Chemical Reaction Engineering 1 (Homogeneous Reactors)
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Lecture No 45
Non-Isothermal Plug Flow Reactors Part II

So we will start now I think iso thermal PFR sorry non isothermal PFR what we have discussed yesterday. There are one or two things still left out, non isothermal reactor. Plug flow reactor we had the last equation I think what was that equation? Yeah material balance and energy balance of course what we had both.

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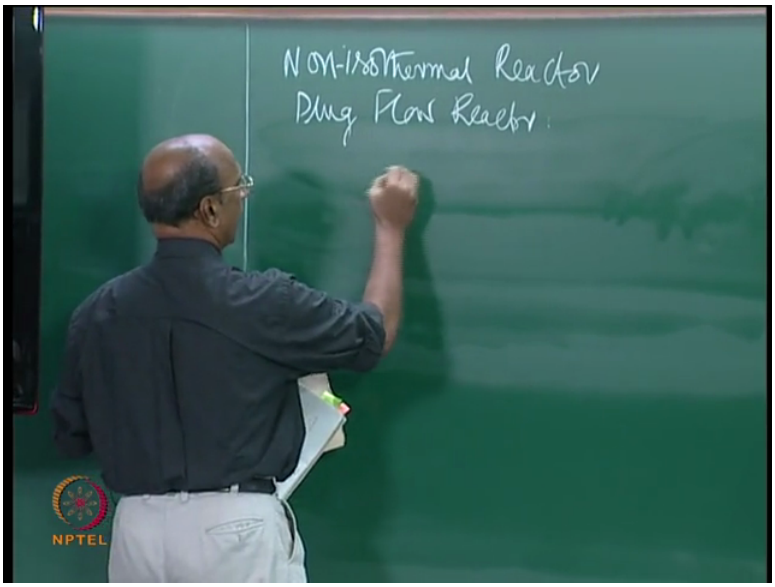

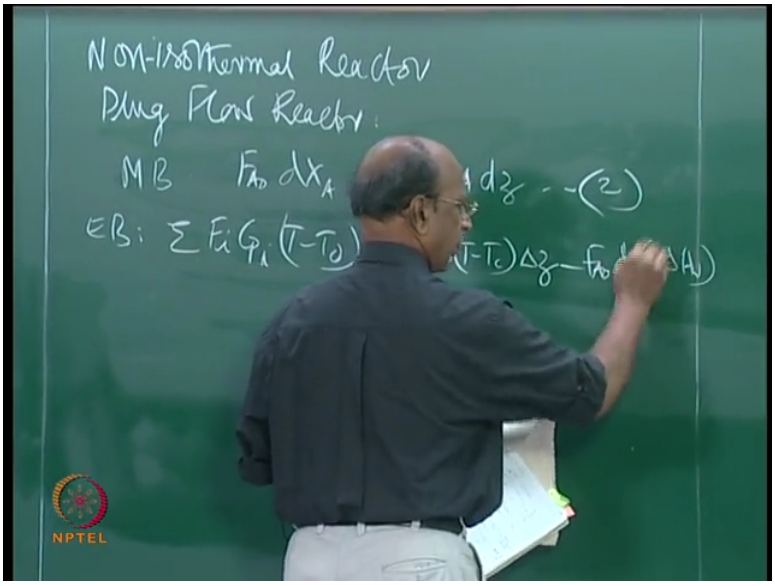

Let me write those things. MB FA nought DXA equal to I am writing minus RA A dZ I think this is 2. Yeah so the other equation energy balance was yeah, sigma Fi CPi T minus T nought plus you have pie UD T minus TC into delta Z minus FA nought DXA minus delta HR equal to 0. Correct? I think yesterday I would have written this minus delta HR first I think.

Student: (())(1:47)

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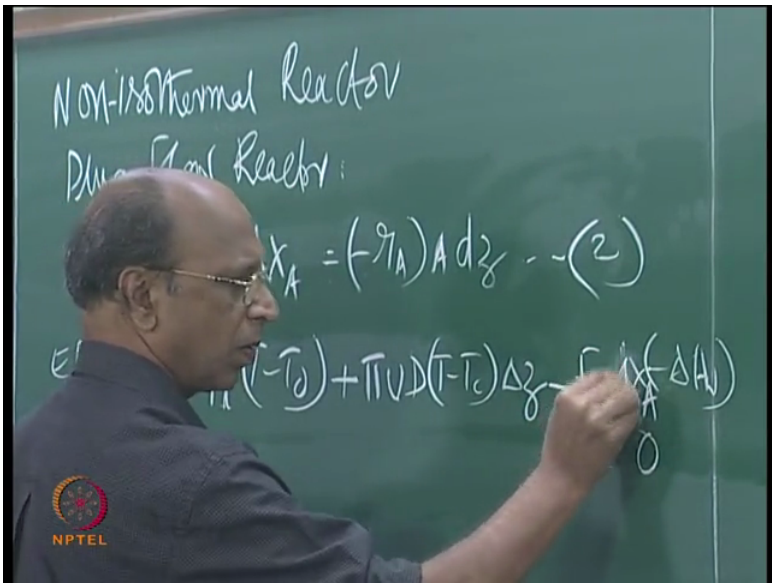

Professor: sorry dX this is delta okay this is the one. So now we have also seen what is the procedure to solve that but unfortunately in all non isothermal reactor this is the only 2 equations are available you to only do in this way there is no way how you can design the reactor. Without this trial and error you can not do things okay, I mean how do you do trial and error is there manually or computer that is left you right?

But because there are only two equations and three unknown you have to do only by trial and error check whether what you guess it is right or wrong. Right? And if it is not correct then again you have to guess and then like that but if you do manually with one or two guesses its not that terrible right with one or two guesses then you will guess means what?

I am talking about you assume delta X equal to 10 for example this also delta X I have to write this is also delta Z I will write, yeah your first assuming that you know you have delta X equal to point 1, ten percent. And what will be the temperature raise or what is the distance you know what is the distance that is required for that 10 percent conversion.

So that you can guess in the beginning you know just blindly after one titration you will definitely know that what will be that length approximately okay. Like may be 5 centimetres I mean depending on kinetics and everything right. So like that it is not that desperate thats why unless you do one or two problems. I think you can not really enjoy that, right.

I think those people who have done I think Ramkrushna you have done yah even the batch reactor which I gave you the other day with UA equal to some value that you can try. that only you have tried yeah. So once you try only then you will know what are the difficulties otherwise you know you will not know definitely right. Okay good so now let us see what will happen to this for adiabatic case.

