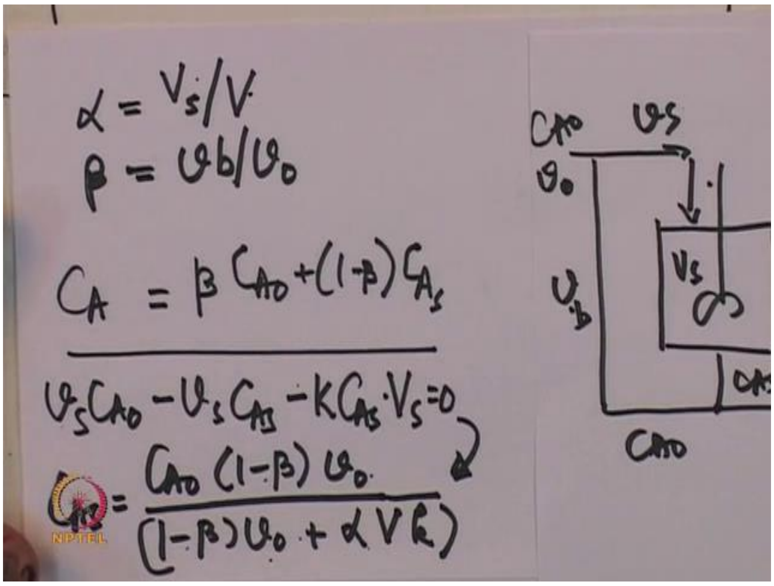

So, same figure now that balance this 1 CA I will right expression for this now before, so let me as let me say that alpha is equal to Vs by V0 what is Vs? Vs is the volume of this reactor and what is V is the total volume that is the alpha is a fraction of volume which is active fraction were total volume that is active that is nothing but alpha. Then let me assume, beta is equal to vb by v0, so your total floored v0.

So, out of which vb goes as bypass, so this is bypass ratio beta vb by v0. In that case, my this expression look at this expression CA let me write it here; CA is equal to beta into CA0 plus 1 minus beta into CAs look at this expression. I get using beta there I just divide numerator and denominator by vb and it is all is fine or no need to do that see vb by v0 is equal to beta and vs is nothing but 1 minus beta.

So, I have express CA in terms of CA0 and CAs in term of and again with the parameter beta. Now what about CAs? Now, how where does, so how you how will you get a value beta and all we see later. By the way like can you guess where will it come from, it will come from it is an experiments; how much bypass is occurred tracer experiment will tell me right. So, beta value is to be determined by through tracer experiments independently alright.

Now, in this expression if beta is known what remains is only CAs right. Now, how do you calculate CAs? CAs is yours simple reactor here you see it is a reactor and CAs is the outlet concentration of this react. And this reactor is well known to me no dead volume, no bypassing, it is the area which is fully active as for as mixing is concerned is well mixed stirred tank reactor nothing but is CSTR.

So, outlet concentration of this CSTR can be very well found out variety material balance here. So, this CAs I just write a balance for this CAs to be found out. So, vs into CA0 inlet minus vs into CAs outlet minus reacted K CAs into vs is equal to 0 is a normal CSTR balance.

So, CAs now can be retaining in terms of alpha and beta so this expression, this equation and this equation I do not need this equation for this. Let me say, so CAs is equal to C A0 into 1 minus beta into v0 divided by 1 minus beta into v0 plus alpha into v into k by the way why alpha is there? Because, I get multiplying it by V; V just total volume because from outside I get just going to look at a total volume, I do not know how much is the active volume. So, total volume into alpha, so Vs for vs have substituted and got alpha into V.

So, this expression you can derive it from this I get this is very simple, because you know the expression for Vs; Vs is 1 minus beta into v0, 1 minus beta into v0, 1 minus beta v0. So, this vs is going to come over as 1 minus beta into v0 you can derive it on. So, this is the expression that I have got for CAs and that is what I want in this equation right. So, substituting for CAs here from here from here as substitute for CAs here what is this? This is outlet overall outlet concentration that I get at outlet as a net effect of these 2 bypass and this. Incorporated bypass have incorporated bypass have incorporated dead volume as well through alpha.

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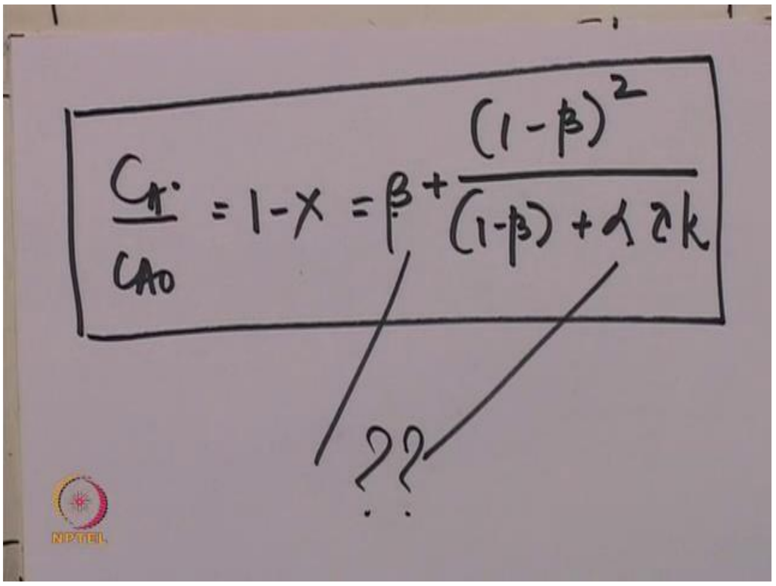

