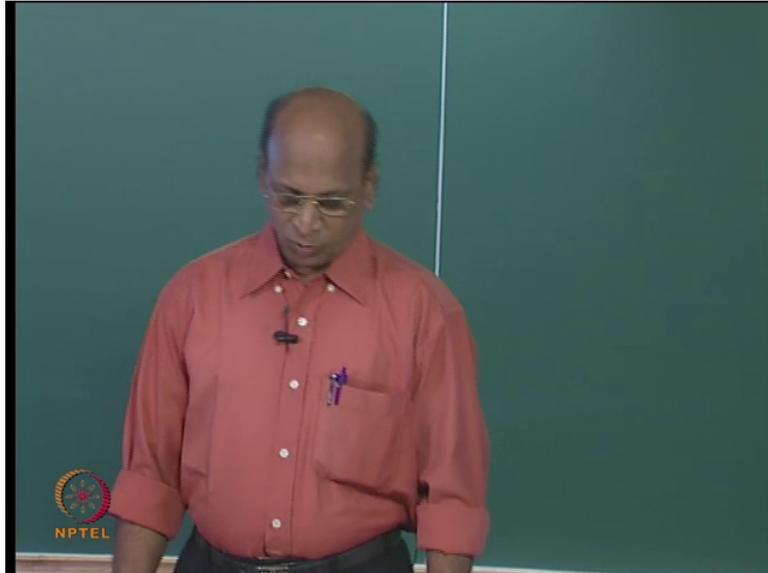


Chemical Reaction Engineering 1 (Homogeneous Reactors)
Professor R. Krishnaiah
Department of Chemical Engineering
Indian Institute of Technology Madras
Lecture No 02
Motivation and Introduction Part 2

(Refer Slide Time: 00:10)

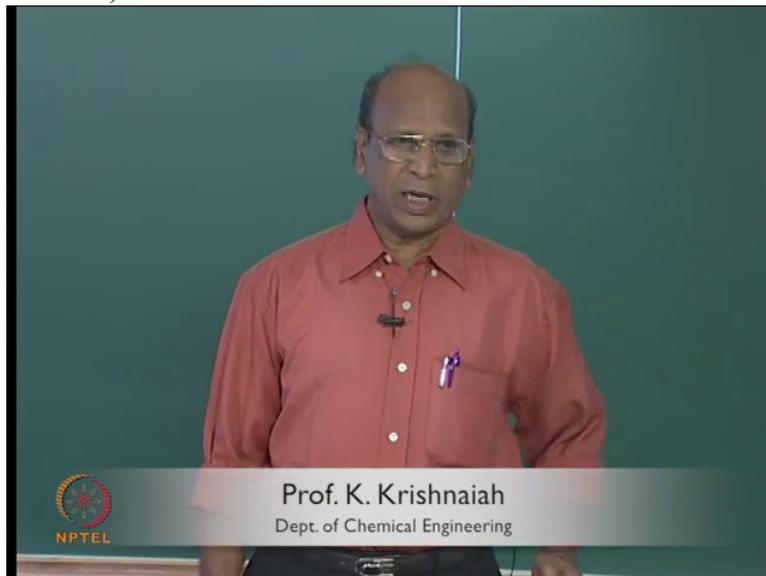


We will start now. In the last two classes we have learnt two things. What is the first thing we learnt? The first thing we learnt was that we do not have much knowledge in chemical reaction engineering. And chemical reaction engineering is the basis for entire chemical engineering, Ok.

And then second thing, at least I asked you to learn is the attitude for learning or the pleasure in learning. So it is very easy to waste time in any way, in I I T Madras also it is no ways different, you have many, many different things here to waste your time.

So, but without going to that mode of wasting time,

(Refer Slide Time: 00:48)



you try to read the books or try to read some papers or you know, whatever interested problems for you or interested course Ok, spend more time with books rather than with , you know other things.

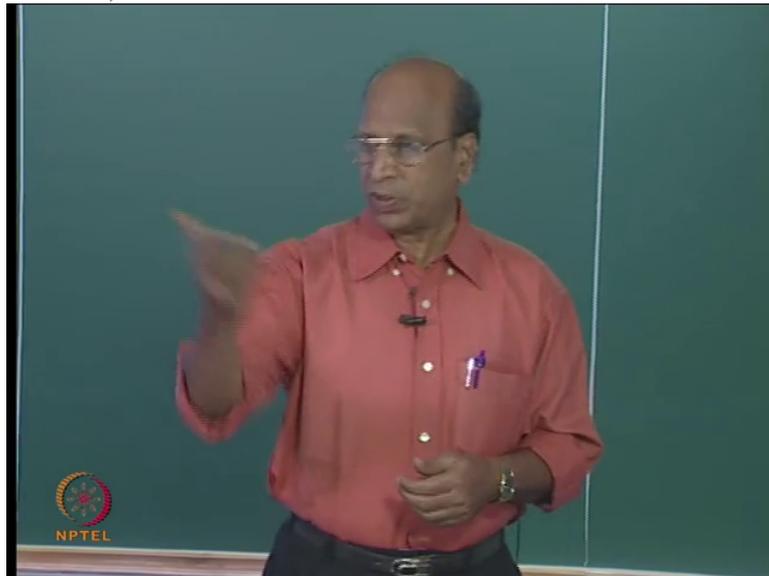
Computer also you should not spend so much time unless it is really required. Computer is one thing which distracts the lot. So these are the things we learnt. That means you know I try to change your mind a little bit for active learning, right

(Refer Slide Time: 01:18)



and 2 years particularly for M Tech is a very short time. And 3 years for M S and M S people also can

(Refer Slide Time: 01:23)



submit within 2 years also.

Theoretically speaking, one and half years you can submit the thesis, M S paper, right? So that is very short time to learn. But it does not mean that you stay here 10 years or 12 years, Ok. That is also too long time to learn also, because I think you know you will get bored and then slowly lethargy, everything will come.

So that is why there is optimum time, you know for you, 2 years for M Tech and 3 to 4 years for P h d. Then that time should be very optimally used. So at the end of that 4 years you should see yourself a different person. If you look at yourself particularly in the, in mirror, Ok. That is why everyday you see mirror and try to change the, try to look at that change. When do you have that change?

You will suddenly have, all of these kind of things will come, most of the time, suddenly, Ok. You discover at least suddenly. The progress may, the change may be very, very slow but suddenly one day you discover that, yes now I changed.

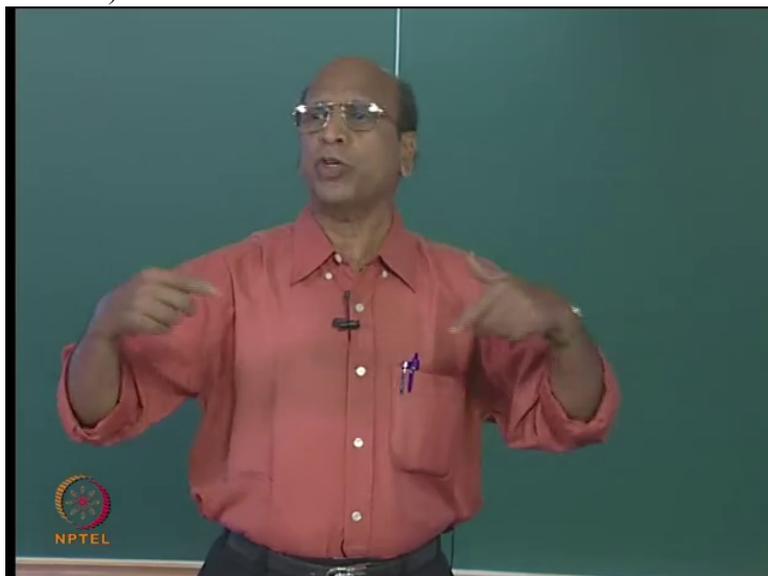
That means change remains not physically. Your nose will not change or you will not have 3 eyes, Ok. And then 4 legs or

(Refer Slide Time: 02:27)



10 legs you do not have. But only problem is that your attitude

(Refer Slide Time: 02:31)



in learning and suddenly that beauty of learning something, that happiness you will see.

That happiness will come when you learn some concept on your own or after discussing with some people. Everything you do not have to learn on your own. So that is the happiness you have to search for during your time here. Then I will tell you one concept thoroughly learning Ok, either with discussion or on your own then you yourself feel that happiness.

And none, you cannot share that happiness with others. Even if you and tell your friends, Oh my God, I am very happy now, because I learnt this, a small concept which I never knew

earlier, I had lot of difficulty in learning that concept but now suddenly I see the clarity in that concept, they may think a mad fellow year, I think you know you would be talking like that.

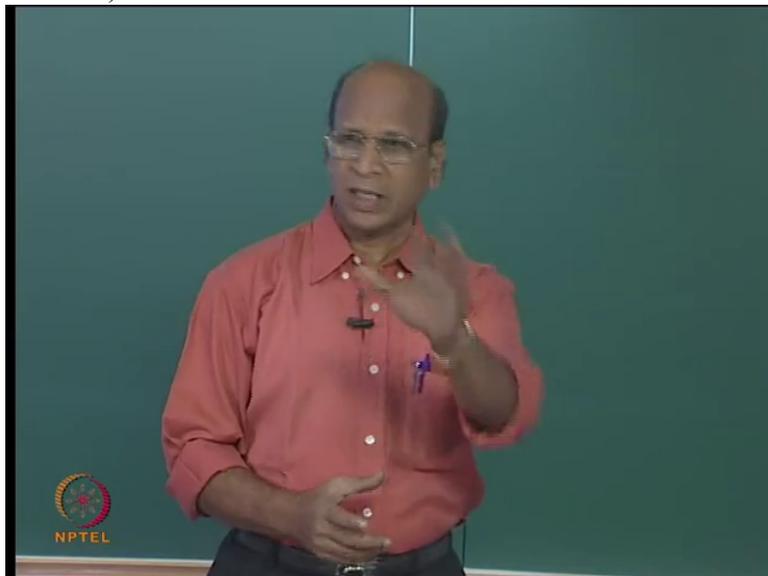
(Refer Slide Time: 03:18)



That they may say. But your own pleasure is more important.