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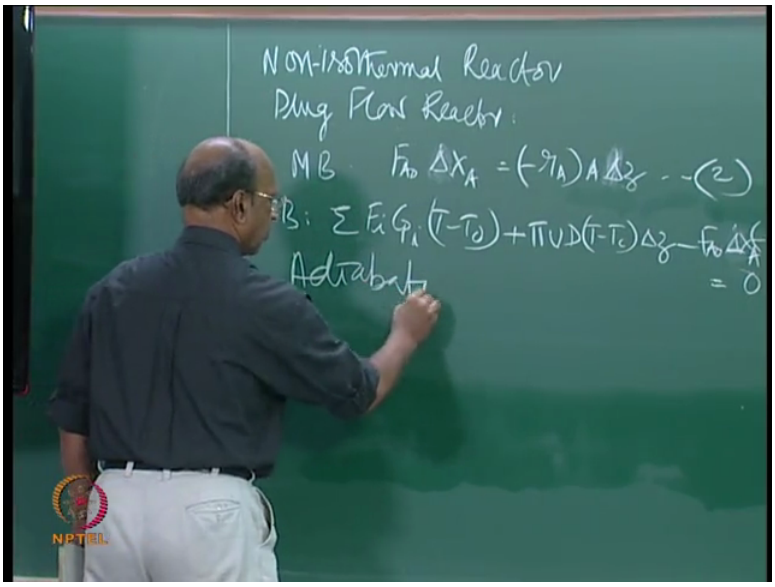

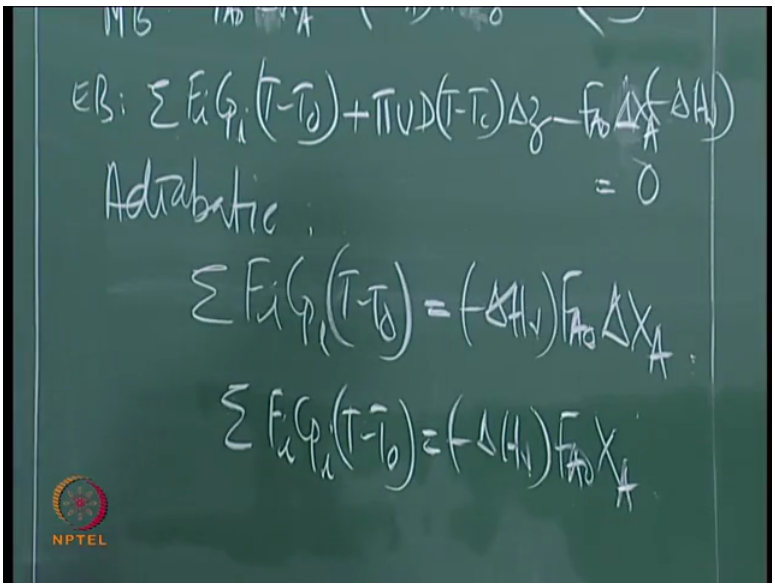

Adiabatic case, adiabatic case this is 0, correct? So then you will have sigma CPi delta T or T minus T nought equal to minus delta HR I am writing again (())(4:12) delta HR first FA nought dXA or delta XA. Okay and yeah delta XA I know that it is not XA nought equal to 0. You know that XA nought equal to 0 so that is why you can write this one as sigma Fi CPi T minus T nought equal to minus delta HR FA nought XA.

Okay delta X also you can leave there but I just want to show you that the equation which I have told you in the beginning for all adiabatic reactors whether it is batch or plug flow or mixed flow you will get the same equation so that is the reason why again I want to so this is the one and numbers if I put what was this number?

Student: 9

Professor: This was 9?

Student: Yes

Professor: okay so this is 10 this is 11,

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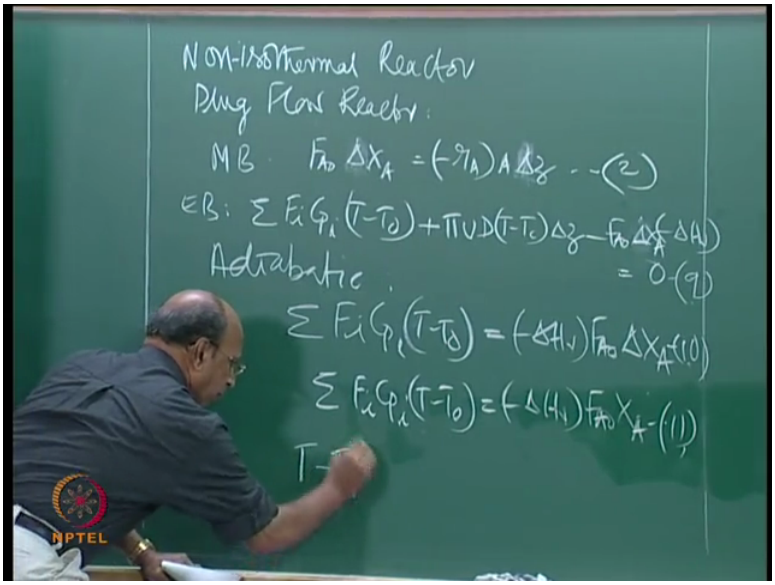

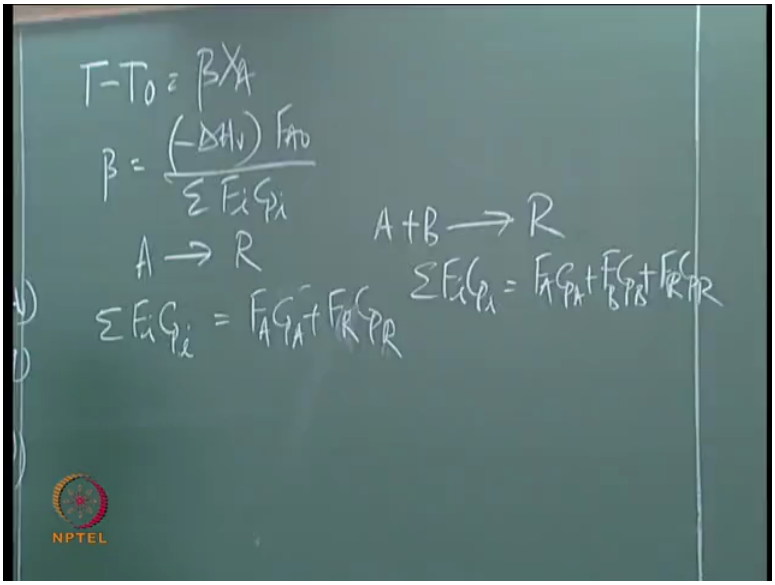

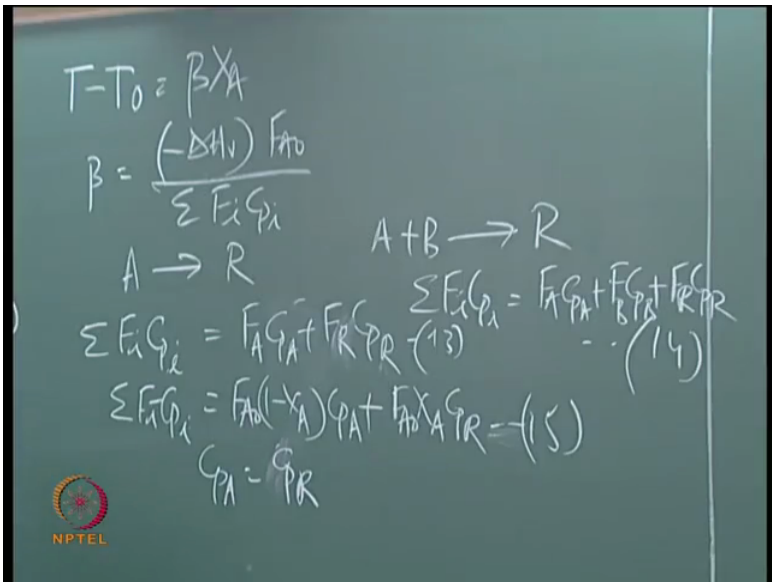

So now yeah I will write here T minus T nought equal to minus delta HR FA nought by sigma Fi CPi into XA. Yeah so this is equation number 12 and we have been taking this T minus T nought equal to beta XA. Okay T minus T nought beta XA and where beta equal to the slope minus delta HR and FA nought sigma F of i CPi. So now we know that with this slope you have to draw the line if it is adiabatic reactor we are assuming that beta is constant that means delta HR nought is delta HR is not a function of temperature and CPi also is not a function of temperature, right?