Fine now, I get the expression by substituting for CAs if I do that than c a by CA0 is equal to 1 minus X you know that know a by CA0 see I have I had a expression for CA now I get this dividing by CA0 that is nothing but 1 minus x then I want conversion ultimately. And if I substitute for CAs I get expression you can derive it on your own see what is more important is a methodology and not a final expression that give get off course, you need to get a right expression.

But methodology is important more important what have you see on the right hand side beta and alpha. These are the 2 parameters, this text of the dead volume this text bypass, k's rate constant first order reaction have considered here. And is there residence time based on total volume do not forget that, then nothing to do with vs. The total volume that I know off in the sense I just go and to measurements in the actual reactor at measure a diameter, I measured a length and from that I calculate a volume blindly.

So, I do not see what is the active value and all I just see this is the liquid level height and this is a diameter pi d square by 4 into l. So, this is what I get go to calculate, so that is base how will you base on that volume; volume divided by volumetric fluoride. So, this the expression for conversion it is a 2 parameter model now, the question is how do I get this? These 2 that is the only question once I know how get these values I have a 2 parameter model for a CSTR not a CSTR for a stirred tank which is behaving in a non ideal way with bypass and dead volume I can predictively conversion for a given volume given flow rate.

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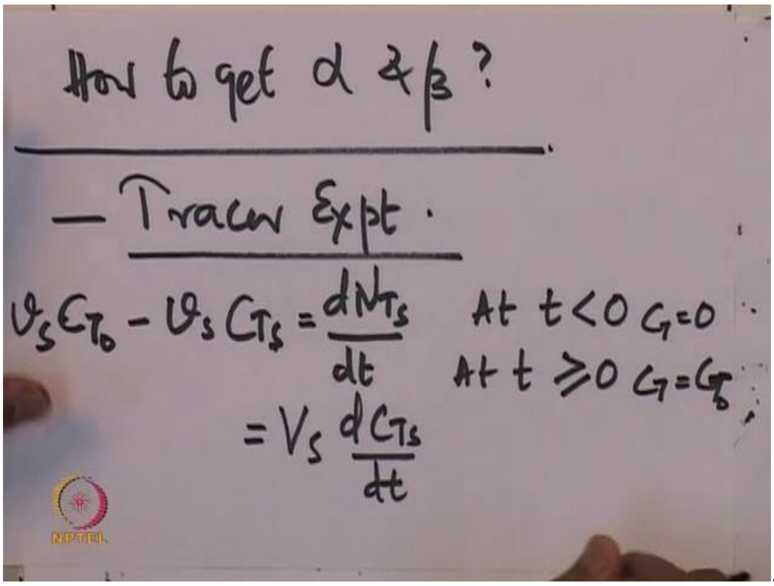

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So, the next question is how to get alpha and beta? Of course, the answer is tracer experiments e curve or C by t CT or CT tanker. So, for the same system can I right unsteady state balance look at this this particular reactor system I will say network. Can I right unsteady state balance for this, that is simple, because this is this no hole of here;

So, I can right there is no interaction with this part of the reactor.

So, I have to right unsteady state balance for this part only right. So, what is that unsteady balance let us write that unsteady state for the CSTR it is vs CT0 not this tracer experiment CT0 minus vs CTs coming out of CSTR is equal to can I right reaction by calling this CSTR is no reaction.

The stirred tank tracer experiment, so d NTs divided by dt d by dt or NTs accumulation term which is nothing, but Vs into d CTs by dt on steady state balance for tracer no reaction and what are the condition for positive step input. At time less than 0 CT is equal to 0. And at time greater than 0 or equal to 0 CT is equal to CT0 tracer equation I know, the condition for positive step inputs are this now what I need to do.

Because, see again what I get going to see at exit concentration is this. So, I need to combine these 2 now these and these. So, I need to take balance at this particular point now what is that balance we have already seen that alright. So, balance at this point for the tracer is CT is equal to vb into CT0 plus CTS into vs divided by v0. At this point I have bit is clear I get just writing this balance for the CT coming out here CT is here.

The combination of these 2, so they have 2 terms here and we know Vs is equal to alpha into V vb is equal to beta into v0 and tau is equal to total volume divided by v0 alright. Now, just a matter of integrating this equation and substituting the substituting for vb and Vs, so what we get is the final expression in terms of alpha beta and tau that is residence time.

