Engineering Thermodynamics
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Lecture 01
Fundamental Laws of Nature, System Definitions and Applications

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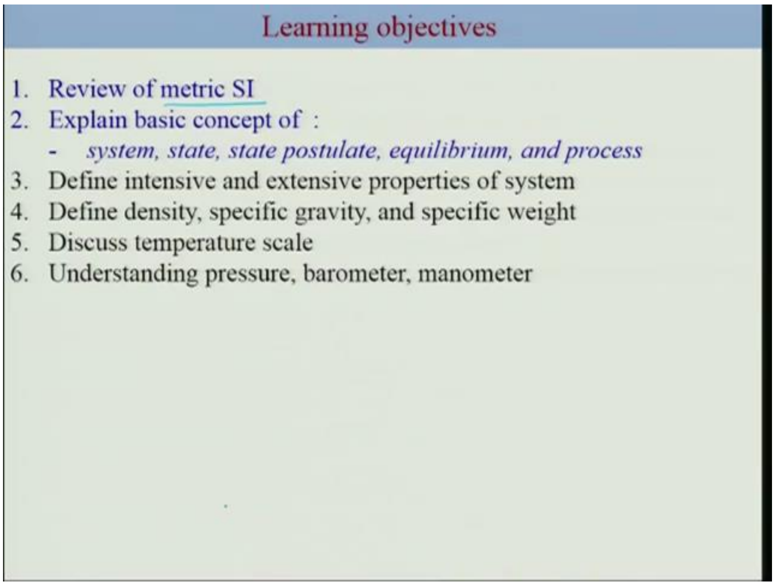

Hi, Let us start now the first module of the chapter of the course introduction is divided into three parts. So, let me go first with the just overview of the objective of the course this particular module. So, we will start with the review of the metric units and we will go through the basic concept or system state, state postulate, equilibrium and process in this part of the module. So, what is thermodynamic as such?

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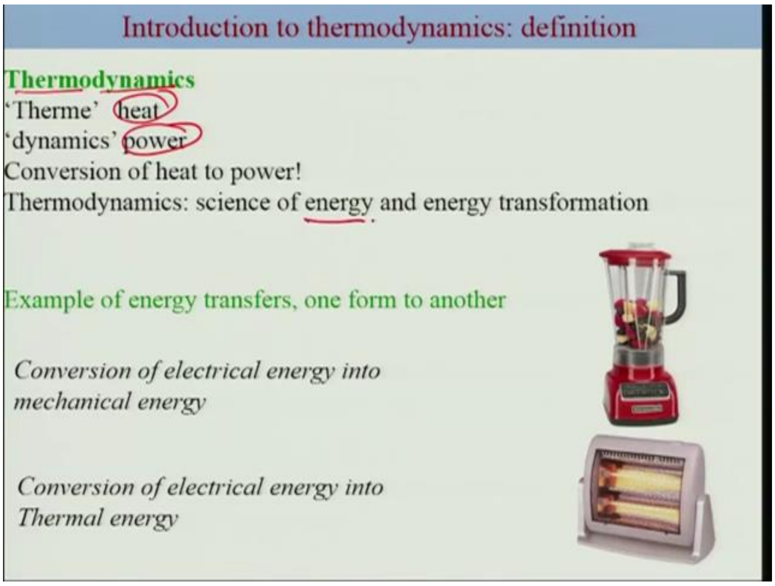

It means heat this is a heat and is dynamics is the power, so is conversion of the heat to the power and is so it says like one from of energy to another form of energy. So, essentially the thermodynamics turns out to be a science of energy and energy transformation. It has become a facility branch of engineering and science because it has a wide application in many expects of our life and engineering applications. So, just take an example we can take an example from the household daily life. So, this is a simple mixture and here you can see that we use it in the daily basis and this converts electrical energy into mechanical energy. And this is example of rule heater which is converts electrical energy into thermal energy.