These are the things which

(Refer Slide Time: 03:23)



we have learnt in the last 2 classes and now we thought we do not have that much knowledge in chemical reaction engineering and chemical reaction engineering is the main topic in chemical engineering. That is the only subject which can differentiate with any other engineering. I will tell you why, you know in course of time.

But right now I think I do not want to explain that now itself. So it is unique course that is why it needs some background of asking even what is chemical engineering.

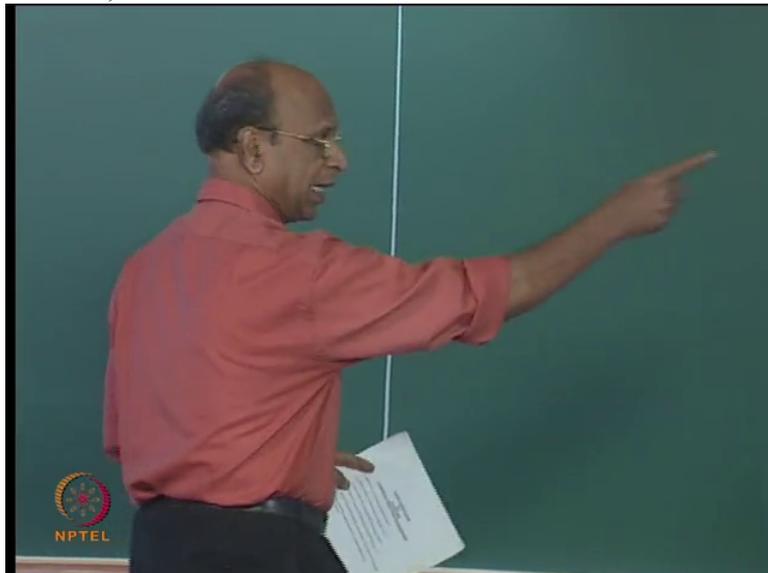
(Refer Slide Time: 03:56)



Ok. So you know that without chemical reaction you cannot produce anything. That is why my first question would be, I will write the questions here.

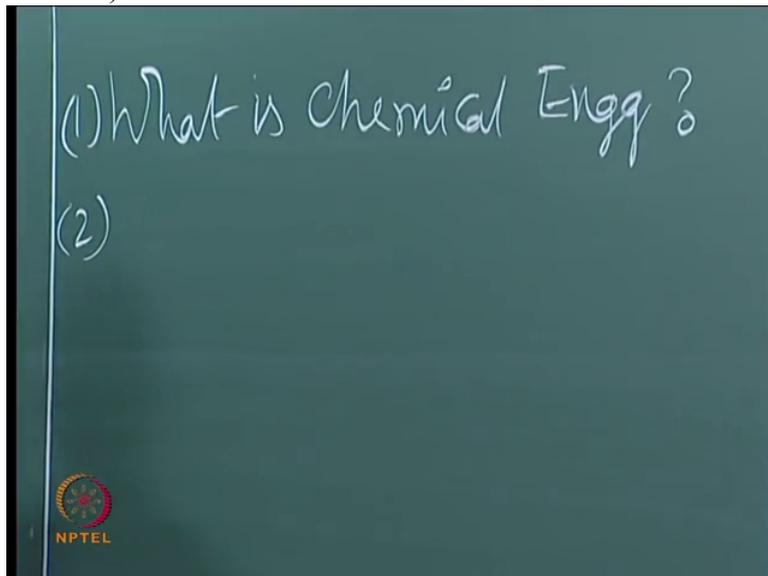
I do not use most of the time,

(Refer Slide Time: 04:03)



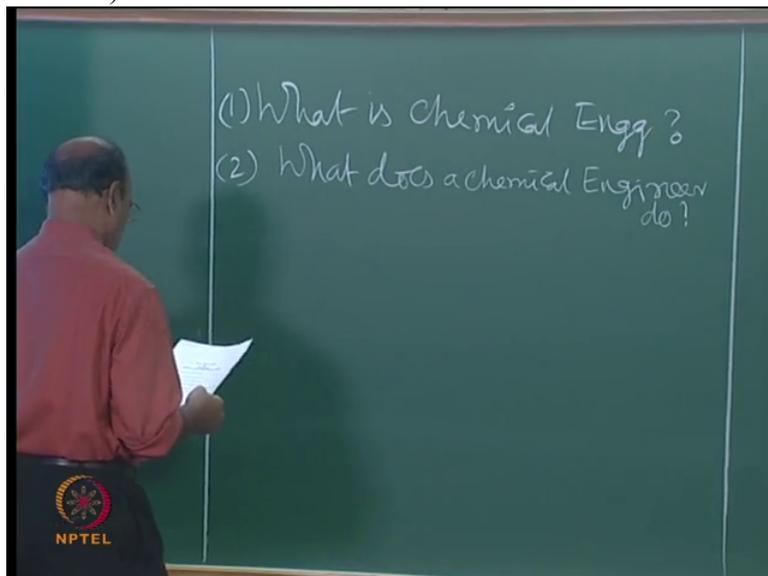
this p p t, I use only this board. So the first question is what is chemical engineering? And second question also we will ask,

(Refer Slide Time: 04:23)



that what does a chemical engineer do? Ok.

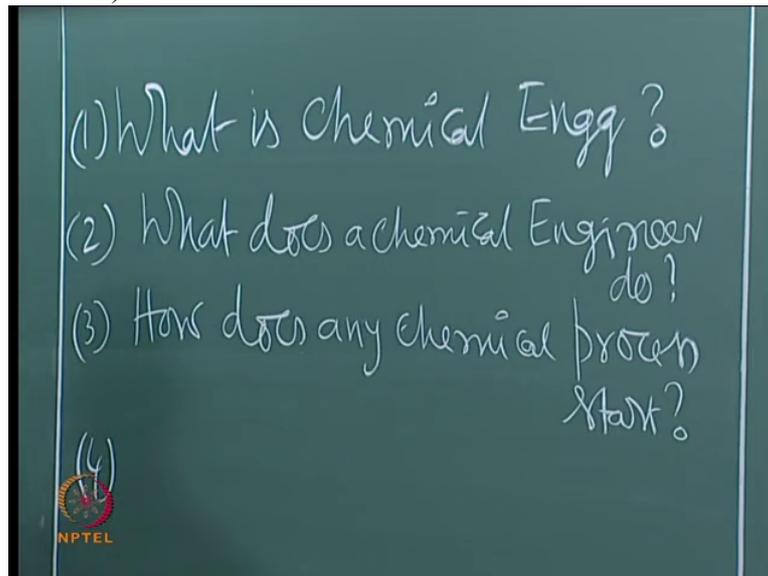
(Refer Slide Time: 04:40)



Yeah the third question is how does any chemical process, any chemical process start, Ok. So actually by looking at the questions you can learn a lot.

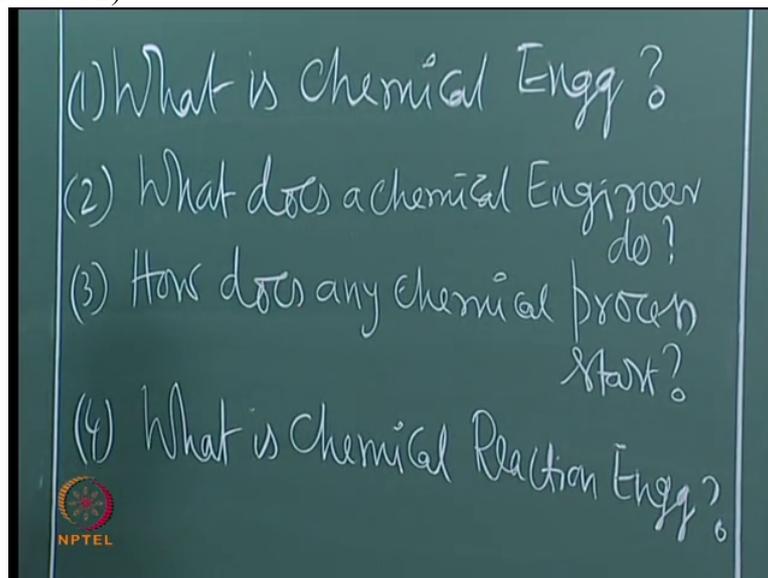
That is why you have to question everything whatever you want to learn, first question. Then if you get the answer to that question correctly then you know what is happening there. So you have sufficient knowledge. Then the fourth question

(Refer Slide Time: 05:17)



will be what is chemical reaction engineering?

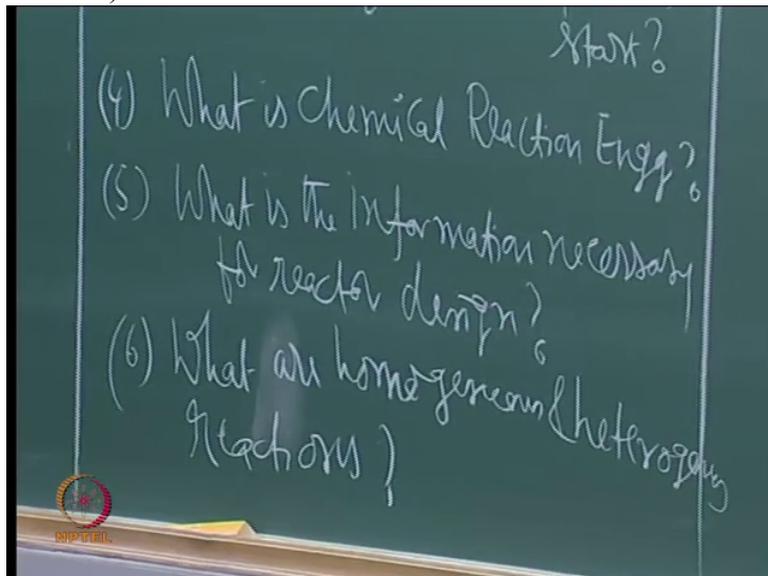
(Refer Slide Time: 05:31)



Yeah and Ok, fifth question is what is the information necessary for reactor design? Ok and last question here is homogenous and heterogeneous reactions, very difficult to write, yeah. These are the questions.

I hope you can see my handwriting.

(Refer Slide Time: 06:31)



Ok, you can understand? Ok good. These are the questions and the first question when I asked what is chemical engineering, can you define now what is chemical engineering? Can you say what is chemical engineering?