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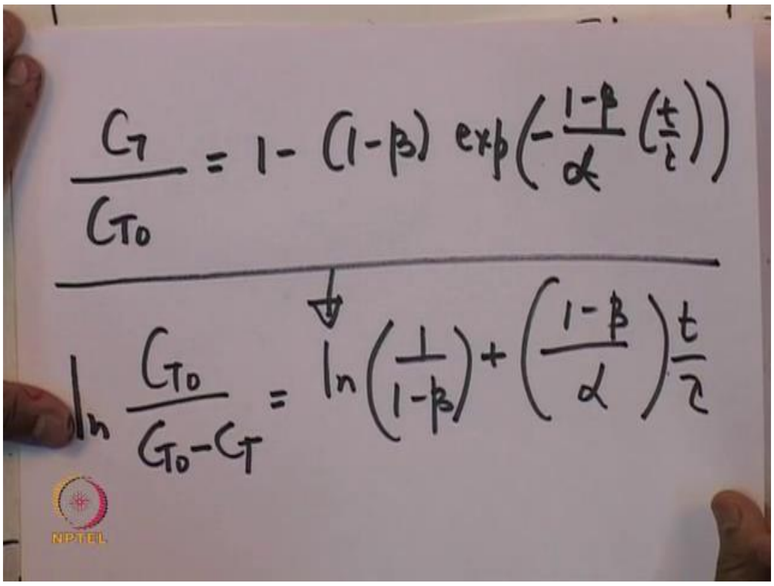

So, the final expression after doing all this is CTs divided by C T0 is equal to 1 minus exponential minus 1 minus beta alpha t by tau. So, this is the expression for the tracer experiment or tracer concentration at CTs this is at the outlet of CSTR Because, I have the equation for CSTR unsteadies balance have been written for CTs.

So, if I solve this I get expression for CTs but is not enough, because what I get going to see thermal tracer experiment is the concentration here this is my CT I get going to see this concentration. So, this is known mean going to measure this, I get going to measure this right. And for that I have the expression have the expression for CT what is that expression you already seen this CT right this is expression.

So, now I know the relationship between CTs and CT I have already determined CTs this. So, I need to just gets CT just substitute this here and get CT that is it. So, if I do that I get an expression for CT which is nothing, but CT divided by CT0 is equal to 1 minus 1 minus beta exponential minus 1 beta divided by alpha T by tau yes. So, this is the outlet concentration, this is the inlet concentration for tracer beta alpha and tau with the respect to time.

So, I have got a relationship how CT change time if I have this parameters; out of this tau is known, because total volume and volumetric are known alright. So, in this explanation if I know beta and alpha I get CT or other way around if I know CT as function of time, I get a values of beta and alpha.

So, I can probably for calculation purpose I need to I this really this equation and will put it in this particular form CT0 CT0 minus CT is equal to ln 1 by 1 minus beta plus 1 minus beta divided by alpha into t by tau the same as this. You can, because spent on time doing this, but why have done this? Because, now I have linear float of what time versus CT0 divided by CT0 minus CT.

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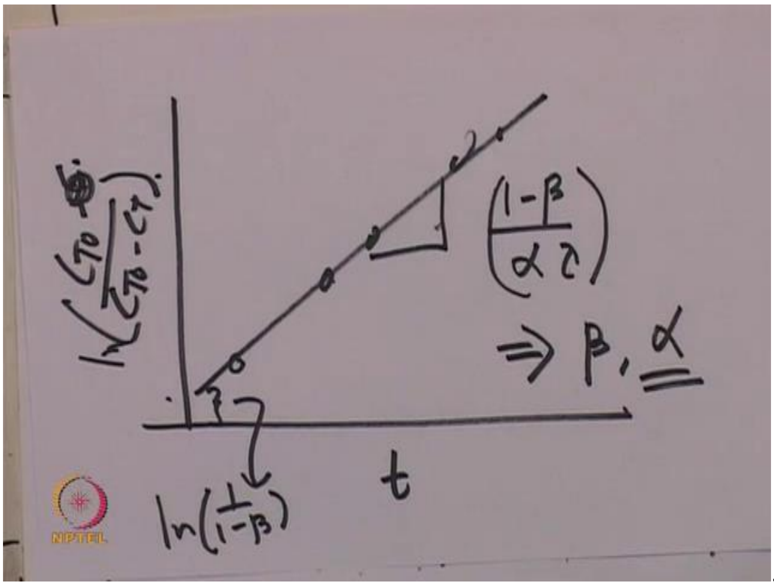

So, off course if have if at do law, so if I float a length CT0 divided by CT0 minus CT ln length versus time what I get going to see is, a straight line you see is time why by is equal to mx plus c why is equal to there is mx plus c right. So, I get go to see a straight line for which the slow page. What is this slow page? Slope is 1 minus beta divided by alpha in to tau and you know the inter side it is ln 1 minus 1 minus beta alright.

So, if I do a experiment in laboratory and float is versus this again it straight line this slow gives me this and a interstate gives me this. So, we these 2 the expression I can determine the beta and alpha for right. So, if I determine beta and other for my job is over, because I know the conversion in terms of beta and alpha and tau is already desire an equation for the conversion, before what is that equation? This the equation right beta alpha and tau k off course to be known.

Now, are the told the processor get alpha and beta right through experiment to tracer experiments. So, once I know the values of alpha and beta, I can get of value of conversion 2 parameter model, strait time with by pass and pockets have in corporated both these effects through 2 different parameters called alpha find beta is 1 example. You make come across another normality reactor; already real reactor which something else happening right. So, what is that?