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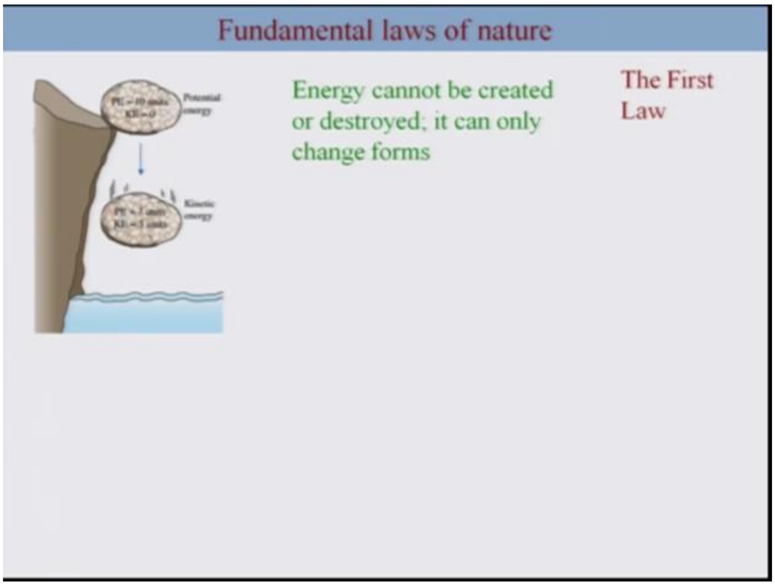

So, let us take (())(1:37) fundamental law of nature tells us by taking an example. So, this is rock on a cliff having a potential energy and it falls while going through this wall, it converts is own potential energy to a kinetic energy keeping the energy of the system cost and assuming there is no loss to the air. So, this becomes or this is fundamental law which we call it other first law of thermodynamics, where energy cannot be created or destroyed can change only heats form. However, this particular law do not talk does not clarify that any process can occur, in the certain direction. Spontaneous process we aware of occurring at a specific direction, for example we can take in take a hot coffee mug and keep it in a room temperature, we know that the temperature of the coffee slowly decreases or the coffee mug cools off.

So, this is we call is spontaneous process it has a specific direction and we aware of that heat flow in the direction of decreasing temperature. However if you take a cool coffee mug and put it in the same room it does not automatically gets heated and that we know that, so process has a specific direction okay. And this particular expect is not covered in the first law this is covered in the second law which talks about the quality and as well as quantity and tells you tells the process occur in decreasing quality and this is something which we are we are going to learned in this particular course.

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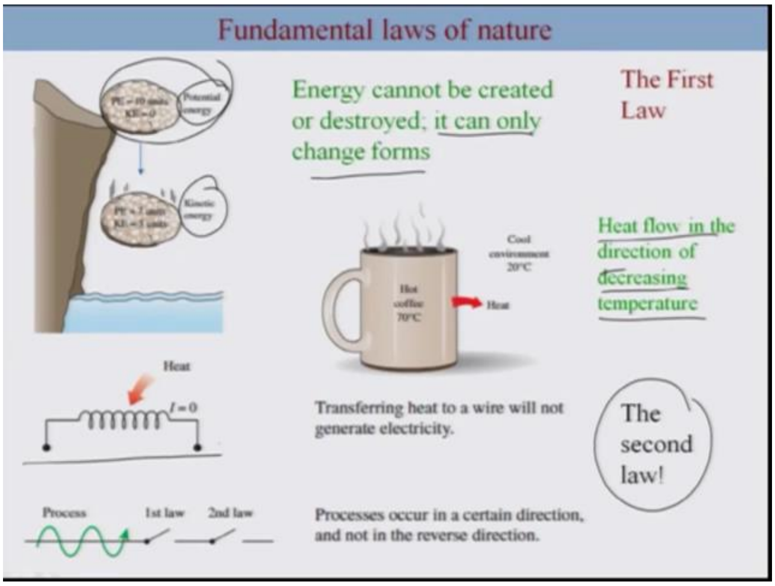

Take another example this is an example of heating coil. So, you use a electricity to generate heat okay, but the other way around it does not occur, for example you provide heat the electricity does not get generated okay. So, this is something we aware of that and hence a process a specific process occur in the certain direction and not in the reverse direction. A process to occur should satisfy first law and second law and this is something which we are which is the basis of this course and we are going to learned more in detail the rest of the course.

Discuss a bit about engineers role, now if you are a mechanical engineer, chemical engineer or electrical engineer or any form of engineer your main aim is to design and developed new processes into the existing process efficiency and while doing so you cut off with lots of questions. So, let us look at a example here which is a production of ammonia.

