Thermodynamics
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Lecture – 10
Thermodynamic Concepts: Revision & Summary

You have questions? We can take more questions, I have time. But, what we will do now is spend a few minutes that we have to get a overall idea what have we done in these six hours and why did we do that?

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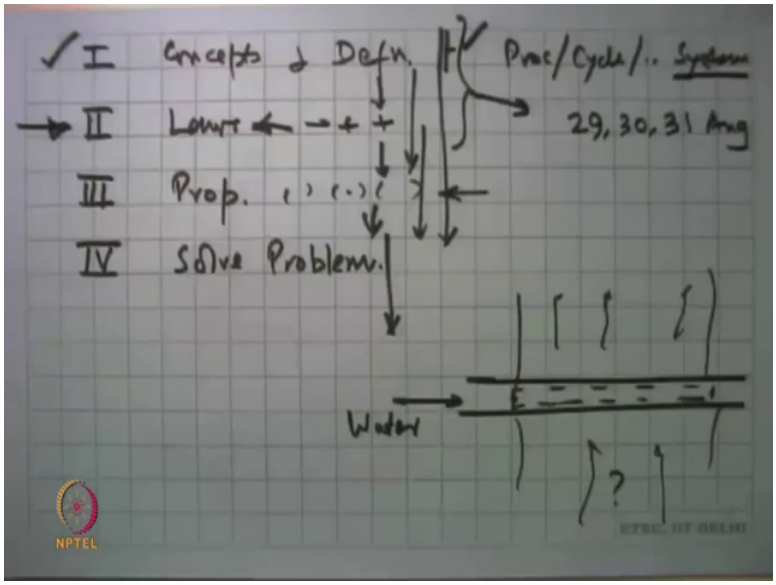

You remember the three the four modules in which I have classified this course. The first was concepts and definitions, the next one we look at laws, the next we will look at properties and then we put everything together on problem solving.

So, what we are doing is essentially developing a procedure on how should I solve a problem and these are exactly the steps that we have to follow in solving a problem and that is where this thing came up first. That, first make a sketch define what is a system, what are mass inflows and outflows, what is heat, what is work, that are the first thing we do. And, then if you said is there a process, is there a cycle all of them. So, in solving any problem whether you are asking question about a fuel cell or whether it is about power stroke of a diesel engine or a gas turbine whatever this is the way to start. So, that is the reason why we took it up first.

The other reason why we had to do it is that unless we have defined things like the system, like the equilibrium, like properties heat cannot fully understand the laws. Moment we take the zeroth law, first law, second law immediately we will use the words system, boundary, surroundings, properties, equilibrium all of that will come automatically the definitions that come out here have to come from here. So, if you have to understand the laws this was a necessity and that is the other reason why we did this and not the other way round.

So, let us start with the laws, we need to get something very clear only then we can talk of applying a law. Remember, laws can only be applied to a system and to nothing else. Now we know why definition of the system is so important and we assignment and the problems you will see that if you do not define the system correctly you could land up in big problems. Having done that what we have done is that this part of the knowledge is independent of what the substance is. So, there is no compromise on this. You cannot say that I will apply this for water, but can I apply for air? Can I apply for butant? Can I apply for aluminum oxide it is a universal truth in that sense and so, I did not even talk about working substance and the properties of that. That is one thing.

The second is the laws will add us some more properties if we have not yet defined and that and all the other properties will get defined and calculated in this section. So, we need to understand the laws in order to decide what is the properties of that substance and so, this leads to this; this leads to this and both lead to this and then all of them lead to solving the problem and that is what we will do. Even it is a very simple example like some of the problems that I have given let us take there is a pipe in which water is flowing and outside this we have hot gases moving around and we want to ask the question that if I know something about these gases how can I predict that temperature rise of this water?

From school days you probably even have the answer that if this is this then rho MCP delta t and you get the answer we are not going to do things that way because that does not help us solve many of the complex problem that we are going to be looking at.

We first go from the first step by defining the system boundary, we do all the thing that we have talked about so far, then we say no for the system I will apply the laws and then simplify the laws and then I say what is the substance that I have then we will go and get

their properties and then finally, we will put everything in that formula and we get the answer. So, that is why we are going in this sequence we have now completed this. Now, we will go on and in the next module which is 29th, 39th, 31st August. We will discuss the laws and derivative equations.

Again, I am repeating both of these are independent of the application or independent of the substance and we should never ever doubt whether this is applicable in this situation or not applicable it is always applicable. How can we understand where to choose CV method and where to choose CM method.