So this is the reason why we are taking that as constant and then we can start drawing the straight line but there is some problem here I think actually you have to calculate the Fi Fi CPi how do you get that information? In fact sigma of Fi is nothing but it is a mask. Okay the

total sigma I told, sigma Fi is nothing but the total okay, total of your molar but anyway if you multiply by correspondingly with that you know molecular weight it is mass flow rate.

Mass flow rate will not change at any point across the because mass is not changing is only converted from one to the other thats all. Okay good so this why and I can give you one example you can just find out and tell me if I have A going to R can you tell me what is sigma Fi sigma yeah what is this one?

Student: (()(7:40)

Professor: yeah first of all, yeah when I write this is FA plus FR you know still some people may not be knowing this. I have to write this both yeah. FACPA plus FB FR FR, FRCPR okay now you tell me what is that value? What is FA?

Student: (())(8:10)

Professor: FR nought is 0. Now you tell me what is the thing? How do I cause finally you have to write that in terms of commercials. Because now I have 2 FA and FR I may have also ask you so do this also. A plus B going to R. So here A plus B this one is yeah this is equal to FA CPA plus FB CPB plus FR CPR I am sure you will definitely make mistake in this, thats why I am now again telling you once more, many people still may not know.

How do you get that information. What is the relationship between because you have to convert everything in terms of FA what is the relationship you take the first simplest one.

Student: (())(9:14)

Professor: yeah so this FA equal to FA nought into one minus XA.

Student: XA

Professor: right? So FA nought into one minus XA CPA, okay. And then this one.

Student: (())(9:26)

Professor: yeah if you assume FR nought equal to zero this is simply nothing but FA nought into.

Student: XA

Professor: XA CPR, okay. So like that even you to write there for the other one also. Because now again you see why I am telling this one is different case is that now you have FA nought you should also here FB nought that is why when you assume that Fi nought equal to FB nought that is equal equimolar flow rate when you take then only you will have one otherwise you will be in terms of again FB nought.

FB nought you know no problem so these are the things where you make mistakes in the examination. Okay because your interest also examination. Yeah so that is the reason, okay so now finally if I have in this equation sigma Fi CPi so let me say this is equation 13 and this is 14 this is 15 okay if CPA equal to CPR possible no? CPI equal to CPR is possible many times we take equal yeah so what is equation.

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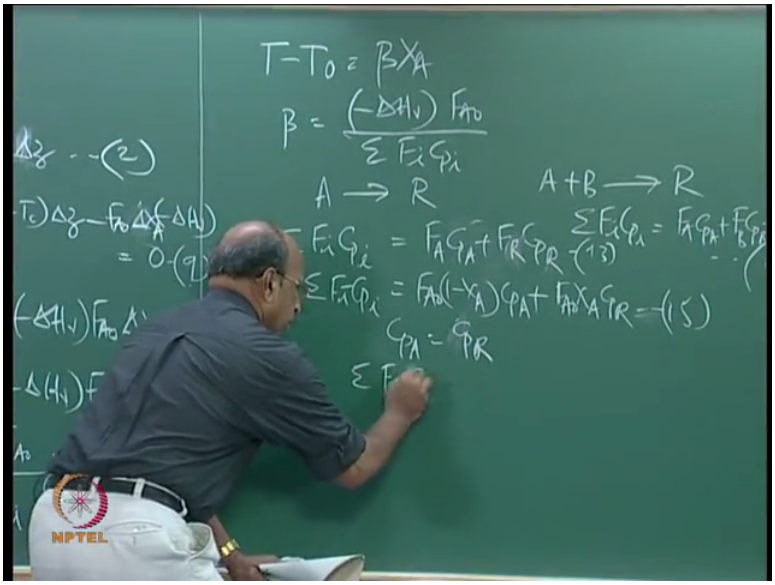

Sigma Fi CPi equal to

Student: nought CPA

Professor: FA nought into CPA yeah now substitute this in the, in this equation I think sorry I think this equation number okay just leave it right. So what is beta now?

Student: CPA, minus delta HR by CPA

Professor: minus delta HR by CPA XA. sorry so not beta I am writing the final one sorry. Yeah beta is okay, so T minus T nought equal to beta is minus delta HR by CPA into XA so this is the one, so now slope is simply minus delta HR by CPA. That is why some books you know when they are discussing academic problems most of the time they take minus delta

HR is by CPA. If you take (())(12:01) you will get minus delta HR equal to I mean minus delta HR by CPA as the slope.

Because he has taken that all the assumption you know CPA equal to CPR and all that and also A going to R, the moment you don't have that like for example here you have FB nought and all that you will not get this kind of equation and in fact you get XA by in the denominator also XA which is not a straight line. Okay this I am not I am just leaving to you.

Just to try for you, and here also we have the 1 mole, 1 mole, 1 mole yeah you know you assume everything in the beginning and complicate with mathematics and you don't understand what is the use. That is the reason even crude assumption are made for making the subject clear okay and the next point is that you know how to use you know all the complication we know now.

Our assumption also is wrong we know because most of the time you may not get this kind of cases. But yeah but I think you know if you start with very very complicated things like you know tensors and vectors in the beginning. No really I mean because you loose your interest the moment you say dell. Okay del, del thats all I think you are gone.

Okay so that is why we give you know these explanation first once you understand everything then you put del. Then you have the feeling for dell. Right, what are the terms you have so all the how do you handle them all that we came later, so that is the reason why in all these you know academic courses, we first assume simple things and then make complicated, thats why you know the definition of teaching is that, taking students from known to unknown.

Understood? Known to unknown that is why I we give very simple examples what you see everyday or if I give you some complicated example no one has seen then what is the use of that example. Example wise also more complicated than you know the actual one so that is why that is the reason why you know one definition of teaching is some of you may become teachers and I tell you teaching job is excellent job, absolutely no responsibilities coming to class and going.

Simply come to the class take class and go home. Okay no one is there to a particularly in IIT is no one ask what you are doing. Okay what you are doing only depends on when you go on promotion at that time. Okay at that time they may ask what you have done. Right I think in

university is also I know there are many professor where they take class and go home and do side business.

Okay many people have in many university I know that okay, thats why this is a wonderful job if you want to enjoy your life. But only thing is you should know the subject and you should teach well and anyway automatically students will be happy there is nothing like you know making students happy I say. If you have very dull student and angry students are indifferent students in the class there is no use at all.

Okay instead of seeing at you I may talk to board that is much better. Okay so that is why many faculty member do that they only talk to board most of the time, right okay good so this is what I think this is the reason why we get minus delta HR by CPA even if you see Iris book which is very complicated book yeah Rahul. Iris book which is very complicated he uses till this one, he uses lot of very complicated mathematical part still slope many times you say this for explanation.

Student: (())(15:34)

Professor: yeah don't be linear, right but I think that is another assumption where I think you know range of operation we are always taking that the temperature is not affecting both of them. delta HR and CPA and you know these are the lousi temperature function you know. CPA is function of temperature as T square, T cube and all that you never get any straight line there okay.