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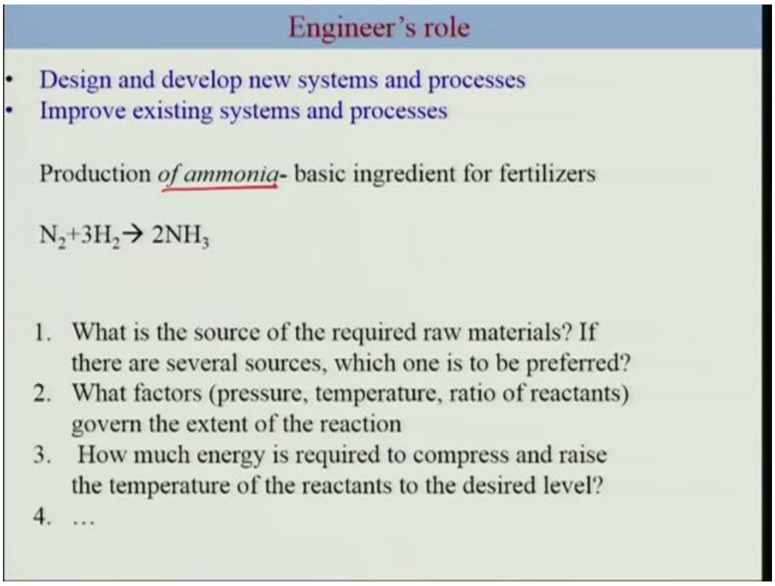

The Ammonia is a basic ingredient in for fertilizer; you know the reaction from chemistry. So, it is N2 + 3H2 goes to NH3 at a certain temperature in pressure. Now you want to design a plant or design the float (())(4:38) sheet where you can operate such kind of a reaction and produce ammonia so that is the source of the required raw material we need to separate N2 from the air. So, you need to compressed the air and liquefied it and separate nitrogen out of it. So, essentially you have to provide some energy in order to compress it.

So, what is the source of raw material so you have to think our raw material is N 2 and H 2 okay? For the case of H 2 the hydrogen we have to do various different options are there in terms of reaction you to choose one of them which is most efficient particularly for your processes because of they are where is different possible ways of generating hydrogen, now in addition we have to worry about what factors pressure, temperature ratio of reactance and the extent of the reaction depending on the conditions. So you have to to worry about that how much energy is required to compress and raise the temperature reacting to the desired level and so on.

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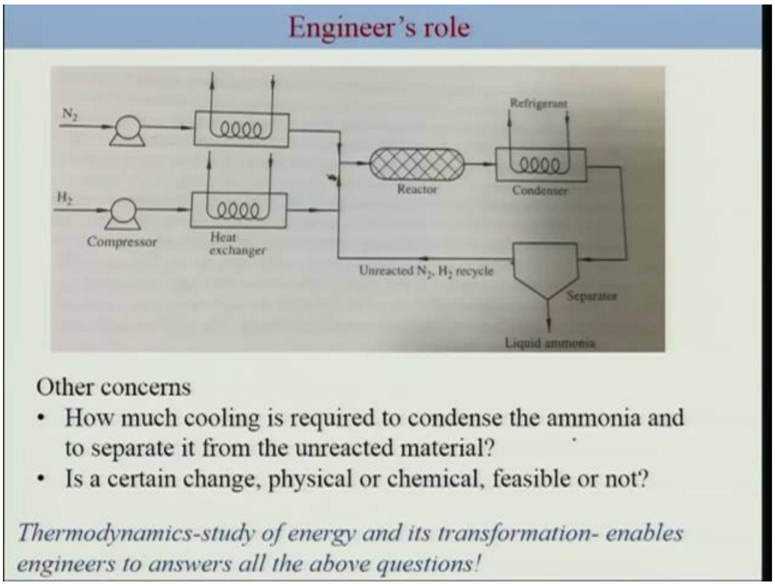

So, there are many questions which should come as an engineer, when you designed such a process okay. So, let us look at to the process, so here we have N 2 and hydrogen let us assume that you have already separated from the raw material. You have of got the nitrogen and hydrogen and you need to compressed it and heat it that you (())(6:01) to need to increase is pressure and temperature to a certain specific temperature and pressure of the reactant and the once it the reaction occurs. So, here the NH3 is produced and then you need to use some refrigerant in order to condense it and once you condense you can separate in the separator and the remaining un-reactant nitrogen and hydrogen goes backs to the initial field to the reactor. So, this is the overall process however there many aspect, when you design such thing.

So, how much cooling is require to condensed the material, condensed the ammonia and to separate it from the unreacted material, is this or are there any changes in these phases or the structure of the fluid whether it goes from gas to liquid and so for that is called physical change or chemical if their reaction is occurring is this reaction feasible at the condition which you is specified. So, having knowledge of thermodynamics which is a study of energy on it transformation enables engineers to answer all these questions and hence you can design more efficient plants okay. So, this is in a just an example that what are the applications of thermodynamics. This is a steam power plant okay. Where the coal here gets burned and still essentially after this burned the steam is generated because was water comes from here.