(Refer Slide Time: 06:45)

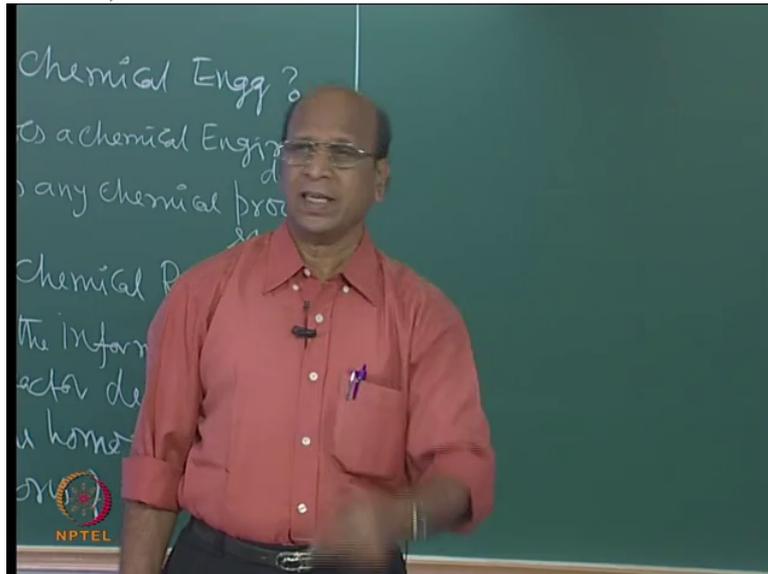


(Professor – student conversation starts)

Student: 0:06:45.5 to a given product.

Professor: Yeah, good, yeah any another definition? You understood no, what he says? Repeat

(Refer Slide Time: 06:50)



Student: It is the science that involves the processes involved in changing raw material to a given product.

Professor: Yeah, it is the science, he says. But what...the question I am asking is engineering. What is chemical engineering? So he says it is science. It is not wrong. It is correct only. But any other definitions you know?

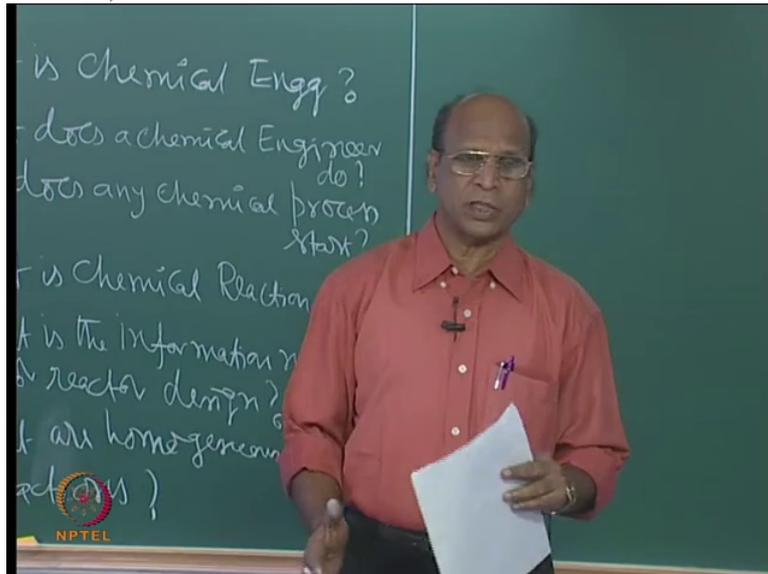
Student: Unit operations. It is unit operations

(Refer Slide Time: 07:13)



Professor: Yes, so. Because it is unit operations

(Refer Slide Time: 07:17)



can you call it is chemical engineering?

(Professor – student conversation ends)

Because you know, he is right. Every time different people will tell different definitions for chemical engineering. But when you want to explain what is chemical engineering it needs some time for you that means you have to understand what is happening in chemical engineering then only you can tell. Any other definitions?

He says unit operations, deals with unit operations. So there are no unit processes, there is no process control, nothing. Only unit operations is chemical engineering. You see how many things we are missing now by saying that, right?

But again you are not wrong. You are right because everyone is right when they are giving the definition because that is what; at this point of time they understand that is chemical engineering. Yeah, any other definition?

(Professor – student conversation starts)

Student: It is how to design a reactor.

Professor: Sorry?

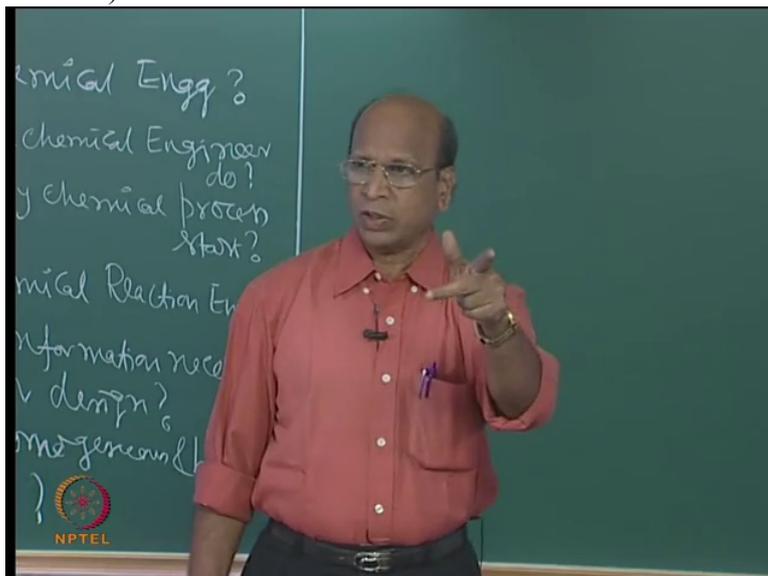
Student: It is how to design a reactor.

(Refer Slide Time: 08:07)



Professor: Yeah, so

(Refer Slide Time: 08:09)



you see now there is again...that means he does not bother about unit operations. He only designs the reactor and that is chemical engi/engineering; that is chemical engineering, right. Like that we do not have a particular definition for chemical engineering. All of you are right. (Professor – student conversation ends)

So at this point of time, really you should know, you should be able to explain, my thumb rule is that always you should be able to explain your brother or sister which is, who is younger to you then if they are able to understand you are able to understand what is chemical engineering. That is what your thumb rule.

They should not run away the moment you open your mouth, right. So if you are able to convince them this is what is chemical engineering, that is what, I mean, which means you have to explain in a very, very simple words. Like even Gani, what he said, is he won't understand. Can you repeat again? It is a science deals with, dealing with?

(Professor – student conversation starts)

Student: Converting a given raw materials to product.

Professor: Yeah, you try to tell that one to your brother? Because he does not know first of all know what is science. Do you know what is science, what is the definition of science? OK, so this is official definition, where official definitions most of the time we do not understand clearly. These are only a bunch of words. But for that you need lot of information in your mind, information should flow in your blood then only you will try to explain that.

(Professor – student conversation ends)

Like for example if I ask you to explain, Ok that is the definition, so what is chemical engineering in simple words? The simplest thing which I find is that chemical engineers produce chemicals on very large scale. Ok, this very large scale is very important. Why?

Chemist is also producing chemicals, right. So the moment now you know that you are trying to produce on large scale, I can give you a very simple example. Chemists, we also have some chemists here, Ok, you have also done physical chemistry experiments or organic synthesis experiments, Ok. All of us have done in our B Tech days. So what do we do?

If you want to produce a new chemical, how much you take? In the laboratory?

(Professor – student conversation starts)

Student: Milligram.

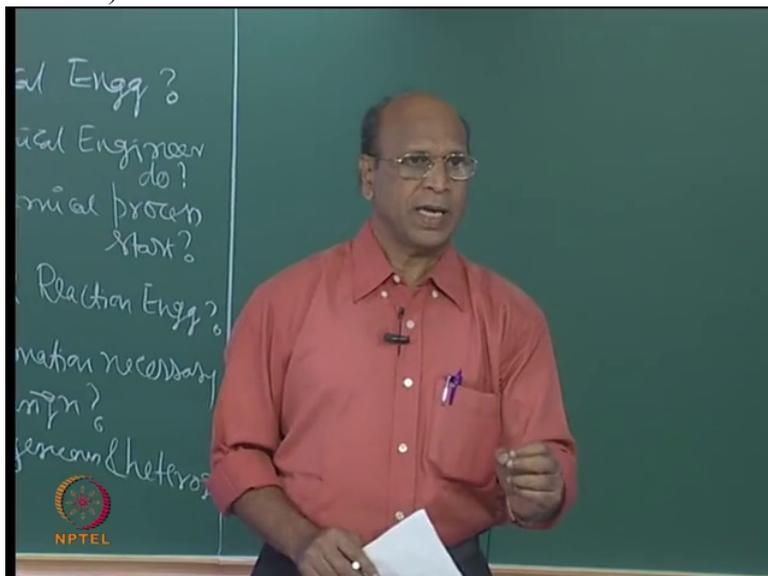
Professor: Milligrams.

(Refer Slide Time: 10:20)



May be 100 milligrams of A,

(Refer Slide Time: 10:22)



one component, and another 100 milligrams of other component, right?

(Professor – student conversation ends)

So then what do you do? You put that in the test tube, right and then after putting this 100 grams, 100 grams then temperature is required for this reaction to take place. You go to Bunsen burner. And then you put there, shake it. Put there, shake it. Why do you shake it? If you just put there it won't react? You have, why should I mix?

(Professor – student conversation starts)

Student: Energy 0:10:53.1

Professor: Yeah. So all these things, without your knowing yourself, you do all that, Ok. So at the end how much product they get? Something may evaporate also.

(Professor – student conversation ends)

So then he may get, they won't get 200 milligrams, they may get only 150 milligrams or 160 milligrams, Ok. And then you try to remove that product from there and then try to find out whether you have really that product or not by some other chemical test.

Now just imagine you want to produce one ton of sulphuric acid. Can you put that in a test tube? Go and shake it? Ok, so that is where the engineering principles will come, right? In, for example when you are trying to produce some chemical large scale, may be 1 ton scale, 500 grams, 500 k gs, 500 k gs then you charge this in a batch reactor that is imagine simply batch reactor first, right and then it is 1 ton capacity, you do not know how to shake it. So that is why you have to put a stirrer. That is an engineering problem, right.