So, let us considered another example this to appreciate by that it is not that difficult to considered the effect of flow patterns on ideality what is more important what is different here. We have use the same reactions in engineering principles that we are learn earlier, only the difference is that tracer experiment is able to give me the idea about of flow pattern. So that I can formulate the reactive reactor model in already reactor model with different parameters unit right and these model is able to give me the right conversion.

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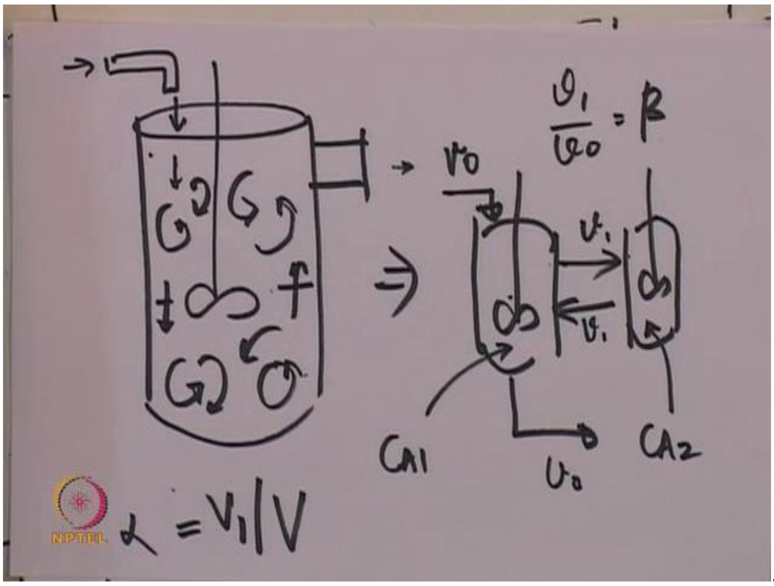

Fine, now this another example were you are talking about it a reactor were you have an nose and is star it is the long reactor; relativity long reactor. And it is phi that is coming in that is for the feed see what happens know you kind of flow pattern I do not know it all depends on kind of inspiring an using. So, it quite possible that you have in the upper part, you have some circulation happening if lower part of you also some circulation happening.

Now, what is a difference in this reactor and normal reactor difference is that, you can see that is known flow path or other thereof if you flow path, which are taking stream from here to here the always an exchange between these 2. But you can see at us distance holes form, so you like upper part where is the mixing happening; lower part of the mixing happening the b beams an exchange this is not stagnant this is not stagnant there is some exchange.

But, then this concentration may not be same as this concentration; because of the extent of mixing that is happening and the exchange that is happen again these 2. The exchange is size that, the concentration is not same in these 2 reasons. So, can be tread this as a normal CSTR or ideal CSTR we cannot, because ideal CSTR means that the concentration is uniform very well constant very well right.

So, how can formulate of model for this particular reactor? Of course, of all whether this happens of not who will tell me again it tracer experiment. This sometime the tracer experiment tell me about of flow pattern. So, the see now if your expert in this feel then then moment is see the tracer experiment results CT versus CT or e t curve we know what is happening in side of the reactor.

So, it like doctor examine in the patient base on seem tone he would know what exactly happening. Similarly, based on this tracer experiment you know what is happening in side. So, try understanding point important on tracer experiments e curve right fine. So, this can be looked upon has 2 CSTRs exchanging matter and if it is going to this is here and product is coming out from here. As simple as that is which is the CSTR here, feed is going product coming out and this is the exchanging mass with the upper CSTR.

If this was here I would a put a here as simple as that this is the network now. Now, what are the parameters for this network this is v0 this is v1 and this as to be v1 all though. Then we accumulation what we going a in would come out, whatever going in would come out. And off course, this as to be v0 this would be CA1 and this would be CA2 cannot, they cannot say with a same in the know point in making 2 different zones why that to different 2 zones? Because, a concentration that different right.

So, this is my network model now you can identify the parameters what of the parameters? First parameters would be v1 divided by v0 this is 1 ratio. And other parameters would be the volume of 1 of this CSTR divided by total volume. So, V1 divided by V is another parameter this can be beta, this can be alpha. The meaning of alpha and beta different here, than not same as what we with a it was there it was bypass ratio but in order to

So, I can use of others important can not a ratio, but then it is very clear in all the x v1 by v0 this flow rate it is 1 parameter, this is another parameter. What are we going to now? I get going to right equation for both of them right both this CSTR combined them solve it together. Now, it is like exchange so I have to solve this equation simultaneously. So, mathematical exercise will becomes slightly difficult because a modernist a relatively complex model, but not nothing to very much about it.