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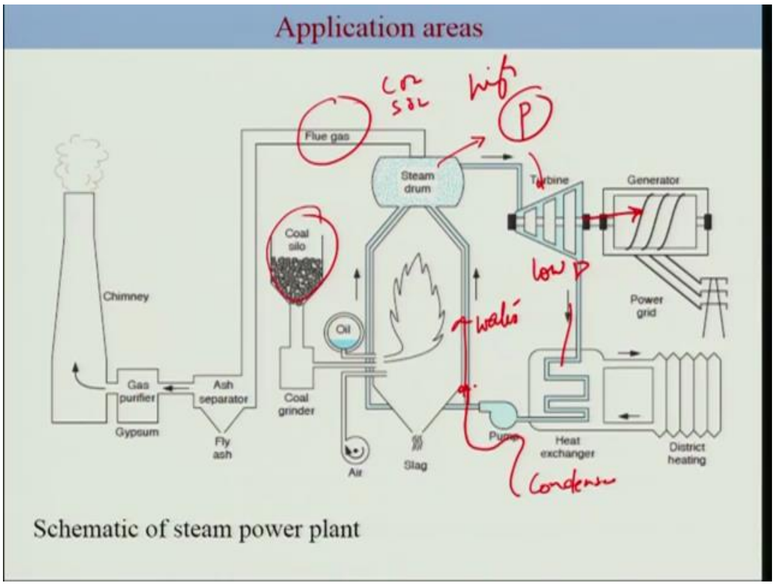

This is at high pressure and what are the remaining gases such as CO2, S2 and SO4 goes as part of the flue gas or also the high pressure you pass through a turbine, turbine with extends and thus some work the work gets converted into electricity through generator and the remaining low pressure steam gets condensed and then recycled here.

So, this is the overall application which we are going to work on study in this particular course many times the important is of course various different phase changes occurring the heat and so forth. So, there is the large scale of large scale application of the thermodynamics. Now you noticed that there is the lot of water being used and hence such plants are much closed to river or ocean.

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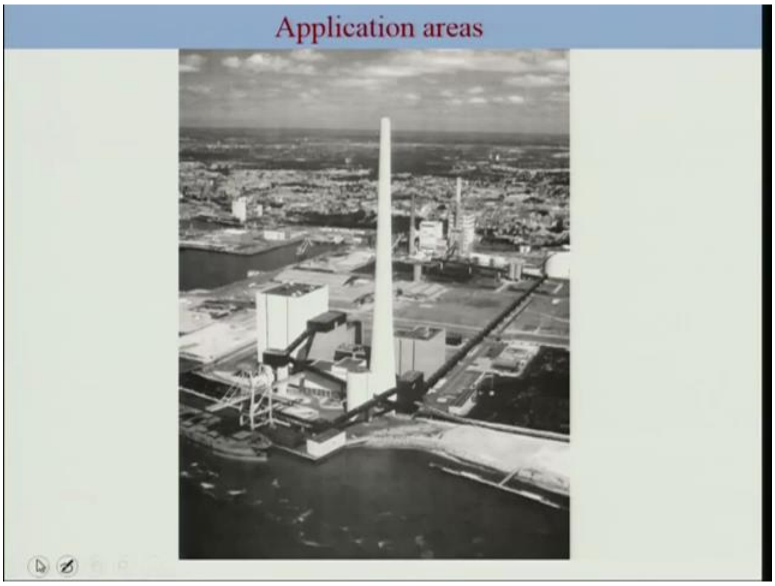

This is a real picture of a power plant in Denmark (())(8:37) and this is one of the very efficient plant where 45% of coal combustion gets converted into electricity. So, we will talk about the efficiency why not is 100% what happens to the 55% is. So, this is this will comes as a part of our second law of thermodynamics okay.