But I think you know in most of the time as engineers that assumption will make many our life very very easy and understanding is very easy so that is the reason you go for that very good so this is one and yeah so now the design of adiabatic reactor is so I know I have this equation T okay this equation T equal to T equal to T0 plus beta XA. That is equation forgotten to write the number there so may be this number will write 16 so what is the procedure now for adiabatic reactor.

Adiabatic let us say plug flow reactor you know for mixed flow reactor it is very easy you also get the same equation that we will talk about little bit later but for plug flow what we are discussing now is under plug flow I think I have to underline this right. So plug flow equation what is that I have?

V by FA nought equal to. yeah repeat. 0 to XA dXA by minus RA which is also equal to if I have first order reaction XA dXA into K nought E power minus E power RT CA nought, 1 minus XA right.

Yeah so again this constant things I may take out that is K nought CA nought. So then it is 0 XA, d XA so here I have minus E by RT into 1 minus XA, so this is not integrable because I think I have T as variable and also XA as a variable so now I have to substitute for that T, CA nought is here, I have taken it out.

Student: Sir second one.

Professor: Here

Student: CA nought

Professor: No, no it is CA nought, okay nought is nought CA okay that is CA nought only, this is CA nought okay so yeah, now this has to be written in terms of that equation, T this equation then you have to integrate, V by FA nought equal to 1 by K nought CA nought 0 to XA dXA, E power minus E by R T0 plus beta XA this is one tab into 1 minus XA. That is at the top okay good.

So there is one solution that is available for this okay you can also actually integrate that. Right, I will give you very simple equation no, then you can appreciate the mathematics much better than what we have being discussing so 16 okay this is 17, so when I integrate what I get is like this V by FA nought is not that easily integrable because I have here exponential term and also you have X term here.

Okay this is E power, E power AX into X thing you know number of times it reoccurring, recurring formula something they say okay, so this is K nought CA nought Ei, heard of what is this Ei symbol E by RT minus E of I, E by RT nought okay, yeah here E by minus alpha again K nought CA nought, Ei Z minus Ei Z nought okay now we have to define an a that is the equation and where A is called what exponential?

Student: (())(20:55)

Professor: Ea is exponential E power minus is also exponential what is been an exponential, who said exponential from here? No no, your afraid, yeah what is that exponential there is something else, exponential something, yeah Rahul.

Student: (())(21:19)

Professor: Not heard till now it is called exponential integral there is definition of EI. Okay yeah I think first we have to draw that exponential integral. E of So this is in fact you see this derivation you get not the way I told you, you know this, this X also you have to convert into actually you can leave this in terms of T I have written in terms of this but if I convert this okay this X in terms of T.

That means 1 by beta and all that will come there right so that is what so this anyway equation yeah 18. Okay you can write there equation 18 is obtained because I can not write this and then give this one because you may try this some of you who are interested in mathematic. Okay equation 18 is obtained when equation 17 is written in terms of temperature that means not only this here, here I have temperature E power minus this term and okay why don't you write that.

Can you write that? Or you will understand, yeah so X is converted so this one is as same term as it is then this 1 minus XA is nothing but yeah beta T minus T nought by beta of course 1 minus 1 minus you have to write and then substitute there not only that you have to differentiate this for dXA. Okay you have to differentiate that dXA and then write convert it into dT so that means everything should be in terms of only okay so thats why I thought we will better write correct no? I know your memory is not that great okay now tell me Pooja what is equation? 1 by K nought CA nought.

Student: sir (())(23:23)

Professor: Yeah in fact, in fact not only that you have to even convert limits. Limits also you have to convert yeah.

Student: error function

Professor: Error function it is exponential integral not error function, exponential that time I will give later definition but first letters see, from which equation you got this first. Okay let us see that one first, good yeah so then here I have 0 to yeah so now XA how do I write this one in terms of this?

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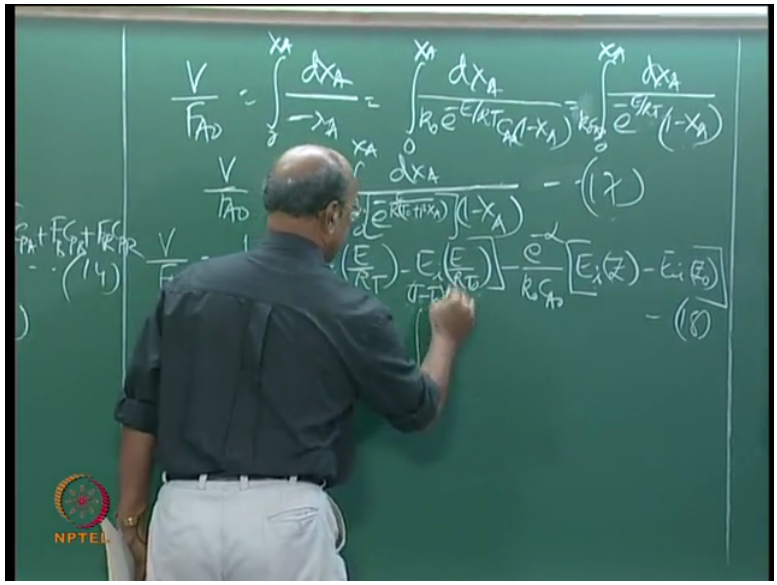

Yeah this is T minus T nought by beta, that is the upper limit first of all okay, good so the next one is yeah dT, differentiate and tell me.

Student: (())(24:19)

Professor: Tell me date delta X dX equal to what?

Student: dt by beta

Professor: 1 by

Student: dT by beta

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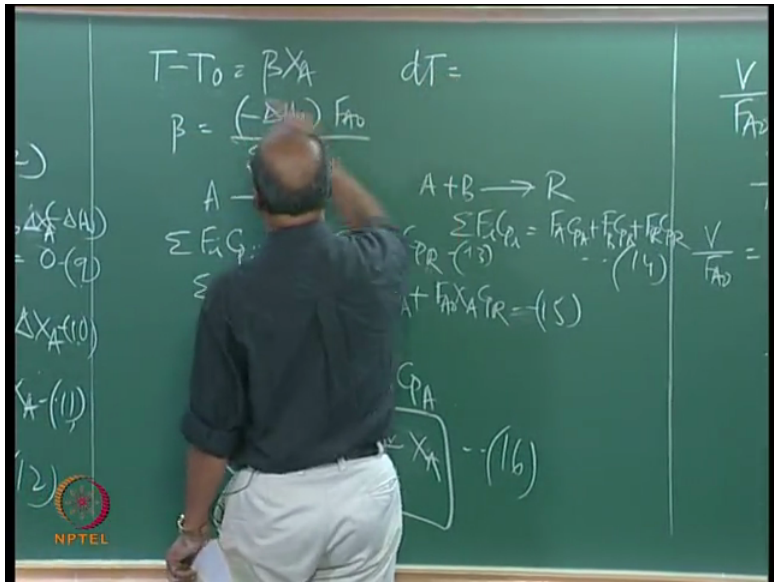

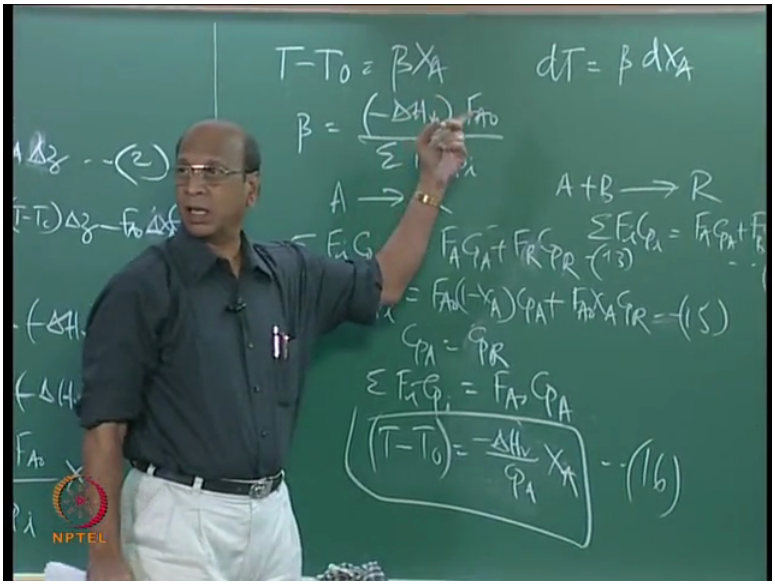

Professor: dT this goes to 0, thats all, what is that all stories you are telling. Thats what he said?