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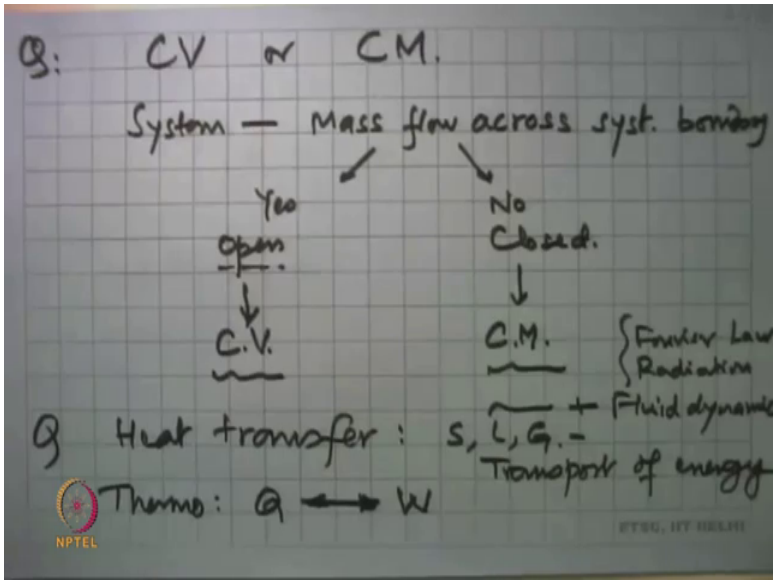

The question is we have two options of analyzing CV or CM. How do we decide which to choose? What we have done is we define the system and then we say is there a mass transfer or a mass flow across the system boundary. If the answer is yes, that means, you have an open system; if the answer is no we have a closed system and remember mass means bulk mass not electrons or protons or photons that we have do not included.

If it is open system we have the first and we will put say we will fix the volume and allow mass to go in and go out. So, here volume is fixed, the system is fixed now as a volume a closed hypothetical space and we will then apply equations on this. If it is closed we would apply a control mass approach even if the system changes its shape and size. Here the system will not change its shape and size ok. So, that is the conditions under which you write whether to apply CV or to apply the CM formulation.

What is the difference between heat transfer and thermodynamics?. These are two different subjects the subject of heat transfer whether it is mechanical engineers, chemical engineers and many civil applications, aeronautical applications it deals with how heat transfer takes place in a solid liquid or a gas, basically the transport of energy. So, the shape, the size, the properties, the temperature gradience, the flows, that is what is looked at here. Whereas, thermodynamics is essentially looking at the inter convertibility and the relationship between heat and work. So, that is the science different.

Here heat is something that went from surrounding to system or system to surrounding. Here we say look I have a rod and (Refer Time: 07:58) would taking place or I have something which is hot over which air is being blown, what is the rate at which it cools? That question is not answerable by the knowledge of thermodynamics, but that answer comes from knowledge of heat transfer and at least in liquid and gases cases you also need to have a knowledge of fluid dynamics.

So, it is the governing laws of physics here or Fourier's law of conduction and the radiation laws neither of these come into a course on thermodynamics and the inter convertibility of heat to work is not talked about in heat transfer ok. So, that is the difference and yes, all the applications we have seen fuels cells, power plants, aircraft engines, human body everything there is a thermodynamic aspect to it, but really making it happen designing of the components we go to the heat transfer part and then do all the calculations concepts so, the two go one after the other ok.

Next question, get it what is the dead state in thermodynamics? I do not thing we use this term here. Then there is a question that says that electricity has better quality than heat, then why it is not used in automobile system?

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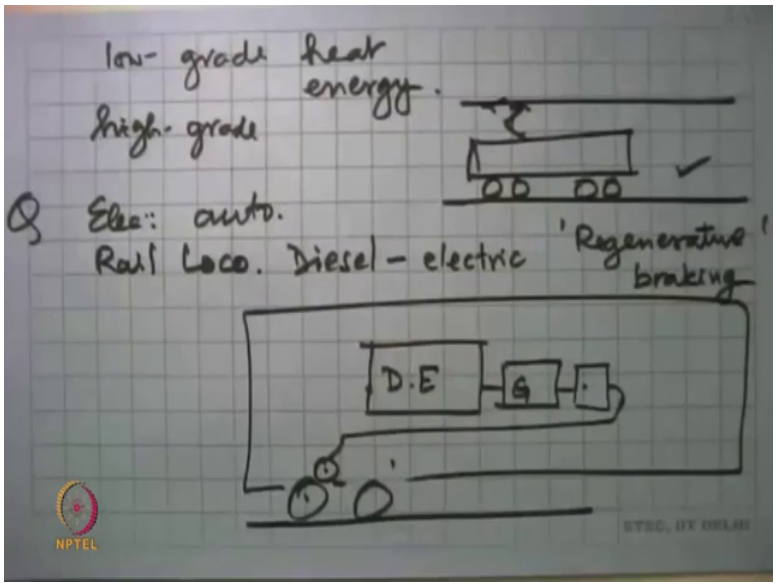

You will find the term in several books and articles on what is what you may call as low grade heat, low grade energy, high grade energy these terms are you will come across these. Never defined it here, we will wait till the second law comes in and then we will see what do we mean by saying that what is low grade and what is high grade at that point we will look at these discussions. So, we need to come it to that point, but why electricity is not used in automobile it is fairly straight forward? You have problem is how do you generate it and yes, you can in that question is there.