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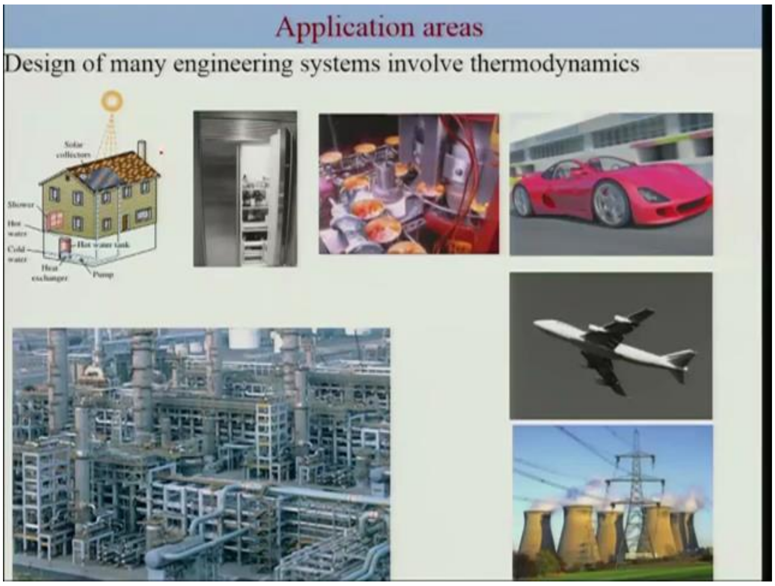

There many different application, so you can see this solar hot plant within for **for** your home there is one application you can think of refrigerator, the food processing, automobiles industry you basic car designed and is basic engines, plane then you have power plants, then you have refineries there are lot of applications of thermodynamics.

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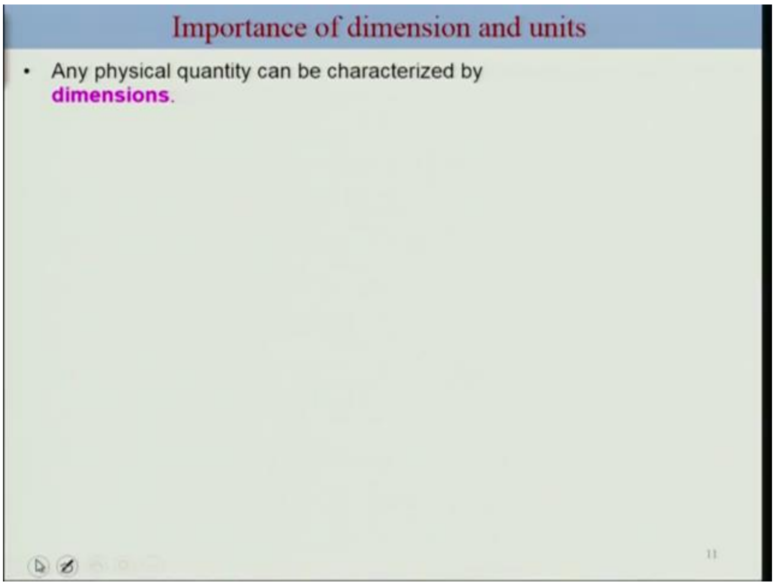

So, let us go to the formal introduction of course you will start with dimensions and of the units. So, any physical quantity can be characterized by dimensions okay. This is a something we ware very well aware of it and the magnitude is assigned to the dimensions are called units. You can have many different forms of units. So, there are primary units or fundamental units these are something called let us say mass, length and temperature, time.

So, these are called fundamental units and they are others units which are derived from the fundamental units such as if you divide length by time it becomes velocity so, these are called derived units, so the velocity, energy, volume these are all the these are expressed in terms of the primary dimensions and thus these are secondary dimension or derived dimension. Now they have many different ways to represent length you can represent length in terms of meter, you can represent in centimeter and the they are many different ways in different part of the world have tried to make use to represent a length of a let us say a scale.

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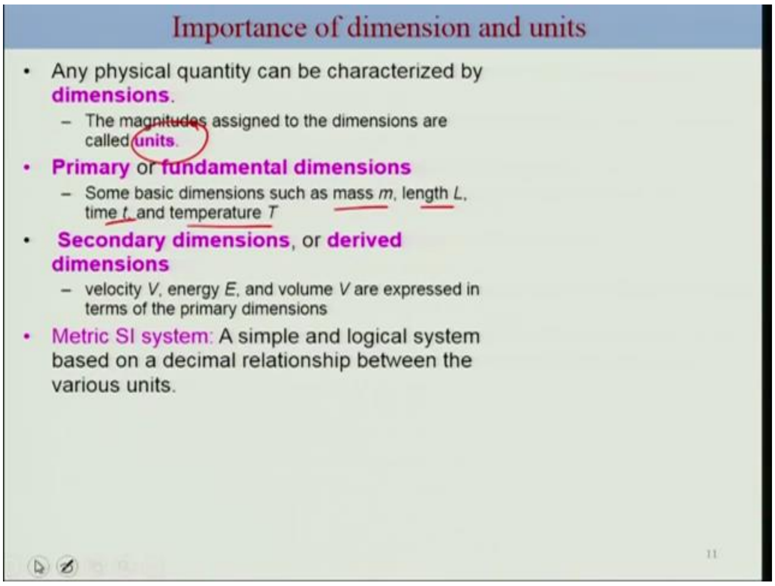

So, however to make sure that engineering divisions are application we make use of a generic units a metric standard international standard system is introduced and which is a simple logical system on a decimal relationship between various units. So, in this system the length is that the is in terms of meter, mass in terms of kilogram, seconds time is seconds, temperature is Kelvin, electrical current ampere, amount of light candela or moles.