So you have to learn principles of engineering where this mixing principles, right, so this is what, what you study in which subject? You have mechanical operations or sometimes fluid mechanics, fluid mechanics also they have mixing chapters. Ok, so then that information, that engineering knowledge will give you how to design a stirrer.

And there are various kinds of stirrers. It is not one kind of stirrer. There are so many kinds of stirrers. So now you have to see with your experience, with your knowledge in that subject and you know what kind of stirrer is the best for this fluid, so that means what is it you are trying to do again?

You are trying to find out what are the physical characteristics of fluid what you are dealing, whether it is highly viscous, or it is only Newtonian fluid or non-Newtonian fluid means again you will have different, you know it is not easy to mix or whether you have solids. You see one reactant may be in solid form, another reactant may be in liquid form. So then how do you stir these, right?

Or it may be one liquid is in gaseous form and another liquid is in liquid form. So now this liquid will be bubbling, yeah the gas will be bubbling through liquid. Like we have seen no, soda or Pepsi or Cola whatever you see, that kind of bubbles. Now you have to stir them. Ok, stirring means again when you have these kind of two different phases, like gas and liquid, how do you ensure that we have good mixing?

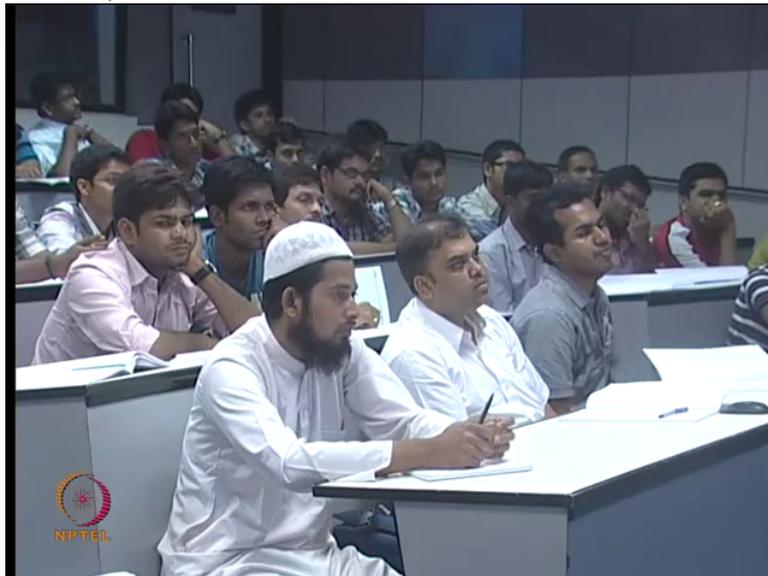
That is what we do in chemical engineering. And these principles, this engineering knowledge is not required for chemist. Their job is... we cannot blame them. Because they need not worry about this kind of large scale production at all, right?

Their duty is whether a new reaction they can find or not, which will be useful for the society, for the humans either may be in terms of medicines or it may be in terms of some intermediate for these medicine or it may be some paint or it may be some other, you know, you know some acid or it may be benzene or toluene, some other new component where it will be useful or some plastic component before that, you know, chemical reactions should take place.

So this is what is, you know the engineering principles, right? That is why when you talk about chemical engineering what you do is that on large scale you have to use always engineering principles. Because it is dealing with chemicals it is called chemical engineering, right? So now other thing which I want to tell is we have only talked about mixing, right?

What about heat transfer? Because now you taken this test tube, put in the Bunsen burner and then exposed that for temperature. Because the diameter of the tube is very, very small, heat is uniformly distributed so by shaking even inside that liquid also you will have uniform distribution. So there is a possibility for the reaction to take place throughout that small volume uniformly. So that is why you are shaking them,

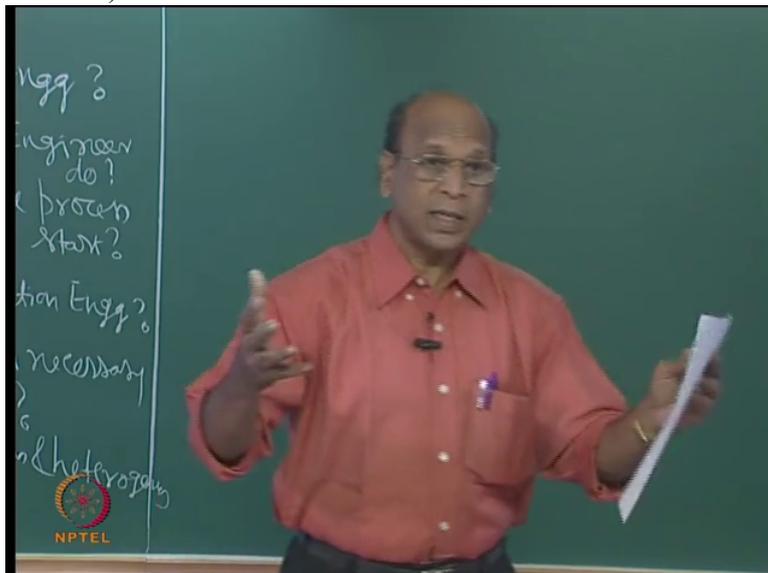
(Refer Slide Time: 15:14)



right?

But we cannot do on 1 ton scale. So what I have to do now, stirrer we put but how do I,

(Refer Slide Time: 15:21)



supply heat, right? It may not be supply heat, sometimes you have to remove heat. Because if it is highly exothermic reaction, you do not want that kind of heat to be generated because you know, it may catch fire or it may spoil the product. So that is why you have to control the temperature that means you have to remove heat, what do you do?

(Professor – student conversation starts)

Student: Cooling jackets

Professor: Yeah, cooling jackets. Again, many questions will come. Where do you put these cooling jackets? Directly inside the reactor or outside, why outside, why not inside?

(Professor – student conversation ends)

So all of these things are chemical engineering subjects. These all form engineering subjects. But when you talk about that chemical reaction alone, how your molecule is going to attack another molecule and then the collision of these two molecules will give the product. That is the science.

He is not bothered of how it is being removed at all, at that time a molecule is coming and hitting another molecule and that energetic collision will give the products, all that theories we have, right? So for all that he need not use any engineering principles there. Only thing is one molecule he will visualize. Another molecule will come, collide and then resulting collisions, some energetic collisions will give the product.

So now he has to interpret. Ok. When so many molecules are coming and colliding, how do I find out what is the rate of reaction? Because finally so many molecules are colliding, so much product is formed. So now what is the formation of product, rate of formation? Similarly the opposite part of that is what is the rate of reaction? Because when the rate of reaction is happening only the production is happening, right?

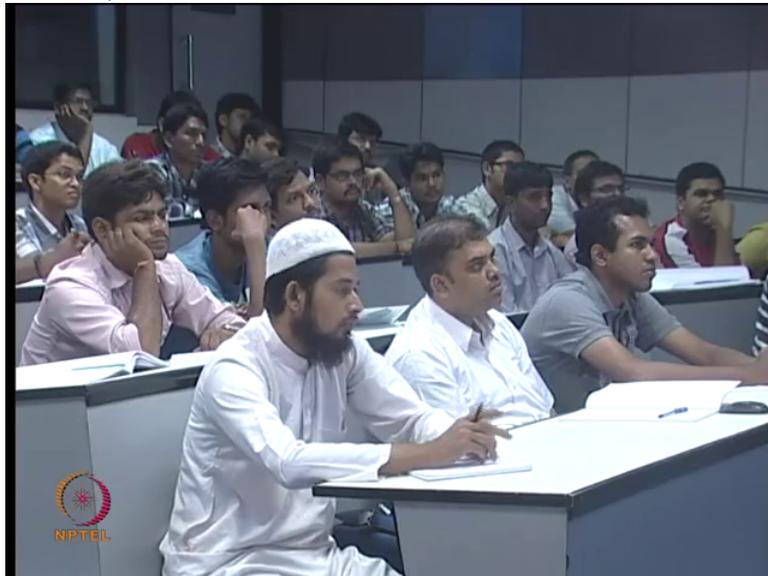
So that is why, that is why you know Levenspiel's great word is minus r_A . Ok, he only popularized that minus r_A , for us minus R_A is rate of reaction for the reactants, right? So products normally we never use. So, but that is the science part for us, Ok. So that is why chemical engineering, one of the simplest definitions is that chemical engineers produce chemicals on very large scale.

That large scale is nothing but chemical engineering. Why? Because for example I told you heat transfer you read in chemical engineering and mixing you read in chemical engineering and when I also have the batch system, so I told you this mixing also come in fluid mechanics. That means fluid is moving. And also after completing your reaction you have to discharge that products and then you have to send it to some other may be distillation column to separate again unreacted reactant and product.

So that means that is a mass transfer equipment. That also sometimes they do, chemists do, right? How do they do that? They also have a very small distillation column, it is single stage, only one beaker and then just heat it and the vapor will come, condense in a simple condenser and then they get the product.

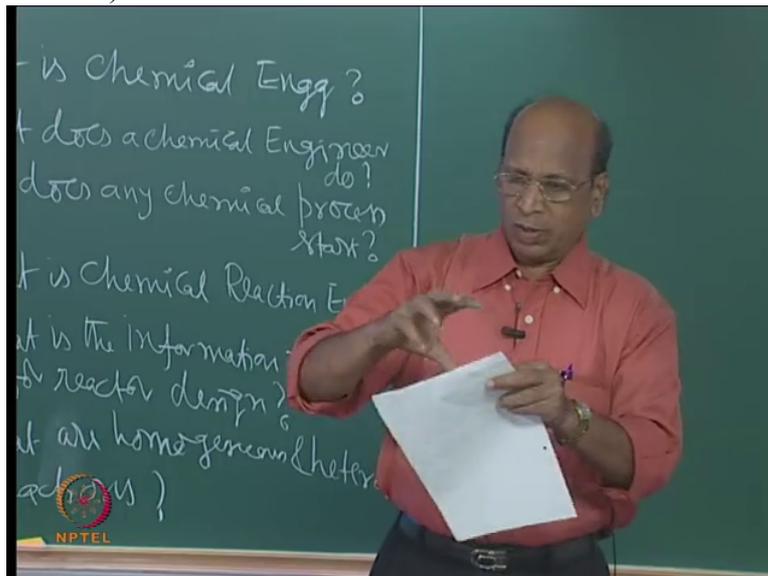
But imagine that to be done on a very large scale with you know hundreds of tons per day, what kind of big size of condensers you require? That is why we went to distillation which is a wonderful operation, right. So all these things, you know fluid flow automatically comes. Mass transfer, distillation, this is mass transfer operation.