Student: (())(24:46)

Professor: Okay so only beta will come there thats all right? Yeah so that beta we can take out constant that is in the numerator or denominator?

Student: denominator.

Professor: yeah you put in numerator.

Student: (())(25:08)

Professor: Here is T nought. I am talking about differentiation of these.

Student: (())(25:23)

Professor: lower limit okay, okay, okay lower limit please tell me what is the lower limit?

Student: (())(25:28)

Professor: lower limit X equal to 0 simply it is, yeah T nought okay good so now, the other form so now I have dT here.

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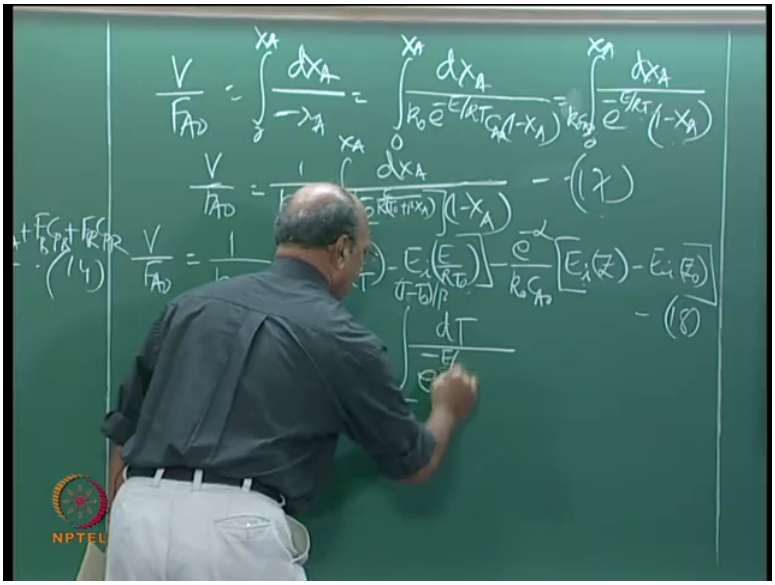

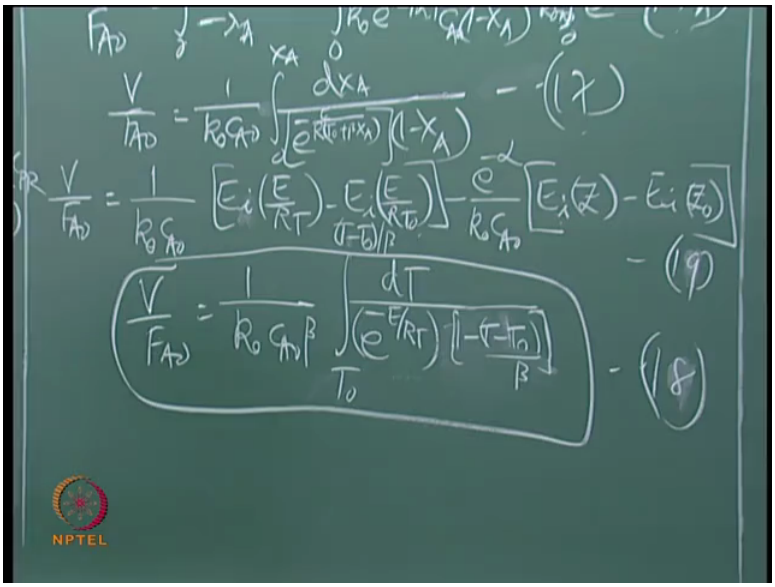

E power minus E by RT yeah, next tell me for XA. T minus T nought “Acha” 1 minus, 1 minus T minus okay in the bracket I will put divided by.

Student: Sir, T minus T nought by beta

Professor: I think you know this is coming here right XA so 1 minus of this now only that much, only this much beta thats all. Thats all? Yeah so this is what you have to integrate. Yeah now you can write equation 18 this is solution before the actual equation. Yeah equation otherwise we will change I think you know this one as 18, yeah instead of writing all that is the simplest one so this is the one.

Now we have to also tell about the functions right? So we don't know what is Z right? And also we don't know what is Ei so those we don't know what is alpha those things we have to write here.

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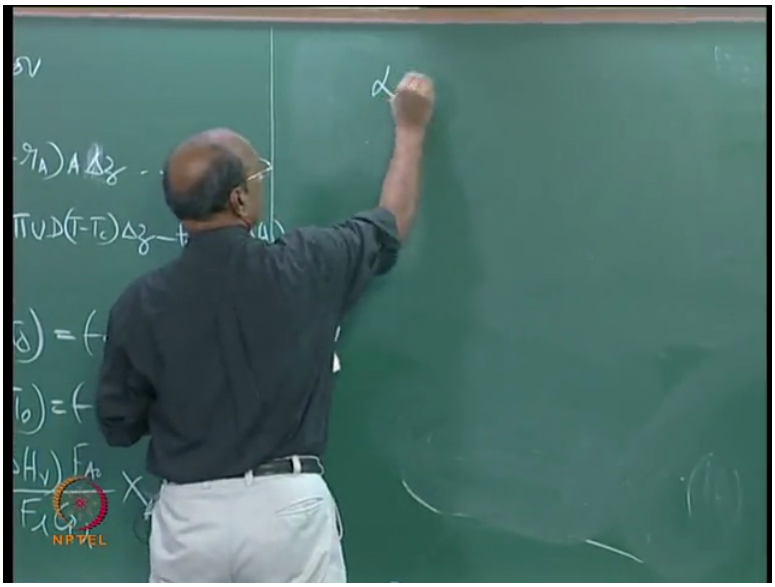

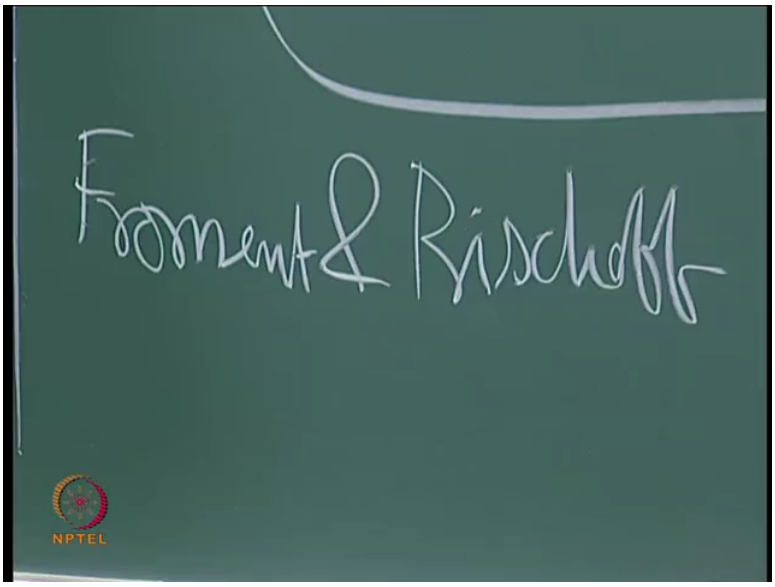

Okay yeah first alpha from this equation I am writing okay, from equation 19 alpha is define as lambda E, R into 1 minus XA nought that can be 0, plus lambda T0. And lambda is and lambda is written as M dot CP that means of course here you know it is converted, I have taken this one from Froment and Bischoff have you heard of that book, Froment and Bischoff, yeah what is the title of the book? No one has seen?