Why do not we use electricity in automobile? So, to see why we do not use it let us see an application where we do use it and the application where we do use electricity is the railway locomotive. The diesel locomotive that you see on the railways, not electric locomotive what it does is that on the locomotive it has a diesel engine this is coupled to a generator. This goes through controls and then this powers electric motors that drive the wheel. So, this power goes there and this is the wheel on the rail which then is driven by a motor energy or system. So, that is what is diesel locomotive and strictly it is not diesel, but diesel electric locomotive.

So, there are many engineering issues that was there why it became diesel electric locomotive and why do not we have a conventional clutch and a gear box in loco, it just broke many times. So, finally, said it is it is yes, I can make it, but in a few days it will break so, do not market it. But, this has become the stable design almost all diesel

locomotives or actually diesel electric locomotives and here controlling is much more easier and it is also possible to do one more thing is that when you want to break you can you will have to dissipate the kinetic energy, but at certain speeds the kinetic energy of the train is converted into electricity by the motor which can be made to operate like a generator and that heat is dissipated through heater (Refer Time: 12:08) or loss.

But, talking of the electric vehicle though if you look at yet another version of the railways and you look at the electric train or the electric locomotive, this is getting power supply from overhead cables. So, it does not have any combustion engine or a fuel cell or anything inside it and what people are increasingly doing now in that when the driver is applying the brakes the kinetic energy of the loco and the whole train is converted into electricity by the motors operating as generators and set that to the line that somebody some other locomotive or some other user can use it.

This is a great advantage and this is called the regenerative braking. And, that now we can recover a certain amount of energy of the train into this, there is a lot of work going on to see how we can convert more of the kinetic energy of the train and make it back into electricity which somebody else can use so, you then do not do not that much fuel in the power plant.

So, in that sense this type of a technology is possibly the most efficient technology you can think of. You and that is why you see energy consume for moving one person in a metro train or an electric train it is much much less than either a diesel bus which in turn is much less energy intense intensive than the car. Regenerative braking in a car or a bus is very difficult because in a very short time you go to convert lot of kinetic energy into electrical energy and then batteries do not have the capability to store that fast. The recharging of batteries takes time and so, regenerative braking in the context of a electric vehicle has a very limited use, but theoretically yes do ever yeah any question please go on.

Student: Sir, how can we check whether a cross system thermodynamically feasible or not?

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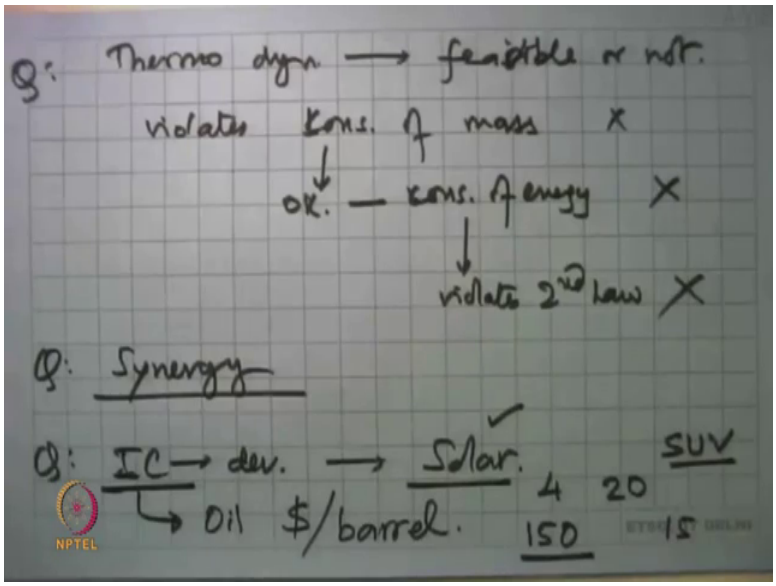

So, the question is how can we check whether a thermodynamic process is feasible or not? We will the actual answers will come when you look at the next module, but very quickly the answer is this. A very process that violates the conservation of mass is not feasible. So, you say that I have something into which in steady state I have 5 kg of water going, but in, but only 3 kg of water coming out that is not possible.