(Refer Slide Time: 18:51)



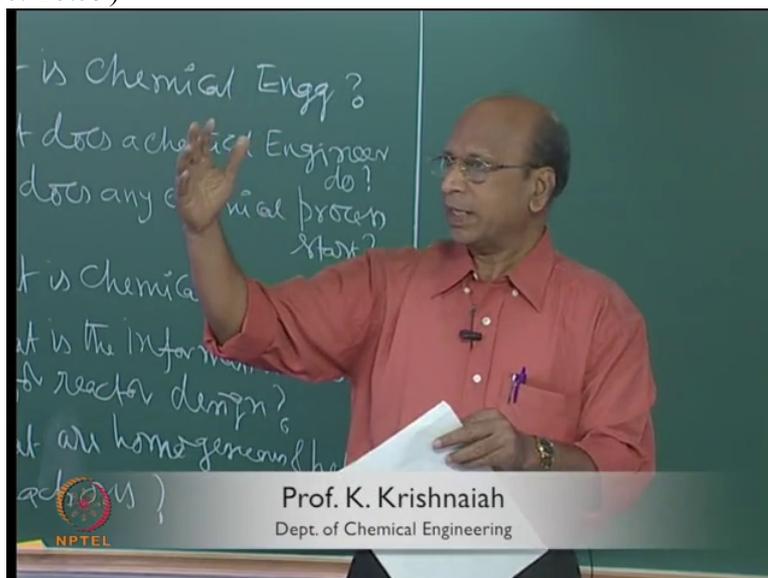
Because you are separating two that means you are making two

(Refer Slide Time: 18:55)



components move separately; Ok.

(Refer Slide Time: 18:59)



Mass is moving from one place to the other place, right? So from liquid to the vapor and then you condense and again take it. That is what is mass transfer. So now if you want to control the reaction temperature, automatically controls will come.

So now you see you know fluid mechanics automatically coming, mass transfer automatically coming, control automatically coming and you know material and energy balance comes much before that because you know how much you have to put in the reactor, how much will come out depending on the conversion, so all these things, all subjects are covered now, right?

So chemical engineering is the field where you produce chemicals on large scale. You try to explain this to your mother or sister. They will happily understand. You are giving examples now. So because we are, we have to produce very large amounts so we cannot take small equipment and then shake it and then take the product.

So we have to, I mean mix thoroughly and you can also tell that, you know, mother is mixing in the kitchen with you know some kind of spoon. Ok or you have that big spoons and all that. So with that, she will also stir. When she is cooking sambar again, uniform, right? So even I think that kinds of big spoons also not possible.

So that is why we have to go for real stirrers with different shapes and sizes. So that is what, what we read in chemical engineering. Then he understands. Ok. So that is why starting point is chemical reaction engineering, chemical reactions and then automatically all subjects will form; they have to support this particular reaction. That is why always I have that dream.

I told to my earlier students also. This dream is to have flow chart with only reactor. That is the minimum flowchart that you can have. If I have a reactor, I designed a reactor where the reaction is taking place at room temperature, Ok because many biochemical reactions are taking place at room temperature. There is 100 percent conversion. Ok.

Now I also have pure reactants. What do I need? And also 100 percent conversion. Pure reactants will go to pure products. So directly you can sell the products to super markets. Only thing is fluid flow. You should have pipes or you should have some conveyor belts where you can just directly sell to supermarkets.

So that is what is a beautiful subject for chemical technology where you do not have to remember any other equipment. Now we know what is the, what the hell you had when you were preparing for chemical technology examination. How many flowcharts you have to remember, right? So I know, most of you would have remem/rememered, I also did the same thing, right? So all of us try to remember only as much as possible.

After the examination one sneeze, everything will come out, forget. So tomorrow you do not know what you have written yesterday in that examination. So that will be beautiful no, if

you are able to design this dream flowchart; that is my dream. Ok. Why can't we have only this kind of reactions if possible? And fortunately they are not possible.

We do not know, after 100 years, 200 years it may be possible, right? So that is why that flowchart you will have for each and every chemical where you have heat transfer equipment, heat transfer you have to study, mass transfer equipment, mass transfer you have to study, flow you will have and also you know storage vessels you will have. So all that learning is chemical engineering.

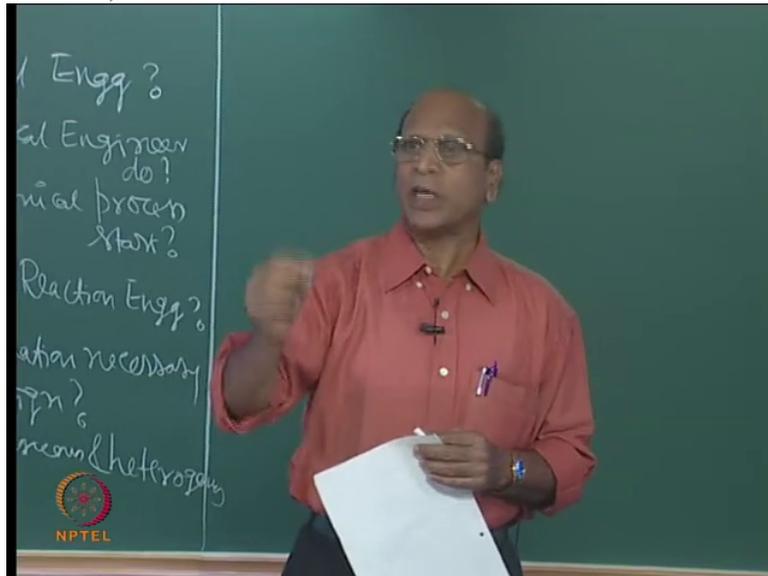
We do not have to tell a particular definition.

(Refer Slide Time: 22:36)



I told you definitions will be always difficult to remember. Anyway I am going to tell you the official definition. Ok, you have to note down and keep it with you. But the simplest

(Refer Slide Time: 22:45)



one is that. Ok and we have forgotten one very important subject.

I have not told you till now. What is that? Thermodynamics. Where does that come? Yeah, actually thermodynamics is the God, says possible, not possible. Not possible means you cannot do anything. Possible means you can do something. Yeah, Ok reactions, plus anything else?

(Professor – student conversation starts)

Student: Equilibrium diagram

Professor: Where do we use equilibrium?

Student: Interface

Student: Vapor phase

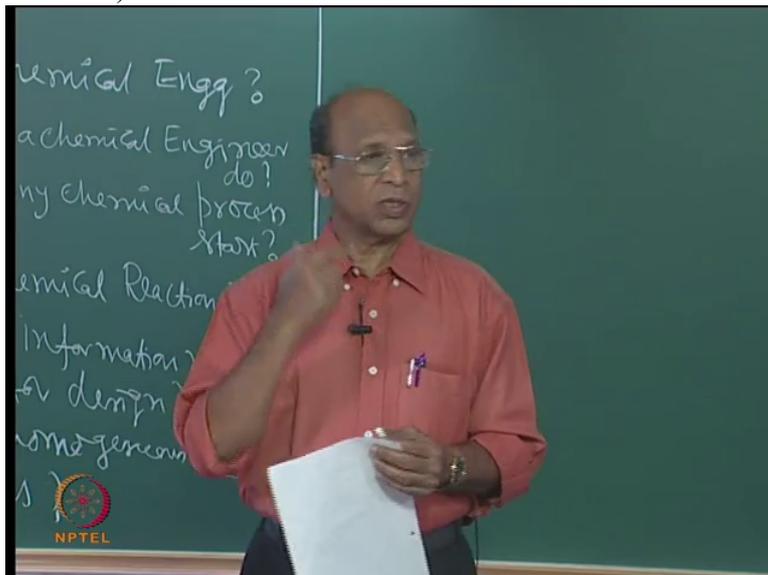
(Refer Slide Time: 23:23)



Professor: We do at the interface but what are you doing there?

Student: Dissipation you do

(Refer Slide Time: 23:27)



Professor: Sorry?

Student: Conversion

Student: Conversion

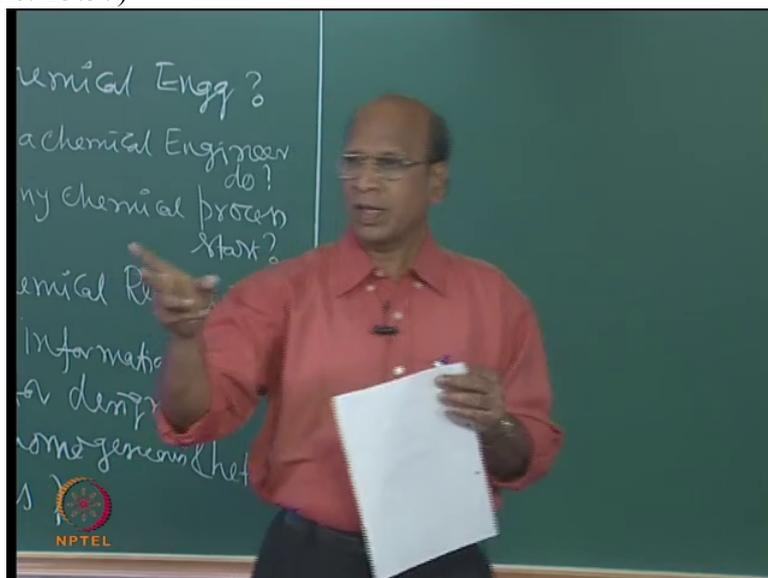
Professor: Thermodynamics will tell you how much

(Refer Slide Time: 23:34)



Student: How fast does the reaction takes place...

(Refer Slide Time: 23:37)



How fast does the reaction takes place...