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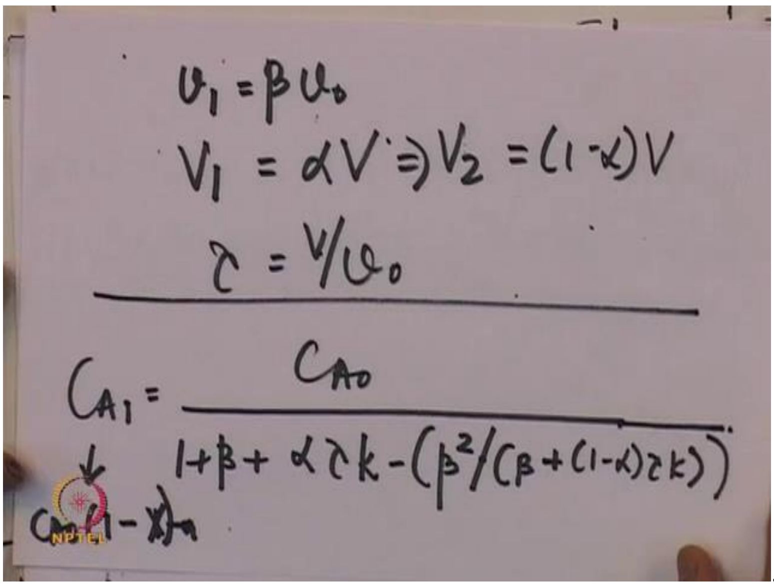

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So, solving the model system what you see like see v1 is equal to beta and v0 V1 is alpha V which means, V2 is equal to 1 minus alpha into V tau is equal to v by v0. This is V this is total volume, so if you can deserved equation right a equation of both the CSTR solve them together; what I would get is CA1 is equal to what is CA1? Look at this CA1 and that is what I want that is coming of here. It will have impact of what is happening here as well for this reactor see is going in coming in going out, going in coming out, from this reactor.

So, this is in the what is coming out from this reacts in let for this. So, this as 2 in lets here this will be determined not only by this, but by this as well fine. So, CA1 is equal to CA0 divided by 1 plus beta plus alpha tau k first order reaction beta square divided by beta plus 1 minus alpha tau k.

So, this is all it is on order writing in equation solving in front of you, but you can very very appreciate adjust right those equations for both CSTR and then solve them simultaneously, I get this expression. And this is nothing, but off course this is nothing, but CA0 into 1 minus x, x is conversion right. So, see this similarity between this problem and earlier problem though geometry was different, method logic is similar.

So, I am just formulating a model coming of a parameters getting then expression for the exits concentration; which is related to conversion and. So, how I get I am no conversion how it depends on the parameters alpha beta right tau off course, it has to depend on tau resistant time and the rate constant and in late constant. Off course, this will get cancel CA0 for the first order reaction right.

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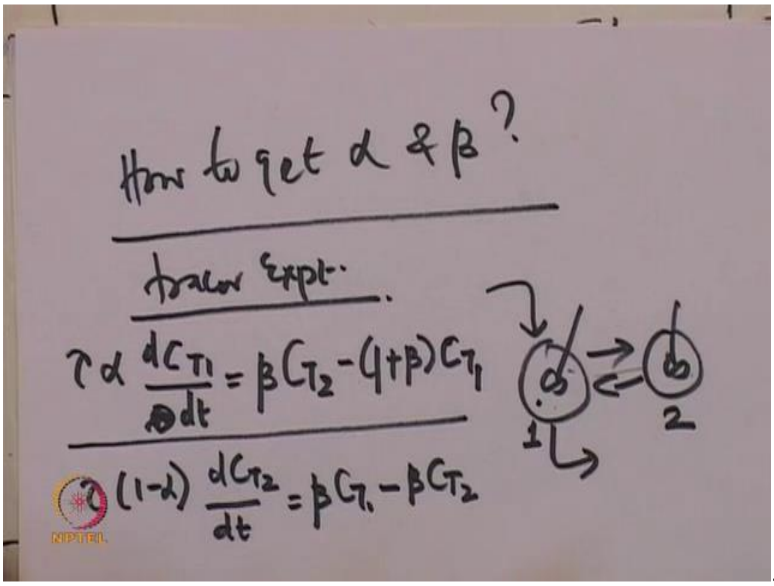

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Now, again the same procedure how to get alpha and beta, same question and same answer tracer experiment I have a system, where CSTR which is the exchanging mass with in other CSTR is not a dare volume do not forget it. This exchanging happening earlier dead volume there is 1 line that head drawn. Now, these are arrow which is going a hence in a arrow going here right.

If a right un steady state balance for this non-reactive condition, because it is a tracer that is going again is tracer that is that of that have that is going in. So, if I right unstudied state balance from both the reactors and converted it 2 beta alpha tau in k, I get expression like this tau alpha you can derive it on own right now, I get just right it directly do show you what explain or other demonstrate how similar the entire excise is compare to the earlier 1.

So, this is for this reactor 1 for 2, then will be another equations tau 1 minus alpha get is 1 minus alpha d CT2 by dt is equal to beta CT1 minus beta CT2; every terms else something. So, you can image very well imaging how this equation come guess the great of is coming in going out accumulation similar the happening here. So, but then now what is happening there is like you have 2 equations there coupled.

Because, CT2 happening here and CT1 is happening here. So, I can't independently solve them, so I to solve them together I have to solve them together is a set of o d is to be solve together. You can use numerical technique are 1 can do it analytically also right and get a values of alpha and beta. Now, the in earlier case it was quite easy for else to get values of alpha and beta. Because, to a linear plot we float rate some a ln CT0 divided by CT minus something versus time.