Student: upper limit

Professor: limits? I am talking about book come to limits later. Yeah

Student: (())(28:50)

Professor: What Rajshri? You are worried about the upper limit, so what is that you are talking about. Is this okay or.

Student: (())(29:05)

Professor: It is 1 minus T minus T nought by Beta, not correct?

Student: Sir upper limit is wrong.

Professor: Upper limit, what is upper limit?

Student: Which is the T nought by beta XA.

Professor: In place of X your simply putting that.

Student: No, T equal to something, XA equal to something,

Professor: XA is converted into T, right only, yeah see I can not have another X here I said then there I will get the solution in terms of X.

Student: Then in lower limit will be XA is good.

Professor: Okay, I think okay let me write this.

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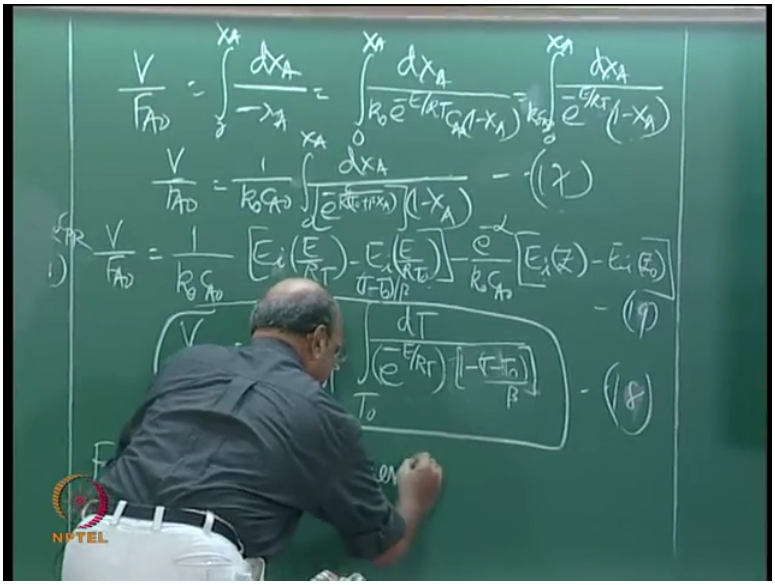

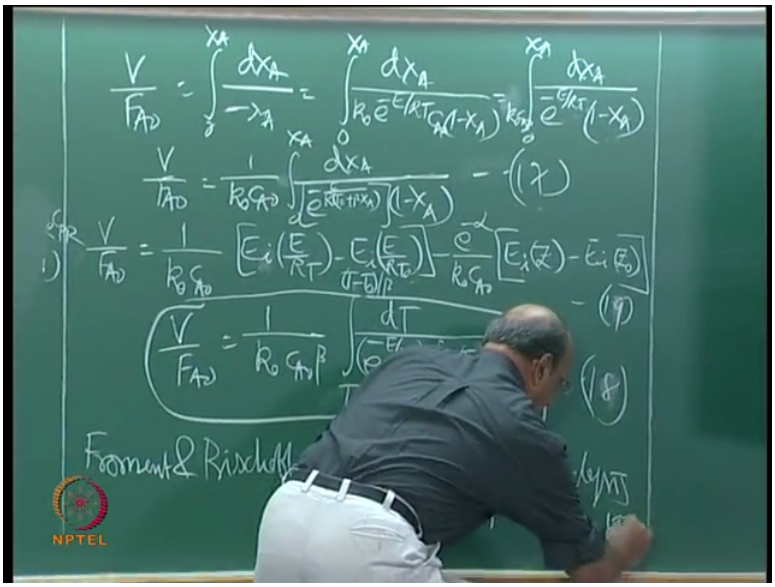

Chemical reactor analysis and design yeah, chemical reactor analysis and design and I think this is wiley, oiley yeah tell me now what is the problem?

Student: mathematical problem?

Professor: Mathematical problem, see that is what you know why we simplify things is only for that, unless okay, that is the limit I am not saying limits are yeah we is it correct or not I have not checked this.

Student: Correct sir.

Professor: Yeah correct you check it and afterward we will see okay, good yeah so this is I think okay okay I think thats why you can check that and let us see now I have given the

book and then you check there whether (())(31:01) has done it okay yeah I have not looked into the details I just wanted to tell you how complicated this will be if you want to, I mean integrate this and that is possible only for first order reaction. Other orders you can not do that. Okay so that is the reason why I just brought it here to let you know what kind of complications you may have.

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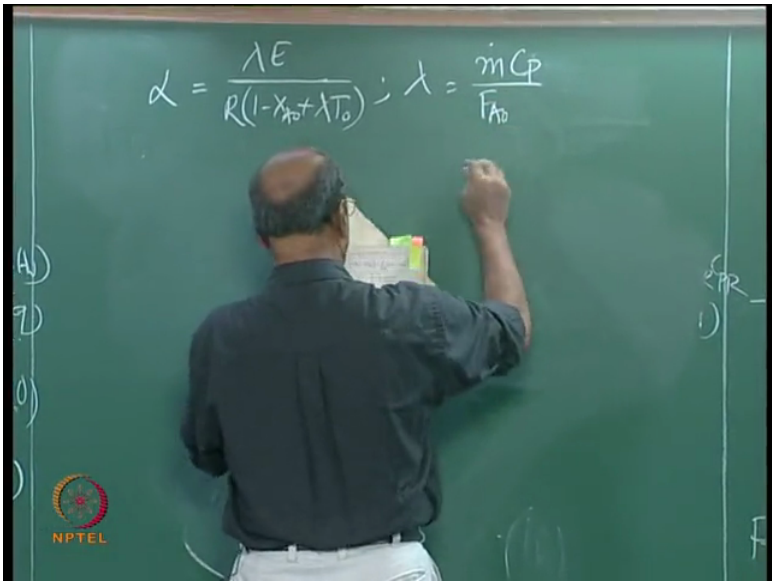

