Engineering Thermodynamics

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Lecture 02

Thermodynamic Property, State, Equilibrium, Process

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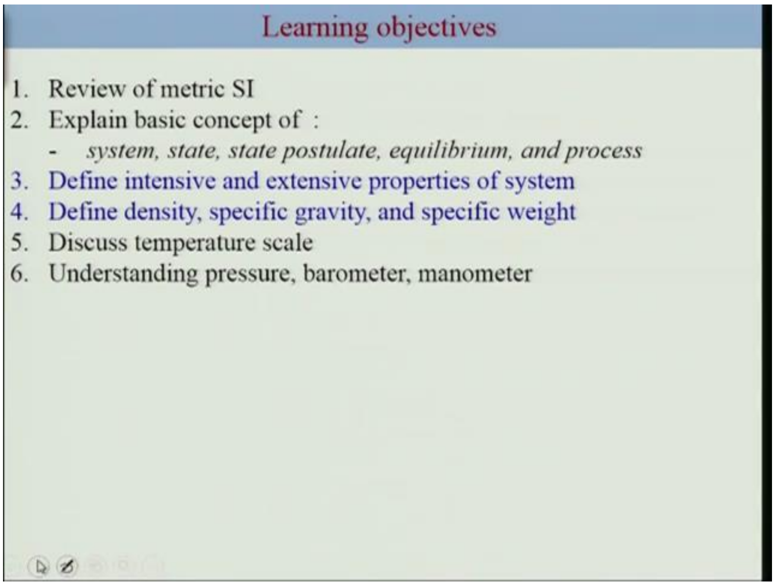

So, in the last lecture what we went through was a review of our metric SI and the concept of system surrounding boundary, now we are going to talk about an intensive and extensive properties okay. So, let us look at a thermodynamic system which may consist of many species, for example you can look at a nitrogen hydrogen and NH3 in the similar example which we had assume in the lecture for the production ammonia.

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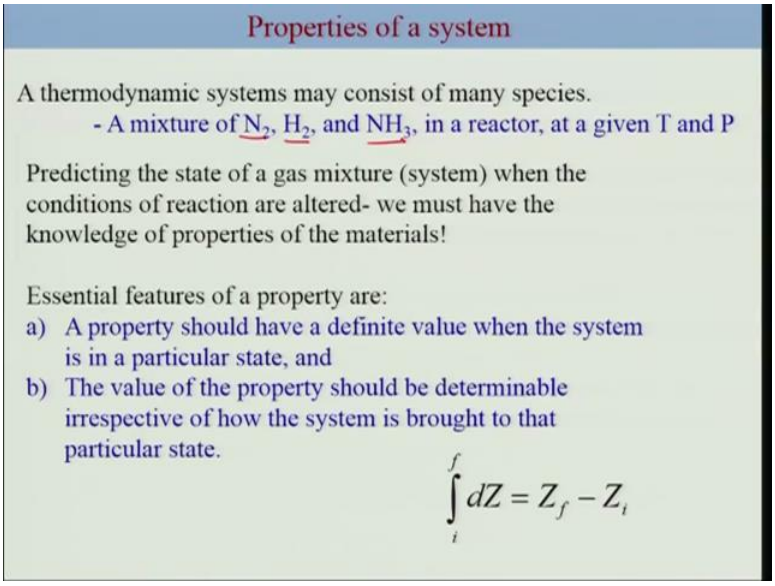

Now if you want to understand change of the state of the gas mixture if you change the condition, then you need to know the property of the materials. And the property of the materials in this case which depends on temperature and pressure and you have to choose the specific set of properties, properties such as odorless or other property which are relevant for portable water, for example is not relevant for thermodynamics. In thermodynamics the properties which are related to energy and its transformation are only useful in the analysis. So, the essential features of property would be that is should have a definite value then the system is in a particular state. Again I will say property such as odorless or tasteless on at useful in the thermodynamics analysis you have to choose properties which has a certain value which is related to the energy or changing energy.

So, a property should have a definite value one a system which is a specific state and the value of the property should be determined irrespective of how that particular state was achieved or was brought to that particular state. So, does not matter how this state was achieved, the property should depend on the final value. So, the change in the property from one state to another state can be clearly written in this expression whereas that is a specific property and it change is a change in there it is value from some initially state to the final state is given by the difference between these two and by the difference between the value of the Z into the particular state.