Then, that float slow by inter side gave a some values of the alpha and beta here, is going to a bit difficult. Because, I have o d is I can even get some equation after solving this after solving this I get some equation and that equation analytical expression for CT1. The CT1 something that is coming out and I need to compare.

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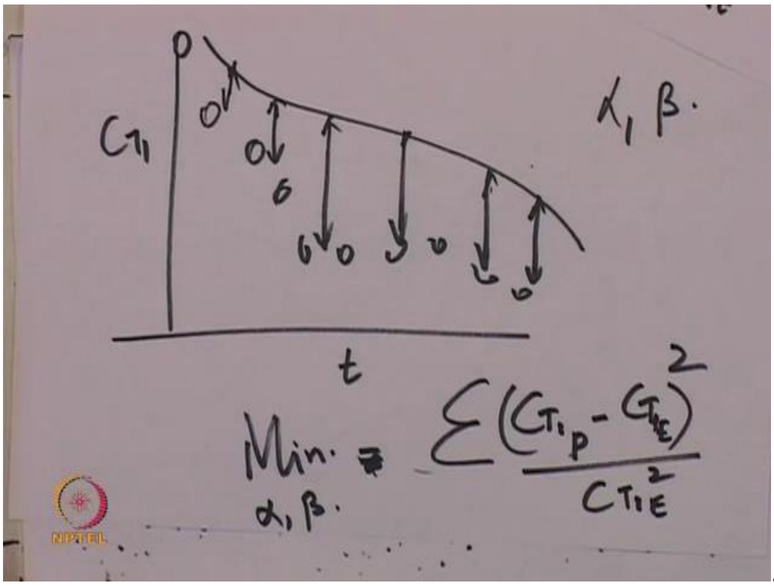

So, this float of CT1 versus time right I may see something like this I get just giving a some picture this guess something the it that CSTR is known go like this. I will get value at 0 was very closely I will get value at 0 also very close to t is equal to 0 right. I will get something like this this is assume that, this is by experiment and by solving this equations I will get some behavior.

Now, these equations if I want to solve these equations I need to have well is beta and alpha. So, procedure may be you assume to value of alpha and beta you make and a behavior like this; which is much different from this. So, there is some error right and this error we need to minimize you minimize it is in such away or other assume the values of alpha and beta in such a way, that this error is minimize right. I thing we are seen in this before also you have to high use in risk were optimization in technique.

So, it is in a numerical technique it is not so easy to determine the values of alpha and beta and this particular k with I do not state for linearly relationship I cannot those in equations. So, that way this particular already slightly complicated compare to the earlier 1 by method procedure risk quite similar.

So, go on changing the values of alpha and beta systematically there are techniques available. Such that, this error is minimize a lease square error minimize at me CT1 predicted minus CT1 experimental square divided off course, you can normalize it CT1 experiment square if this this is minimize sub this is we are to minimize this for the values of alpha and beta otherwise, becomes a optimizations problem.

So, get a values of alpha and beta in such a way that this is minimize this function is minimize. And you can do it using software or other you can be solver and they can optimizer lease square method, which uses lease square method and you know y square and y why called in this square method in order square is because later I do not want to consider the sign of the error.

Otherwise, 2 error may compare side each other and they make give you the function to be there may side function is 0, but that may not be situation much away from the actual real values that is why square it make sure that you other positive values determine alpha and beta. So, like this they can be different situation that you make come across a simple scenario now there are many possibilities how do a identify what kind of model I may I should go for from the v curve itself.

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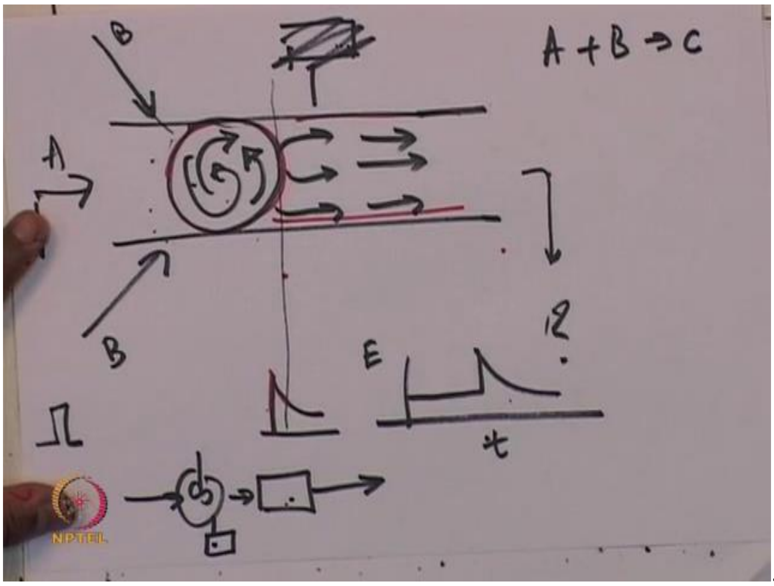

So, let us considered see c situation are I have a tubler reactor, but not a simple tubular reactor were I just have 1 inlet. There are 2 in latest the action of A plus B giving C B is coming this way as judge or along the verify it. So, I have I get showing 2 judge, but I can the multiple judge along the circumference and it is 1 react an coming in this A and all B going this way this is reason why.