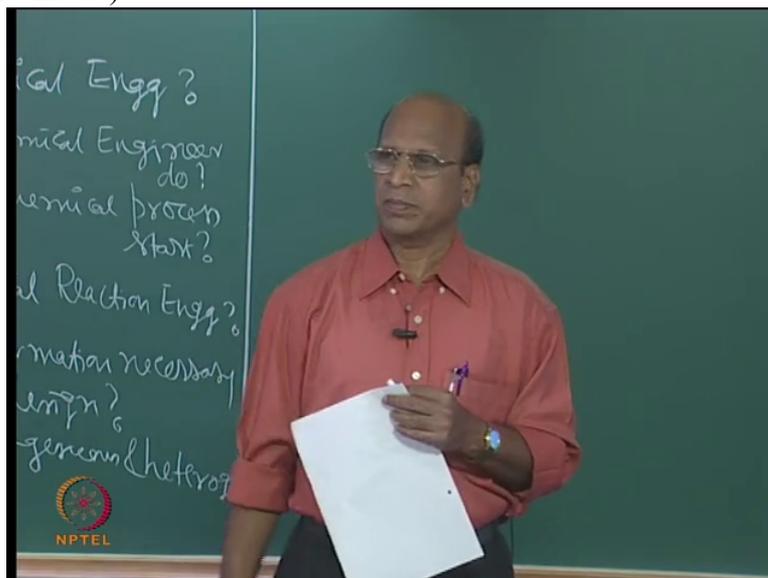
Student: How fast

(Refer Slide Time: 23:42)



Professor: How fast, thermodynamics cannot tell. It is only kinetics.

(Refer Slide Time: 23:47)



Student: Initial and the last stage

(Refer Slide Time: 23:49)

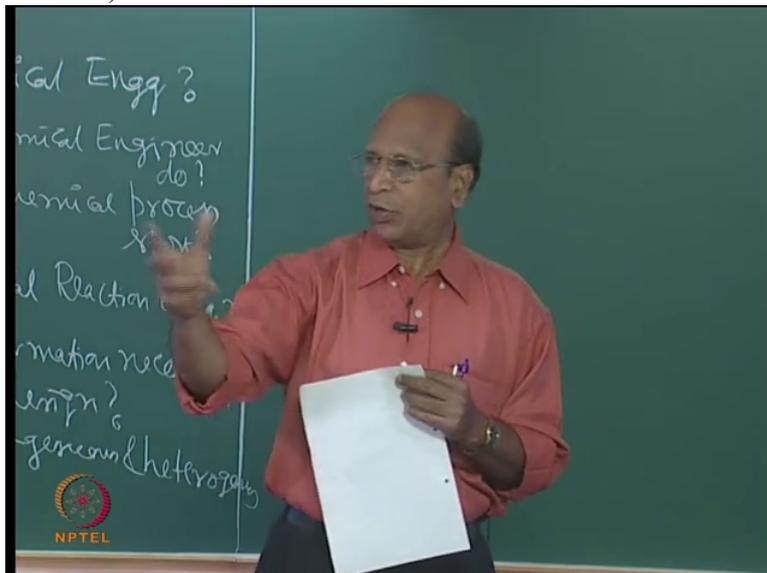


Professor: Yes

Student: Initial and the last stage can be measured by thermodynamics

Professor: I mean, Ok, reaction, we say,

(Refer Slide Time: 23:54)



is feasible or not, that is, that is information you get. But how fast means you have to go to only kinetics. That is what is the reaction you need.

(Professor – student conversation ends)

Ok that is why it is science. Because when you are looking at molecular level it is science. When you are looking at bulk level, that means Ok, forget about molecules, I will put my, may to study kinetics, may be 1 k g of one material, another k g of another material, now

there are millions or billions of molecules in that. I do not worry how they are reacting but after waiting for 10 minutes I will see the product.

So that means you are now looking macroscopically in the system and then try to find out at the end, at the end means may be every, you want to find out concentration with respect to time. So every time may be 5 minutes, 5 minutes, 5 minutes, 5 minutes you try to check whether reaction is happening or not. That is what is again reaction engineering. You are not really talking about science there.

Science is that going into the molecules and then trying to find out that, Ok in what way, in what angle this molecule is going and colliding another angle I mean another molecule? Only some angles may result into products. And then you try to, because all of us are ambitious, we want to produce as much as possible. So we would like to send all the molecules in that only that orientation where you get maximum product. Ok, that is scientific theory.

Experiments also they can do and then they can prove that, right? This is what is the one of the simplest definitions of chemical engineering where you simply say that Ok, we produce anything, any chemical on very, very large scales. That large also is really large. If you go to ammonia production where they use for fertilizers and all that, the plants may be 10000 tons per day, 10000 tons per day, 10000 into another 1000 k gs per day. 24 hours you have to produce that.

Like that even sulphuric acid. You know that bulk chemicals where large amounts you produce and the beauty there is you go that large scale and also you produce may be 1 k g, 2 k g very costly medicines. You cannot produce more than that. Ok

For example in bio-chemical engineering, particularly extraction of some chemicals from you know kidney, liver and all that, you know, we also do that in biochemical engineering. Biochemical engineering is no way different than chemical engineering, Ok. That is what is the simplest definition. You remember this what I explained, right?

What is that you are trying to do in chemical engineering? And if some asks this is the problem, I think even now, many people even in I I T Madras, some, I think I stayed here for almost 30, 32 years. Even now some of my letters will go to chemistry department.

That means the people do not know the difference between chemistry and chemical engineering. Ok but it is very good. Another thing which I started saying in the last 4-5 years, suddenly that idea came to me is chemical engineering starts when chemistry stops, very nice, no? Repeat what I said.

(Refer Slide Time: 27:14)

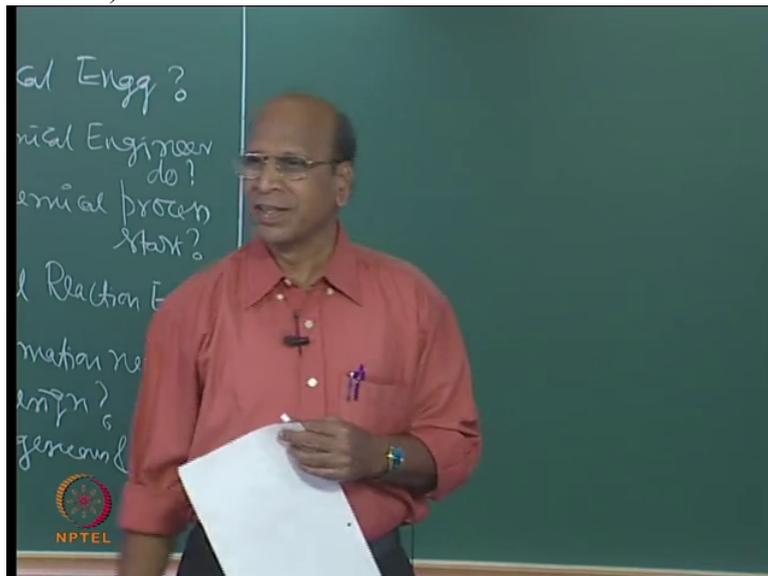


(Professor – student conversation starts)

Student: chemical engineering starts where chemistry stops.

Professor: Chemistry stops. Where do they stop?

(Refer Slide Time: 27:19)



Student: Small scale.

(Refer Slide Time: 27:21)

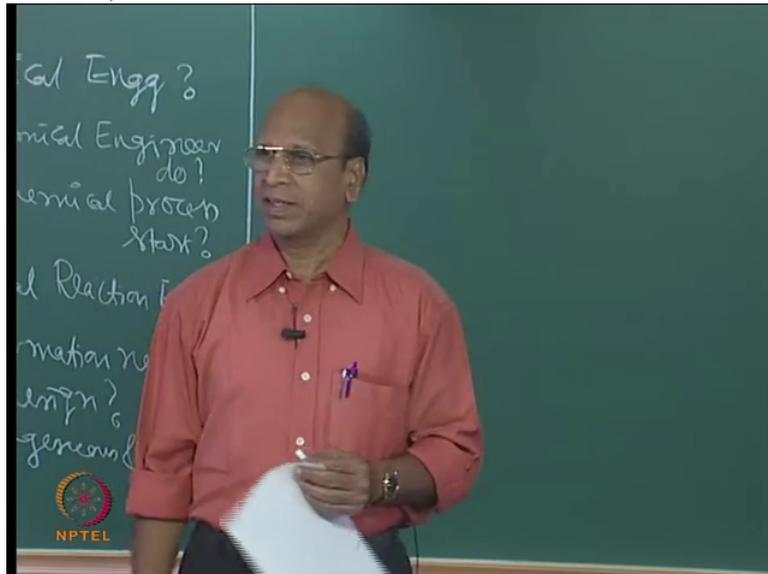


Professor: Small scale. That is all.

(Professor – student conversation ends)

I think that is very simplest one to remember again.

(Refer Slide Time: 27:25)



I told in one of the conferences as this is inauguration for chemistry conference; I told that I mean we are cousin brothers. But you go to till certain place. Afterwards we continue the journey. So then I first told this sentence you know chemical engineering starts when chemistry stops.

That is one of the simplest definitions also you can give. Then you can explain what do you mean by that. Right because many people do not know, I think only we know, you should know then only you should tell isn't it? Otherwise (laugh), otherwise if they ask Ok tell then you may not know, right.

So this is what most of the time it is happening to you in interviews. Only for, for your happiness, or for some great effect you use very difficult term, Ok nanotechnology you use. Then I ask Ok what is nano technology. (laugh). That is all. I think you know only nanotechnology. You cannot, so nanotechnology, and nanotechnology and nanotechnology (laugh)

(Professor – student conversation starts)

Student: (laugh)

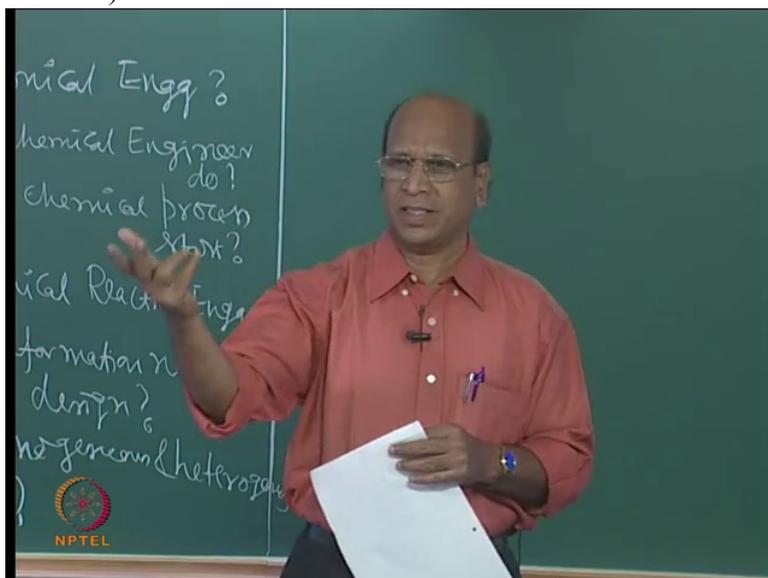
Professor: Because you do not know, you do not have even one example

(Refer Slide Time: 28:24)



where this nanotechnology really works, Ok. I mean nature has taught already nanotechnology,

(Refer Slide Time: 28:30)



right?