Now many times you have large number or very small number in the same units, so for example you can think of let say 1000 meters. So, 1000 meter instead of saying 1000 and 10,000 meter it is useful to use prefixes and SI units allows you to do that. So, the prefixes could be your 10 to the 12 to10 to the - 12 and these are something called prefixes. So, you can have kilometer this essentially is 1000 meter and so on. So that is an advantage of using SI units. The other important of dimension is that dimension must be homogeneous. So, for example if you are relating a variable A to B and C, the unit of B and C is should be same as A and that is the homogeneity should be maintain okay. So, when you apply thermodynamics we look at this specific system. The system is basically interest or quantity of matter or region in space chosen for study.

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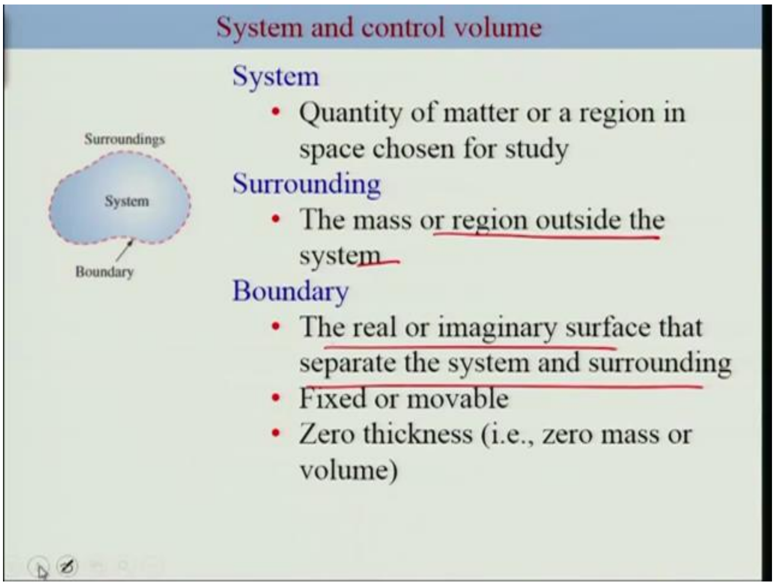

So, so system in this case for example is denoted by this region covered within this dotted line and whatever is the outside the system is called surrounding and the boundary which differentiate surrounding in any system is called the boundary. So, this dash line is basically the boundary okay. So, surrounding as I said is a mass or region outside the system. The boundary is a can be physical boundary can be nonphysical imaginary boundary and typically it does not have any volume okay.

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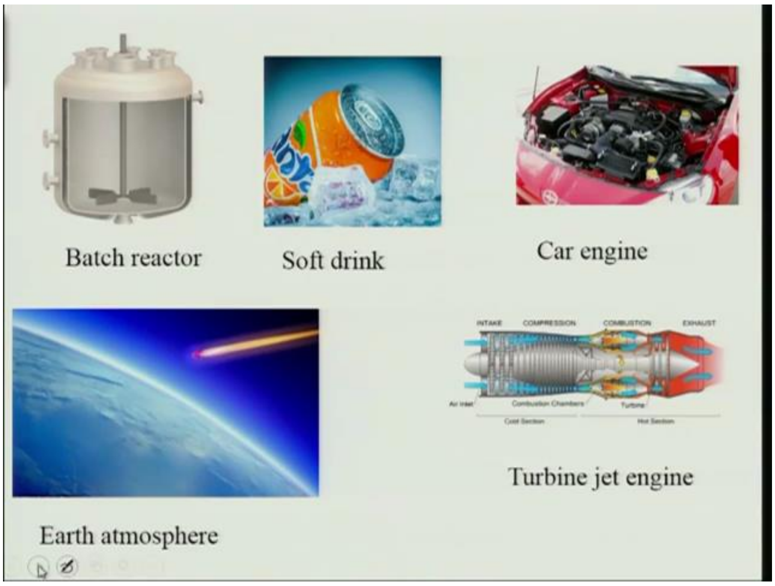

So, the real or imaginary surface that separate the system and surrounding is called the boundary. It can be fixed or movable and it has a zero thickness of zero mass or volume. So, this could be example of system. So, if you have interested you in a in understand the reaction in the in a reactor so, the reactor becomes your system, you can put this dash line like this and you can make this is a system. If you have interested to look into the changes occurring with the fluid within this can then that becomes a system or the car engine or the atmosphere of earth or the turbine jet engine, so, these are all example of systems. Now system is defined to various different forms, you can up closed system, you can open system, you can have isolated system.