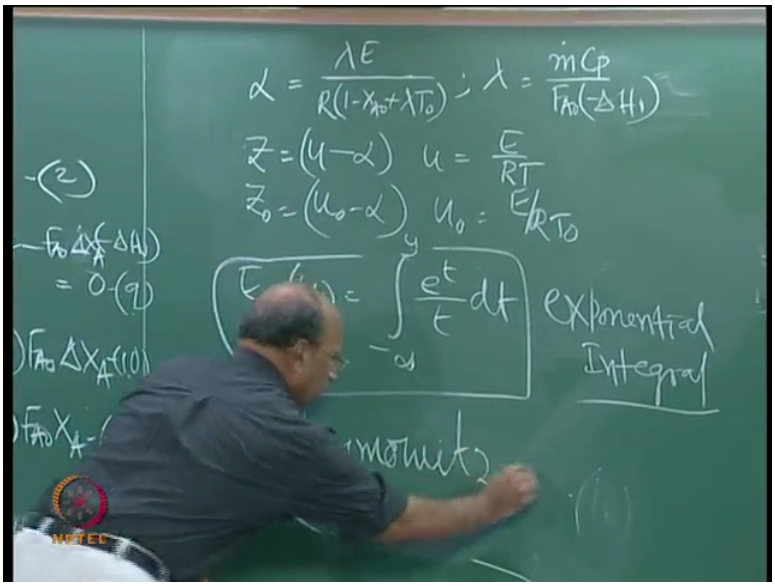

M dot CP FA nought minus delta HR okay where M dot is the mass flow rate, then we will have Z, as U yeah U minus alpha where U equal to E by RT and Z zero is again U nought minus alpha, where U nought equal to E by RT nought okay, so 11 this is okay this numbers not required then I think thats all, all other things we know yeah where exponential integral of Y is define as minus infinity Y E power T by T into dT.

This is called exponential integral. Thats called that is the definition of exponential integral, right and the values of this that means you have to convert the integrals as minus infinity to some value Y okay. Some value Y and now you have to go to the mathematical tables, if E of Y let us say Y equal to 10 or Y equal to 1 or Y equal to 5, or Y equal to point 1 right those values are listed in mathematical handbook of yeah it is mathematical handbook you you have come across any one mathematical handbook? Mathematical handbook?

Student: (())(33:26)

Professor: Crischek is not mathematical handbook you know, it is only mathematics book. Handbook where all the numbers are listed I think someone was telling exponential integral someone was telling another integral.

Student: Error Function

Professor: Error Function, even error functions are also given in that table okay big tables are there in that, one book was Abramowitz I don't know whether you have heard it or not. Abramowitz, A B R A M O W I T Z, Abramowitz, not heard no? At least you heard? No, yeah

Student: (())(34:14)

Professor: Peri I think is not given I think error function they would have given but exponential integral I don't know whether they have given or not. Okay so you see chemical reaction engineering beyond certain point is highly complicated mathematics. Only for that reason I want to tell you this. I will not derive this I don't know I have not converted limits.

But to make you comfortable I said that you have to have that equation converted into temperature and then we are just discussing the solution that is why we need both we need this mathematical techniques beyond certain points but before that we need physics, only exactly for that reason I wanted to discuss this problem in the class, right only for that reason, otherwise I think you know I should have gone to some other you know mixed flow reactor already.

Right so now you know your idea is here that how complicated it is the reaction engineering beyond certain points. Right okay Rahul that is the reason why we always assume things, okay some of the assumption may not be real, but still its okay. Logical assumption only we will take and then try to derive the equation because once we understand the basics then

going to mathematic is only mathematical you know, you know algebraic conversions from one to other.

And then try to find out the solution that is the reason why it transport phenomenon is very complicated for most of us because we always try to have the solution first rather than the formulation of the problem, right that means the physics of that problem we don't spend much time simply we take the derivation and that to we will take that (())(35:56) equation.

And there also you assume that this term is not valid and this term can be removed and all that then you start solving the equation, that that means it becomes simple mathematics exercise and you don't know what we are solving, physics wise, thats why beyond certain point chemical reaction chemical engineer itself is very complicated.

Okay but you have to appreciate beauty in chemical engineering even without mathematics also how people beautifully designing the plats. Okay but not all plants but if you need very very very very purist form of product then you need this mathematics and then only you can design the plants with one example which I already told you SMB they call you know Simulated Moving bed reactor.

You just go to the website and then just see you know in google search for simulated moving bed reactors okay how complicated they are used for absorption particularly getting absorption you know the enzymes from biochemical broth after reaction you have that broth. So there you have mini enzymes and if there are 3-4 enzymes you have to use 3-4 different absorbents to separate them the enzymes are so, temperature sensitive.

So if you want to again you know use temperature for separation like distillation, distillation you are using energy for separation, temperature for separation, right so that is the reason why enzymes cannot be used because they are very sensitive temperature. So only some physical methods you have to use like you know physical absorption like you know the enzymes going and sticking to the surface of the absorbents and later again you wash it that particular absorbent you take out and wash it and then purify later.

See that is why chemical industry beyond certain points it is highly mathematical. Okay so most of you may not be knowing that I think ((()))(38:01) is another extreme without any mathematics we are able to solve distillation problems. It is very simple beautiful problem you know because you don't have that is the mass transfer equipment design what you are making but you never talk about mass transfer coefficient through.

What is information required there, entire mechabethile method for absorption, drying and also for leaching and you know all, all operation distillation, extraction all these operation what do you need there you don't need any mathematics, you need material balance where you normally used this material balance everyday in your life only because what is entering what is leaving, what is converted that kind of balance. And what is the other one you need?

Student: Energy Balance

Professor: Energy balance also you don't use it where did you use energy balance to find out, that is slightly sophisticated thats why I said one end completely one end okay so in this end you need only equilibrium data and you need this material balance as straight lines so you have to really thank you know this original chemical engineers where they made the entire plant look like very simple design but if you go to for example multi component distillation now you can feel again the problem with mathematics.

So thats why I thought in this class I will let you know what are the difficulties in mathematics thats why unless you are good in mathematics you also can not enjoy beyond certain point chemical engineering. I told every times no thats why sometimes yeah.

Student: (())(39:41)

Professor: No no no let me, I am not discussing that whether it is right or wrong, okay you find out that whether it is right or wrong and you tell me later okay, I will also , no no no don't discuss okay you tell me later I will also check with myself okay, I will also check myself whether because I have not checked that I simply took this problem as it is from the book.

And then I wanted to discuss importance of the mathematics in chemical engineering because you may be feeling that whenever I am saying matrix, vectors and tensors you are laughing I don't know why okay but I think it is not simple laughable matter thats what I want to tell you from the beginning of the class whenever I say matrix and you know the vectors.

And tensors you are laughing so then I know I don't know the reason I don't want to know also the reason right but I tell you that it is not that kind of simple laughable matter because you need that kind of things also when you are really solving complicated chemical engineering problems. That is the reason so that equation whether right or wrong, we will I

know I will also try to do you do and tell me later. Okay yeah Dnyaneshwar okay, you say that upper limit is wrong which is wrong you tell me.

Student: (())(40:58)

Professor: Everything is wrong, okay that we will see, okay then what is the correct upper limit?

Student: (())(41:05)

Professor: Simply T

Student: No

Professor: Yeah anyway I think leave it. I think you also prove that in a next class that why it is T and why it is not you know the other one. You can also check that I mean because we are not fighting here and I have not applied my mind so I am sorry for that, thats all. I should have cleared that which is right which is wrong. I have not applied my mind very clearly because my aim of this class was totally different.

And in fact I don't have this equation at all in my notebook so after seeing some faces blank then I thought that we will try to write this equation in terms of T. Right thats where I went to the problem by problem because I will not thought I mean not simply I thought of giving this final equation and then try to say that exponential integral you see this minus and Y and you don't have real analytical expression in here for to use this you know this yeah here if E by RT is let us say 20.