Because, I want these to mix we get well mix here both the as, then come which are the there are some were only b remains or only a remains them is the problem, because it may go under go side reaction. So, in this zone I want them to mix the rally and later on I do not have to any problem. Let I get both together are in a flux flow manner once then mix plug now this is 1 reactor.

How do model this reactor? It is very simple does not it if I the fool that if I this do a tracer experiment on this that means, in nonreactive conditions suppose an inducted tracer at a inlet, what will I see at outlet? There is a material flowing like this know I get this injecting tracer. Now, this reaction and this sending some and in art inlet in this; flow pattern is similar when the reaction is taking this what is have what see here, I inducting tracer a plus what do I see here?

If it was a simple plug flow tubler reactor I see a plus at a time tau right. But now, because this some mixing happening I want to see the something be front. So, let us assume that this part of the reactor is well makes to this behaves that the CSTR and did behave like this particular part behavior the plug flow react. So, what I get known the see is initially at this point suppose I take measurements I will see CSTR type behavior right this is the CSTR. And here it's PFR.

So, after this it is going to behave like a PFR, so this a this particular response is going to come out at this point exacted as after the time interval equivalent the resistance times spent here. So, the behavior is going to the like this, so if I see an E curve or c curve whatever like this combination of a PFR and CSTR. And series off course, we are to remember 1 thing whether it's first the PFR or CSTR, because both cases you are going to get a same e curve.

Then, you not thing about what is the real situation now, I know that I get sending judge here, so definitely first part is CSTR. So, without knowing this just base on I cannot make a reactor model. Then many possibility is of combination this reactors that can give raise the small curve. So, 1 e curve is likely do give you defined reactor models, but knowing more about the real reactor you can short less them and come off with a final model.

So, for this particular case my it curves this is a simple late network is this a CSTR followed by PFR. Once I know this, I can definitely find out conversion what is the parameter for this model? There is only 1 parameter here I know total value how much out the total volume is covered by another each taken off by the CSTR and how much of it is PFR. That is only parameter now it is a 1 parameter model, but if for some reason I see some dates gone here.

So that means, area under the curve for the e curve is not 1 right. It tracers still comes out like it keep coming out long time any under curve calculated based on total value is not matching on that. That means, there some dead volume so fine that means, some dead volume I can say, that is dead volume here not here is a really actor. So, this is dead volume here that is how you looking at it, then the dead volume becomes another parameters alpha something that use before.

So, that is why that is how will look at different types of reactors and at the same time from the e curve or c curve I can very well gets some idea about what kind of flow patterns you may have inside the reactor otherwise.

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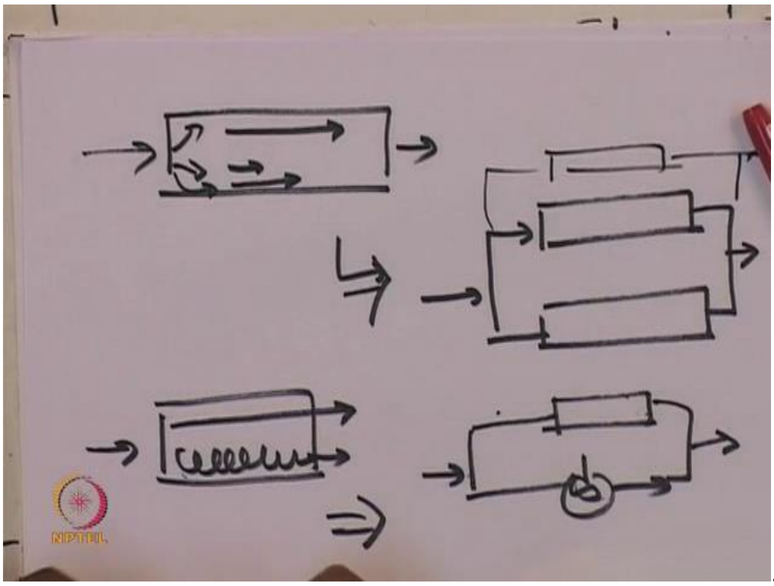
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So, there are many possibilities just 1 of them you have a tubler reactor and some streams a lagging behind some stream the going hide from. So, it gets a big this divided for some reason this is going very fast and this is going slow. What is the model for this? A model lase you have a feed set get divided in to PFRs right is again, 1 parameter model how much goes here, how much goes here. This 2 how much goes here, how much goes here and volume of this, so again is a 2 parameter model.

These a possibility that you have something like this mixing happening here and this is going strait. So, you this is equivalent to PFR and CSTR in parallel right again 2 parameters, how much goes here and what is the ratio here the 1 units right now. So, many such scenarios you can have even more complicated that you may have some 3 o CSTR in series in the then there is 1 plane PFR so many things happening depending on what kind of situation you are in.