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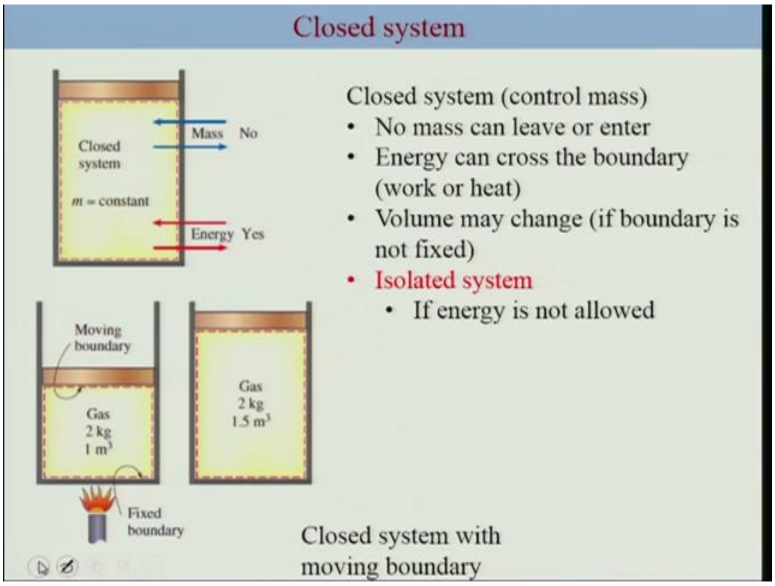

So, let us go step by step, so this is an example of a closed system. So, in the close system we do not allow any mass to leave or enter however energy can cross the boundary. So, in the form of work or heat and we are going to talk about work and heat later on in this course. Now in the closed system the volume may be fixed if the boundary is fixed, but it the volume can be change depending if few allow volume if you allow the boundary to move and this is an example. So, you have a close system with mover boundaries called piston cylinder device. So, heat up a system and this particular boundary will move up in order to accommodate the energy transfer to the gas and hence the volume will increase here okay.

So, this is a example of closed system with moving boundary okay. If you isolate a system such that the heat cannot be transferred to the system, when the energy, energy of the system and as well as the mass cannot be changed in the sense you cannot allow the mass to enter and as well as the energy will not be able to enter if you isolate. So, in isolated system the energy and mass cannot enter or leave.

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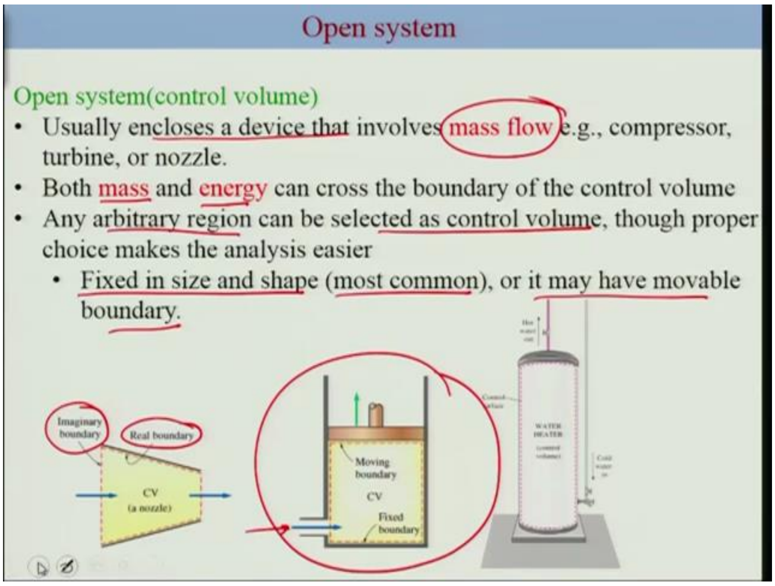

So, but they are other examples where you need to consider flow. Where mass need to also transfer from the system to the surrounding and this is the common occurrence in a engineering applications such as turbine, compressor or nozzles and this is, so this kind of devices involves mass flow and in such case both mass and energy can cross the boundary of the control volume okay.