I cannot straight away get that value I have to go to the mathematical table and then get that value and substitute here. Okay and this one I also got I thought I will also give you apart from giving the complicated problems in chemical engineering I think Raj, shriram Krishna was asking me sir I think you tried to analytically do something in batch reactor yeah.

Student: (())(42:33)

Professor: Yeah.

Student: Then I graph it 5 minutes I got that.

Professor: Yeah that is what my next one is how easy to draw a graph that is what you know the closing of this class I thought only that is my you know the closing of the class that is

instead of doing all this complications we are going to simply plot this one as this entire thing. So not that entire thing the X is not there yeah.

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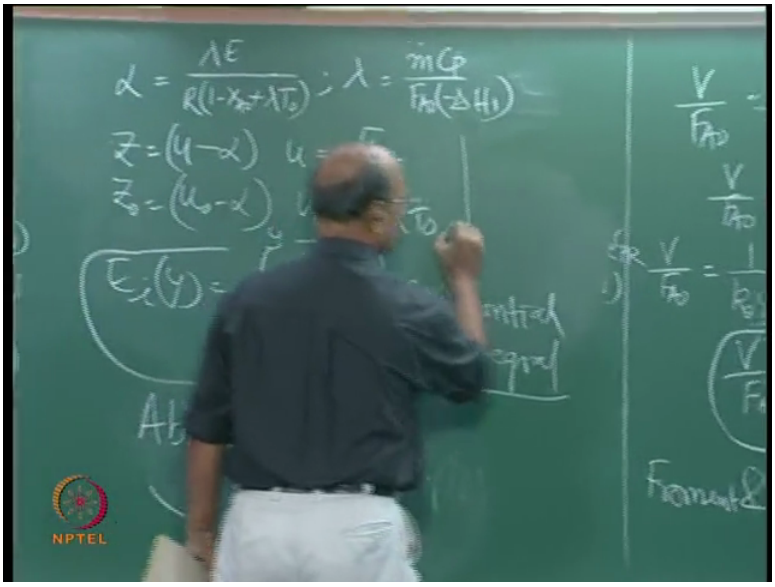

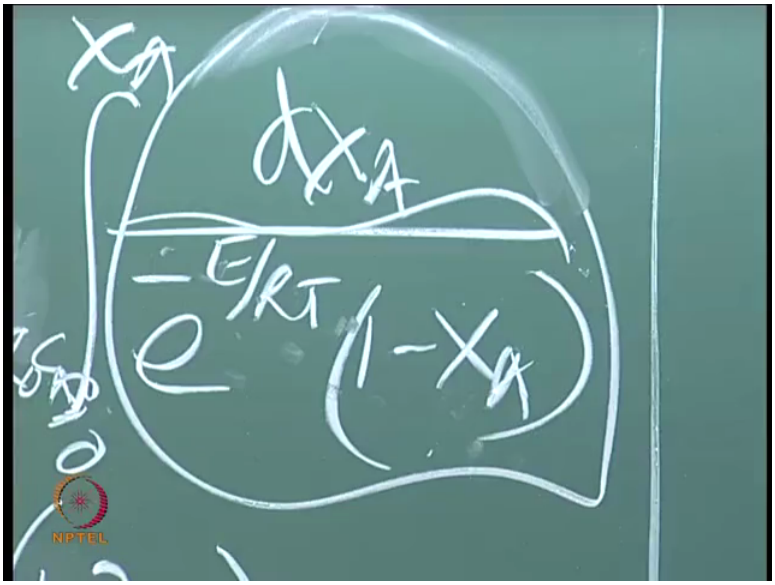

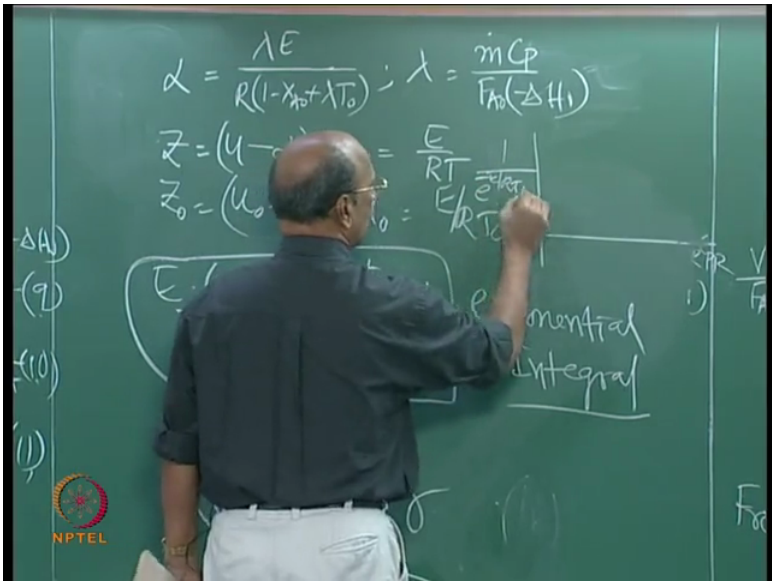

So this is 1 by E power minus E by RT minus into 1minus XA versus simply XA. You will get like this totally area will be V by FA nought into all this you know K nought yeah K nought CA nought. So all this that is what I wanted to tell you, you know I always get excited with the graph, so I wanted to tell you that how beautiful this is and how ugly this is correct?

I mean for me because beauty always depends on the persons eye right for you it may be looking so beautiful. Thats why in our on the planet I think you know there may be awkward people but to some eyes that is why you cannot define beauty. Because if you want to define beauty you have to now go to where? Eye whose eye you are talking right? Yeah so for me some person may be looking so beautiful same person will be awkward for someone else correct?

No? Possible okay yeah that is the reason why I say that this is much much simpler because I want to be a good engineer and trying to solve the problems as simple as possible and this is very very complicated and where it is not that easy to get the solution right? But there may be a some people who are always complicated and then they may like this.

They may really like this and they may awkwardly say that what kind of idiotic diagram that is I don't like it thats what they may say so that is why we have all the people in the society I think you know someone may like if you go to iris you will simply throw this out you may like this one okay so that is why I think as far as I know there is only one book which has given this that is this book.

I don't know any any other book may be of course recently there are so many books have come and at least there are 25-30 chemical reaction engineering books. I don't know how

many of you know how many books are there. Or if I ask you each one how many books you can simply tell as a quiz for example, may be I think I have to give you surprise test one okay one test as write all the titles of the books okay as many as you know and whoever gets maximum they will get 10. Okay

Student: What is the name of chemical engineering books?

Professor: Chemical reaction. Only chemical reaction engineering books. Okay I think its very nice okay Rahul next time okay some time so that is the one you know yeah I think we will close here I have to also go right? I think yeah I am sorry for this equation I did not applied my mind I just simply try to derive on this one here but I think may be I don't know whether this is right or wrong. Is it? What do you say its simply T.

Student: T0 plus beta X. T0 plus Beta X.

Professor: Both yeah anyway she is again telling then I (())(46:24) I should allow you.

Student: (())(46:30) final equation in terms or T, so we have to add someone the limits should be T right. So (())(46:39) when conventional is correspondingly temperature is T.

Student: T0 plus

Professor: Lower limit?

Student: Lower limit means when X is(())(46:47)

Professor: T nought it must be T nought there, okay anyway I will check, I will check and those who have told this you also check.