Normally for a chemical plan our reactor are very well shake reactor, but if a talking about some natural reactor reaction taking place in space or reacts taking place underground, that case geometry is not in your hand. Then, that case that to make assumption or other it can be a more complicated complex network of different ideal reactors and by pass, there volume so on.

What is the key? Is a tracer experiment the e curve, the c curve, tracer experiment you should learn to read the tracer experiment result properly. If that happens then you job is easy off course, mathematically treatment is something that you can definitely do, but an solving the equation numerically an all the many to take help of software is on, but method log is very clear.

So, it’s a tracer experiment that gives in idea about to the reactor, behavior as for is the flow pattern is concerned. So, this is the all about how we use multi parameter models for real reactors an shown you 2 parameter model here, but you can very well imagine scenario you can have. Now, is same case here let for example in this case, like you have 2 stream giving, but you may have another see other some part of the reactor were will have an velocity.

So, will have third PFR in series so and, then the parameter would increase, as simple as that how number of parameter it is will grow that will depend on the complex city. So, first thing is you need to come off with the proper reactor or multi zonal model on network. How do you do that? That 2 things that are required for this first is your e curve tracer experiment and a knowledge of the system as a said only curve can give raise to multiple networks giving the same e curve right out of this multiple networks, whether it is first CSTR and then PFR that I would know base on some knowledge of the system of react the use.

These 2 will tell me of this 2 help me formulate a network once you have the network, right down balancing equations get expression for the conversion. And from in that expression you will have the parameters for the network those parameters at to be determine through tracer experiment.

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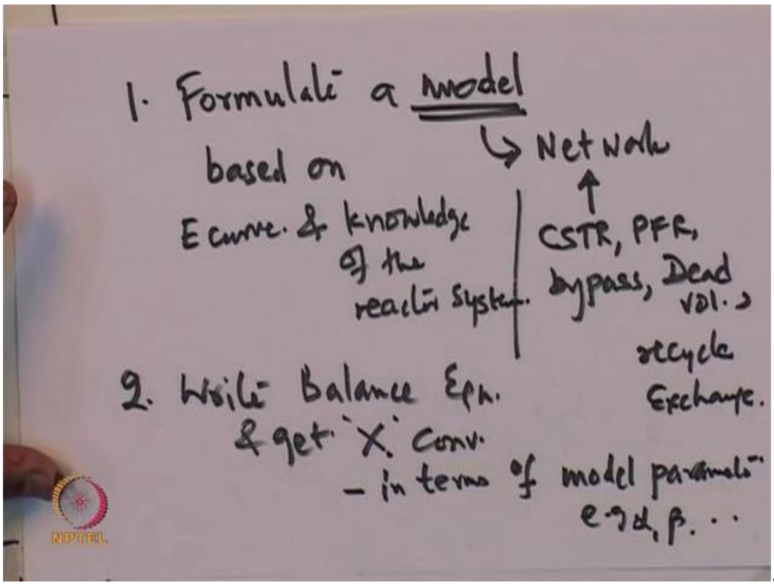

So, just right down thickly what it is formulate a model this is going typically going to be a network which will have CSTR, PFR, bypass, dead volume, you not seen many other case is recycle, exchange, many features possibility who will this is based on what? This is based on e curve or tracer experiment and knowledge of the reactor system. Why do say system? Not just reactor geometry, but lase a where is the out late nodal all this feel with matter.

So, once you have once you formulate of a model, network write balance equation and get X conversion you make it expression for a these are you are to solve this equations numerically, in terms of model parameters for example: alpha, beta and so on right.

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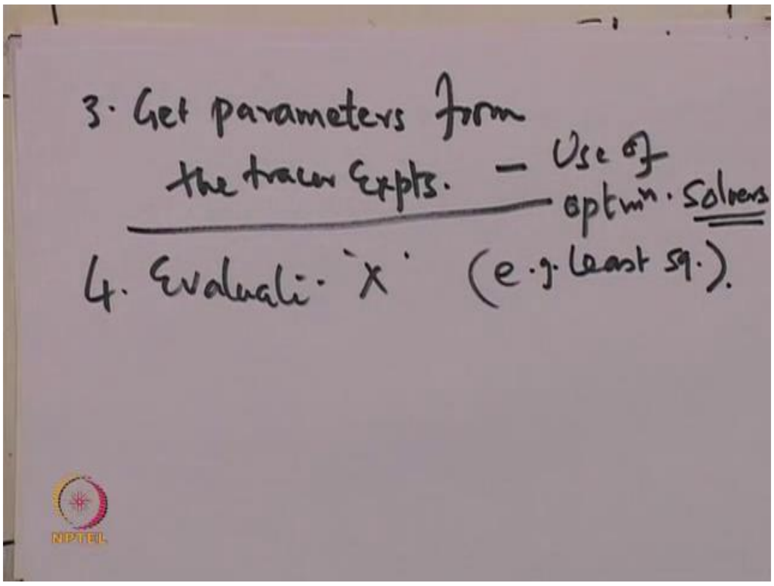

A third step would be get parameters from the tracer experiments and, then evaluate X. Now, this step may need use of optimizations solvers least square whatever. This the overall procedure a hope this is clear were how to corporate considered known ideality in the real reactors and predict the right conversion with the help of e curve.

Thank you very much