So, let us take an example here. So, you have this nozzle and here this dash line becomes the arbitrary region, which we have selected as a control volume, now this control volume you can choose based on your requirement based on your proper analysis. And this typically we again we will be using the dash in order to signify the control volume. Now here you can clearly see that some part of the control volume is a real and some parts are imaginary okay.

Now this control volume would be in fixed in shape and size most common or it may have also movable boundary. Now this is an example of movable boundary, where this particular part of the piston cylinder can change depending on the pressure induced by the frame. So, the open system allows mass to flow and energy can also cross that boundaries. So, this is an example of a simple water heater, where you can clearly see that the cold water comes in and the hot water comes out. So, there is a continuous flow here and hence the mass can enter and as well as energy is also transferred for one because this is a cold and this is a hot so energy is also being transferred or crossing the boundary, so, this is an example of open system.

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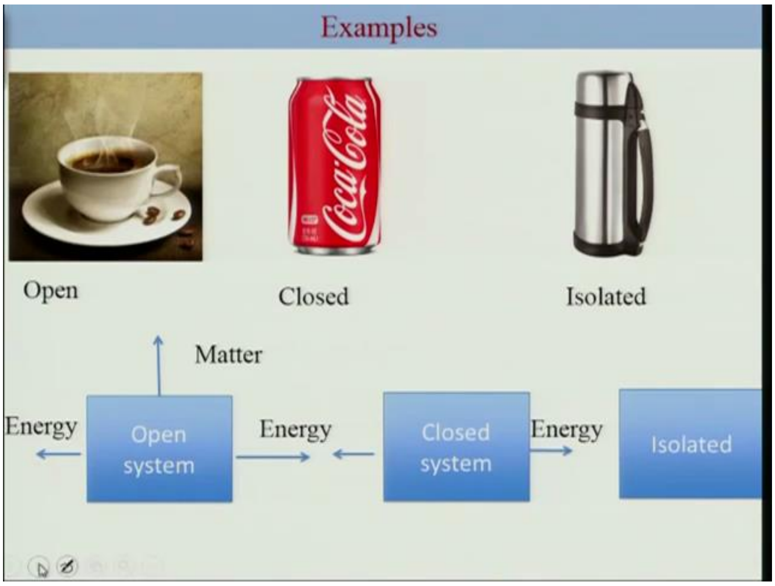

So, let us take other examples for this is your typical coffee and you have a coke here and then you have thermos. Now this would be a example of open system the next one would be example the closed system and what about the thermos. So, that would be an isolated system, so within the time frame of your interest that there will be no transfer of energy from the thermos to the surrounding.

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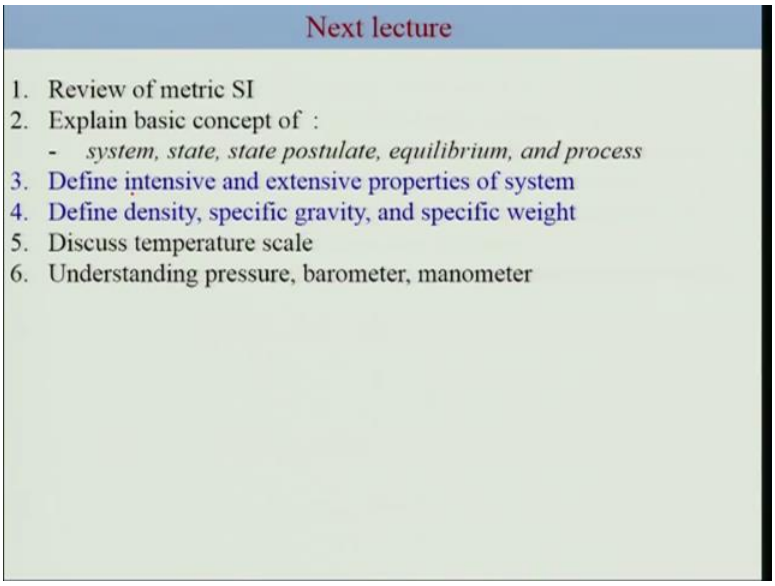

So, we can summarize these examples that in case of open system you have a matter can exchange, in case a closed system, energy can exchange, in case of isolated system nothing will be exchanged with this surrounding. So, in the next lecture what we are going to cover is we will define intensive and extensive property and define density as specific gravity an so we will see you in the next lecture.