(Professor – student conversation ends)

I think Big Bang theory, all fundamental particles and that built up slowly whatever shape it wanted, of course that is by nature, it has done it, but humanly we want to do the same thing. That is what is nanotechnology.

Till now, the molecules, they were combining we allowed to combine. But now we do not to allow them the way they want to combine. We want to have our own type of, you know the products. That is why I think you know, I have been telling also, some of also, some of our friends are here, already taken this course and you know I tell this example always.

I was in Malaysia for 2 years teaching. And I was teaching C R E course and then I asked how do you produce sulphuric acid? So I asked I think in Malaysia, you know, we think that it is a Muslim country, no freedom for ladies. By God! They have tremendous freedom. In fact in our country our ladies do not have that much freedom. If I look at anytime of the road, more than 50 percent of the drivers, you know their own vehicles, are ladies.

And any office you go, more than 50 percent are girls. Ok. In the class, in my class 60 percent were girls, in chemical engineering. Normally chemical engineering women not get many, I think you know in electronics they may get many. Or in sciences our people get. So like that, you know anyway, there are many girls and one girl I asked Ok, please tell me, how do you produce? She says, no problem, Sir. I think very easy you take H 2.

(Professor – student conversation starts)

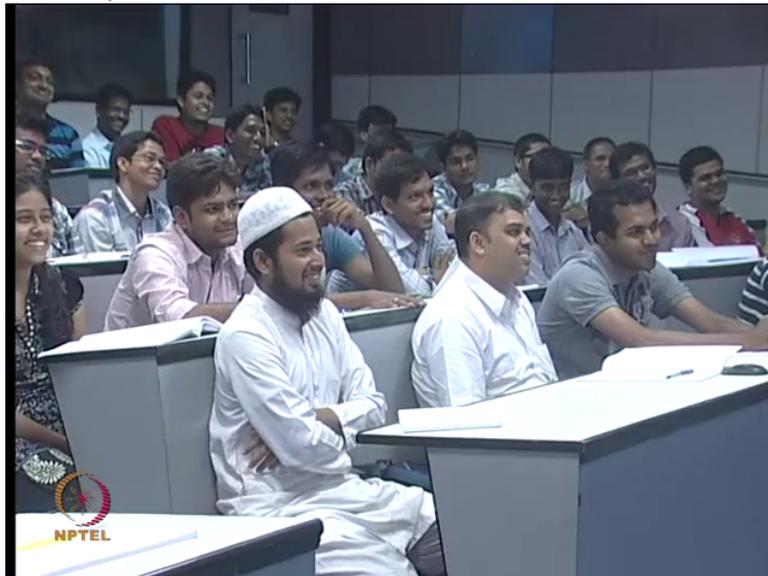
Student: (laugh)

Professor: You take S

Student: (laugh)

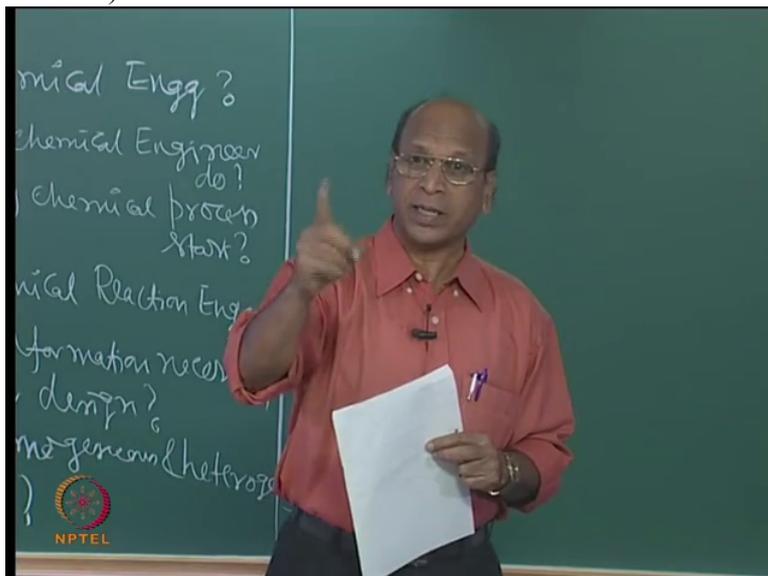
Professor: And you take O 4. Put them in one place. You get H 2 S O 4. (laugh). You know really, all the people laughed

(Refer Slide Time: 30:12)



like this only. I told no. I think she is

(Refer Slide Time: 30:15)



Terminator 10.

Student: (laugh)

Professor: Not 1, 2, 3 because all Terminators come from our future.

(Professor – student conversation ends)

So she has come from your future. Because she is imagining that future knowledge where after may be 100 years we may be doing the same thing. That is what you are supposed to do in nanotechnology. You have to control the products the way you want. How do you start? You have to start from molecules. Even nature does that.

How our body is formed? You know, I mean, at the level of, you know, that sperm and egg level, where is the shape? There is no shape there no? Sperm has separate its shape and egg has its shape. But by combining those two and then the D N A information, in one month you will have one shape. It is not true only for humans.

I think for all life, you know all the mammals, after 2 months it will have different shape. And at the end of ninth month, we are here. This shape will not change. I think only slightly it might change till 19th year, 18th year teens, Ok, so you see that is nanotechnology. It is building up from the molecules. Because now we want to control that at molecular level, you need lot of sophistication for doing this. Why?

Molecules you cannot see. You have to catch one molecule H₂ and then catch another S₂, S and then put them together and then bring O₄, join together and then give the H₂ S O₄. In fact we may reach, we do not know, after 200-300 years later that may be what we are doing.

You go to the doctor. He may call you. Ok, this is the disease you have. So this is the medicine. You may pull out all these molecules, benzene, toluene and all that together

(Professor – student conversation starts)

Student: (laugh)

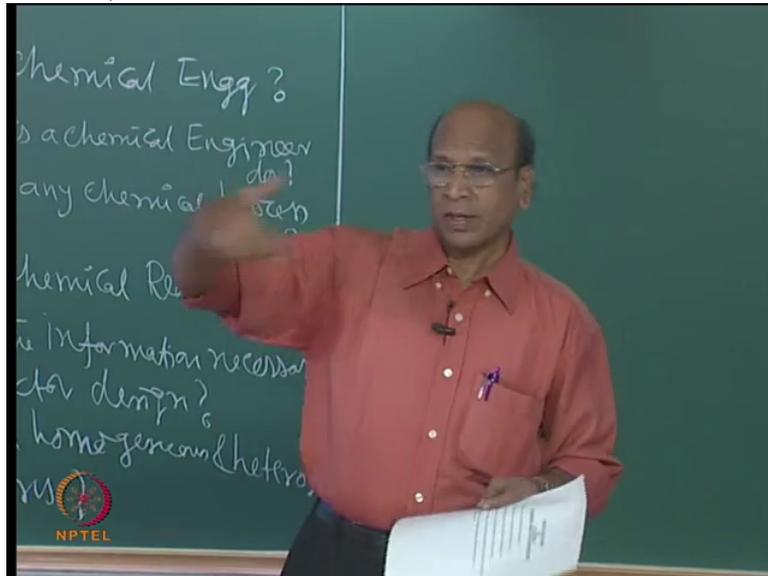
Professor: (laugh), take.

(Refer Slide Time: 32:04)



No it may happen no, it is really beautiful. That is why life is so beautiful if you

(Refer Slide Time: 32:09)



imagine all these possibilities.

(Professor – student conversation ends)

And we came to this level because of our imagination only. This level we have reached because of our imagination. We are able to fly very happily in sky with that big flights where we have, you know, particularly Airbus 800 something is there, where my God! It is like building. More than this building, size wise. How beautifully it is flying!

How did we get this? We got because we have observed birds flying and you felt sorry that I do not have wings to fly. Ok and then, even people tried that. They had wings. You know that Condorman or something they call. So they jump from buildings, broken their legs and all that. So (laugh), so many people

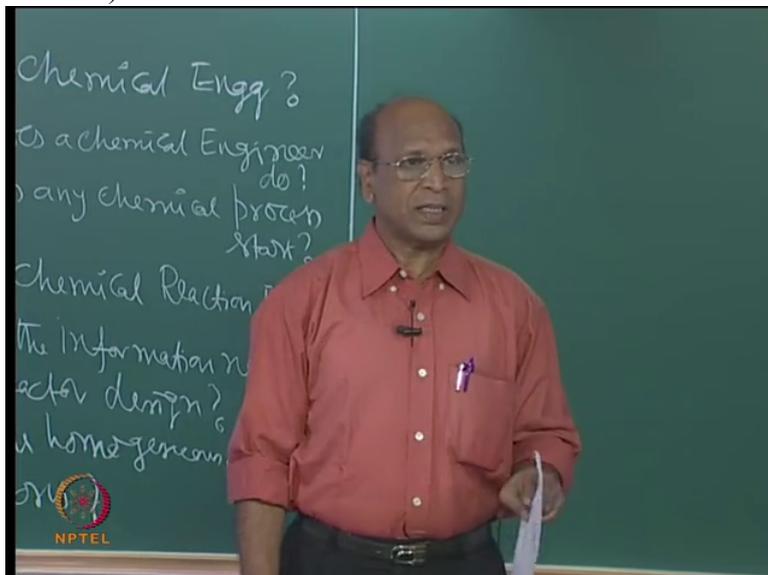
(Refer Slide Time: 32:53)



tried that.