So, if it does not violate the conservation of mass but, violates conservation of energy, not possible. If it obeys conservation of mass is with conservation of energy, but violates the second law not possible. So, if any of these happens we can conclude that that particular process is not possible ok. So, whether it is designing a turbine, whether it is designing a nozzle, a rocket or designing something for heat transfer these things any of these things get violated that process is not possible and in the next module we will start putting criteria by which you can say how can I calculate and say whether this process is possible or not possible.

Even though solar energy and IC engine were known to us a century ago and their efficiency were too low in the beginning then why IC engine is developed faster than solar ok. So, the question is why IC engines have developed faster than solar? Ok answer is very simple. IC engine development and the use of the automobile has only one criteria, the price of oil that is how many dollars per barrel. There was a time in the in the 70's oil was 4 dollars a barrel, then after the oil stock in 73 it went up to like 20 dollars a

barrel, then it went up and down and got back and remained low again for a very long time. Then in between it shot up to 150 and dollars a barrel and then again it came down and hit again like 15, 20 dollars a barrel.

So, as long as there is cheap oil we are not going to go for any of this at all what happened was when oil hit 150 dollars a barrel people suddenly started looking at solar energy and renewable energy in a very serious way. Again in the price of oil went down or before it when the price of oil went rock bottom you saw people driving SUVs and big cars and nobody bothered about the fuel efficiency of a car. So, as to say whether IC engine developed faster not in the limitable question and the fact was that the average fuel efficiency of cars in periods of no oil prices has been worse, it has not increased a lot.

Second; the IC engine in a car has not really developed that much. If you say that how do I compare it with solar, if you look at the efficiency of the solar photovoltaic cells or the way we are able to now run say a thermodynamic cycle solar on the flat back we did have a power plant that runs 24 hours and generate electricity that is a big advantage, that is a big achievement. To say that there were no achivemments in solar is not right. I n the practice that the IC engine has not had that many great achievement to show for itself.

And even if all those things would happen and you make a car which has got 100 kilometers per liter and throws out nothing as a pollution and everybody has that car, ultimately you have to live with the reality the space is limited and you will again be spending all your time driving through traffic charge that does not get us anywhere as a society ok. What is the difference between point function and path function?

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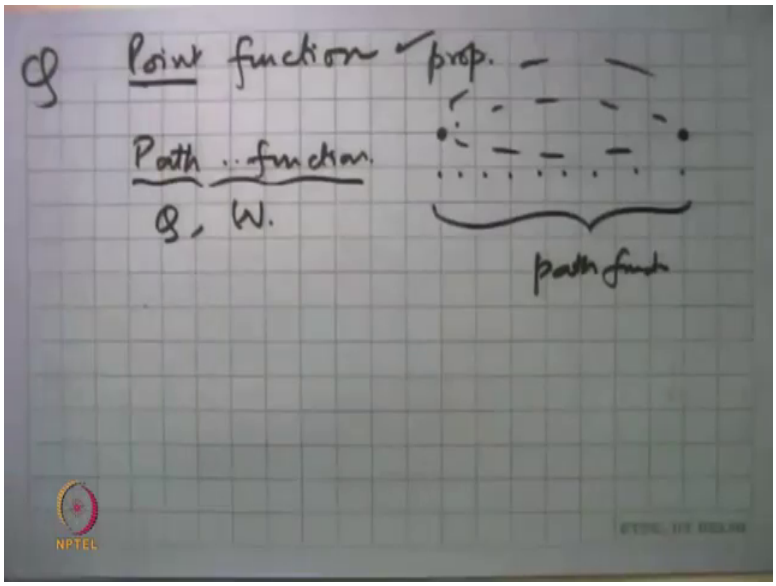

A point function we say that if the practice of the system do not depend on its history then it is a point function. But, if it depends on the path by which it got there then that is a path function; that means, here it went through a series of states and if I do some mathematical operation on these and this depends on the paths taken then this is a path function. But, it is going from here to here whether by this tip path or this path or anything else and it does not care how it happened, then this is a point function.

So, all the properties these are point functions. So, it does not care how you got there as long as system is there, but heat and work are two they depend on that path you took and over that entire path it depends what happens during every little point on that path and then we derive a mathematical operation to calculate and W term. So, they are path function. In this case end states the initial and final states are not just enough that that you can take into ok. So, one could ok so ok.

So, will that brings us to the end of this six hour module. I have given some practice questions please try those. If you have difficulty think discuss among yourself and get do the best you can. You will also get the solution I have given that learn from it, if you make a mistake that is ok, but learning from the mistake is more important. So, learn from it and if you still have doubts we can again meet later on and I can take on your questions. After that I have given a practice quiz. So, you can check how well you have understood the subject yourself if you have again in made mistake please go back and

relearn and figure out why that happened because these are concepts which we keep coming back again and again in the remaining part of the course. And, finally, I have posted (Refer Time: 20:48) quiz. So, that is the quiz on basis of which you will get some marks ok.

So, thank you.