Ok that is their sacrifice, what happily afterwards I think, who are the people, Wright, Wright brothers yeah,

(Refer Slide Time: 33:01)



it seems they used to go to these birds wherever they have in the water, they used to simply observe it seems. How the birds are taking off when they are flying and when they land, how they land, Ok catching fish and all that, they do not bother. Ok but only flying and landing only...our (laugh).

The birds can know. They are flying and then also landing there only to catch fish so that they can eat and then you know, survive. That is their food. But we are not doing that. We want to fly. How beautiful it is! Now rockets. And most wonderful thing is my God! Billions of miles away someone takes a photograph that comes to earth with a beautiful picture.

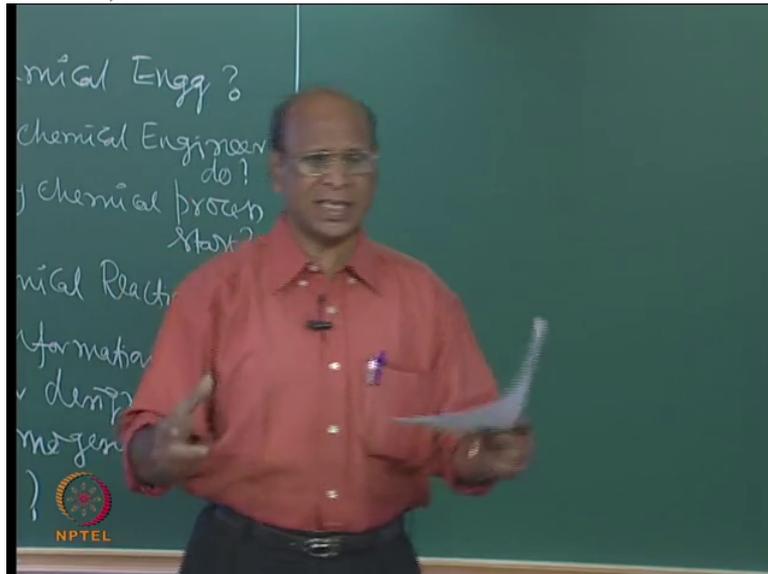
What kind of, you know, our medicines, how many lives are saved, you know, because of our medicines produced by pharmacists and chemical engineers, and biochemists.

(Refer Slide Time: 33:52)



How many, I think you know and chemical engineers saved the world. I do not know whether you know this or not. Because one point of time, particularly Haber process for ammonia and why he was so much interested

(Refer Slide Time: 34:04)



in having this ammonia process? Finally to be used as fertilizers. Only for that.

Ok at that time, population is increasing but fertilizers, I mean the, the growth without any additional fertilizer, the growth of food is not that much, the production of food, so that is why at one point of time chemical engineers really saved by producing large amounts of fertilizers where the productivity increased 5 times, 10 times in the same land. The area is same. But from the same land, because of putting fertilizers then they got more and more, you know all the, whatever they produced, wheat or whatever, right, so that is how, fruits, vegetables all that they could produce.

That is why I think we also contributed for saving the world. And also another saving the world is penicillin. Penicillin invention is one of the greatest, you know, stories for chemical engineers also. For biochemists, chemical engineers and even doctors. All these three people, together they work and then finally they could produce during Second World War, penicillin and then that penicillin saved many, many lives. Many families were happy.

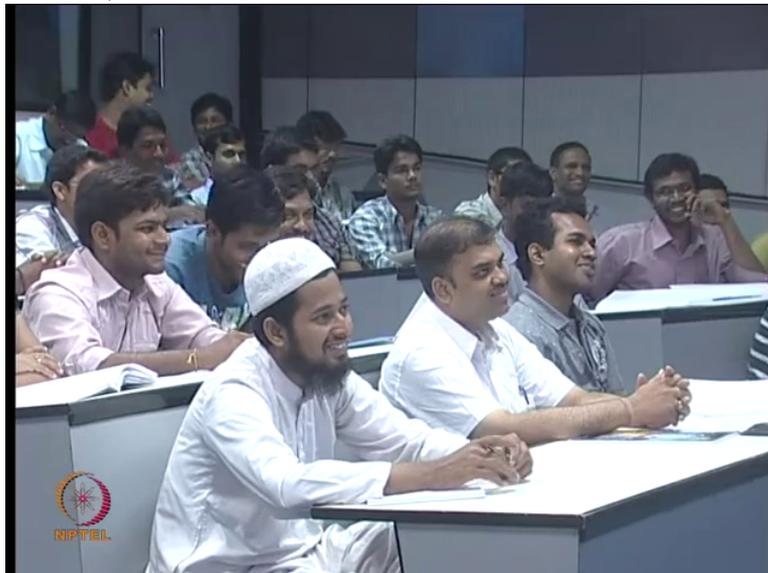
Otherwise I think you know, many people would have, would have been without fathers in that family, right. Because at that time only, only men were fighting. Women were only at home, right? So that saved lot of lives. So like that the chemical engineering contributions just by learning thermodynamics, heat transfer, mass transfer, fluid mechanics, that is all. That is again one of the beautiful parts which I like in chemical engineering.

Any chemical you bring in the world, only 5 subjects, correct no? What are the 5 subjects? Of course reaction engineering is one, mass transfer, heat transfer and momentum transfer, if you combine all these three as transport phenomena that also will become only one subject, right? And then of course material and energy balance and thermodynamics. Thermodynamics will tell you what is possible what is not possible, right?

So that is why now onwards please try to explain, you know, you catch some of the, see here you may be happily enjoying and then you know, you thought that you have understood. But the moment you again cross the door, you may forget. That is why you have to repeat yourself. That is why in your room you repeat, what you have learnt here, just sit down and then try to...because then we do not tell many things.

You know this entire class I have just told you what is chemical engineering. Only one point, to make that one point we give so many examples. That is all. In every class there will be only one point or two points. The moment you go home, you just note down that point. And the explanation and all that, you catch some one. You catch some computer science guy in your room, in your hostel, Ok. And then take him for tea and then start telling this.

(Refer Slide Time: 36:56)

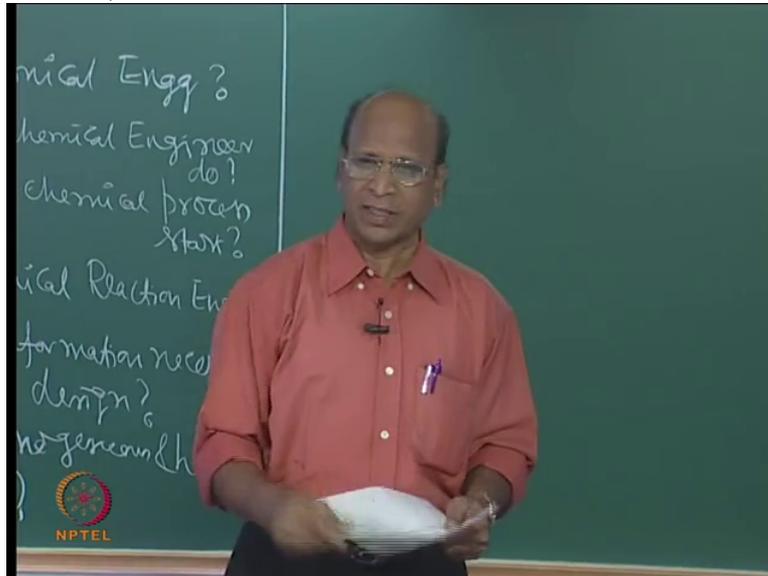


(Professor – student conversation starts)

Student: (laugh)

Professor: Ok, girls also, right (laugh). Till he gets bored. Because he cannot immediately run away

(Refer Slide Time: 37:02)

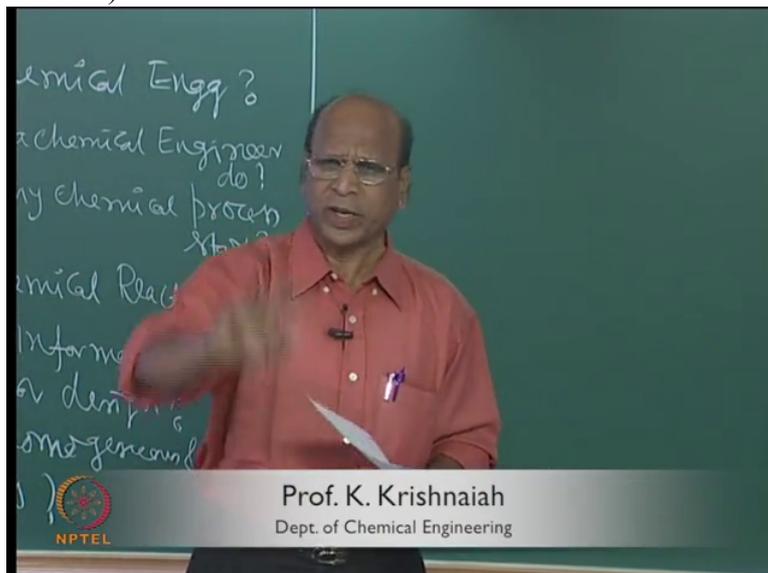


because you bought him tea. So I think at least the tea is over, he will be there with you.

(Professor – student conversation ends)

So till that time you can tell that. You know, whether he listens or not, do not worry.

(Refer Slide Time: 37:11)



Because most of us are like that. We sit here; our minds can go somewhere, right? That is why I told you I like Matrix movie because of that. Because you sit in the chair, put that rod here, you go anywhere, right?

So that is why all of you should see that movie, right? That, that Matrix, so that is what. Because that is what we do. He has shown that in a beautiful way in that movie. All the time you do that. Right now you may be listening to me but your mind would have been thinking time. Ok. May be thinking next class. May be thinking, for those people who do not have next class, they may be thinking food. You know there are so many things in your mind, right?

So that is why this one, chemical engineering itself if you now try to tell, or you discuss on your own with your friends, all chemical engineers together, then you will not forget. Otherwise you simply go out of this room and then Ok let me see when it comes to examination or not. So most of the time you know we postpone till examination, right? So if you are trying to do that you will not learn much.

I tell you; in any class you will not have more than 1 or 2 concepts, points not even concepts. Ok I think I will stop here and yeah this is what is the first question, entire semester I can talk about these four questions.