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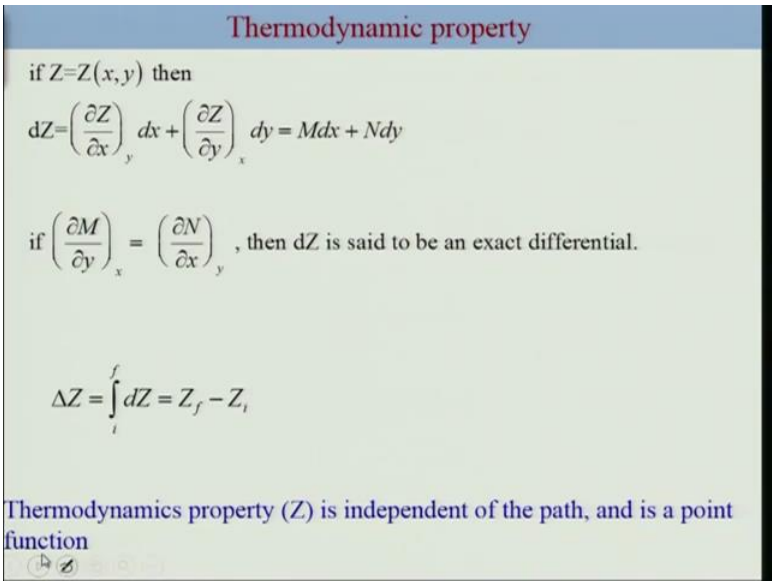

Now let us little bit look at the mathematics so if you says that depends on the two variable X and Y you can write the differential of Z in the following form, where the partial differential in of Z with respect to X is given by M and this is N and mathematics tells us that if this condition holds, then dZ is said to be an exact differential. Now in such condition you can integrate this in this form that means you can write Del Z as an integral of dZ form i to f and this would be given as the difference between Z of final and the initial values.

And therefore, thermodynamics property Z is an independent of the `path because of the exact differential and is a point function, so, this is a definition of the point function okay.

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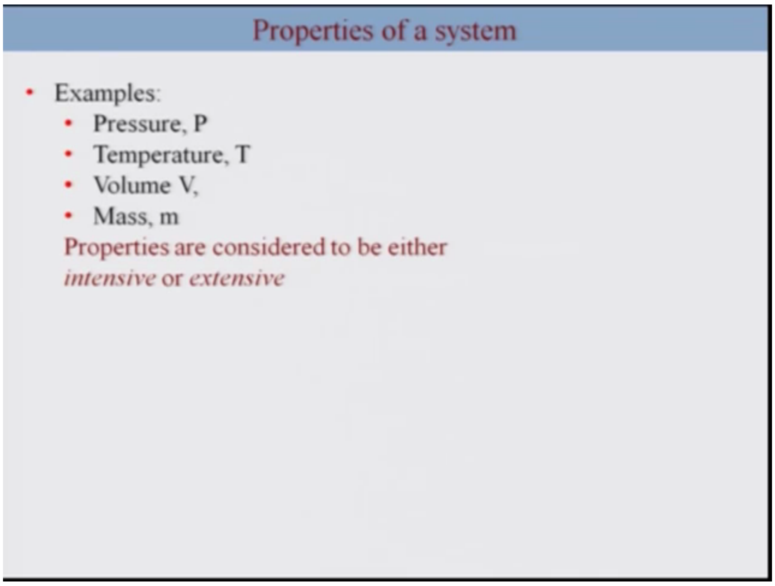

So, let us look at common properties of a system the examples are pressure, temperature, volume and mass. The properties can be extensive or intensive so, just take a an example let us consider a system this system can be simply water or any fluid okay, having a mass m, volume V, temperature T, pressure P and density Rho.

Now you divide this particular system into two parts okay and that you can do in this form where you have divided into two part one and part two. Now the mass certainly gets divided by two volume certainly gets a also divided by two, on the other hand temperature of both the parts should remain same, the pressure should remain same and as well as the density, that is the what we can understand for all daily experience by taking water in a glass and dividing into two parts so. So, certainly certain properties are affected by this aspect of let say division of the volume which means it depends on the volume of the mass.

On the other hand, the other properties do not such a temperature, pressure and density. So, that becomes the basis for categorizing properties into intensive and extensive. So, intensive properties are independent on mass, examples are temperature, pressure and density and extensive properties are which depends on size or extend of the system mass, volume, total momentum, these are the extensive properties okay. Now they are other properties which are calls specific properties which are extensive properties per unit mass such as specific volume which is basically volume divided by mass and a specific volume becomes a intensive property. So, typically the specific properties are intensive property such as specific volume.

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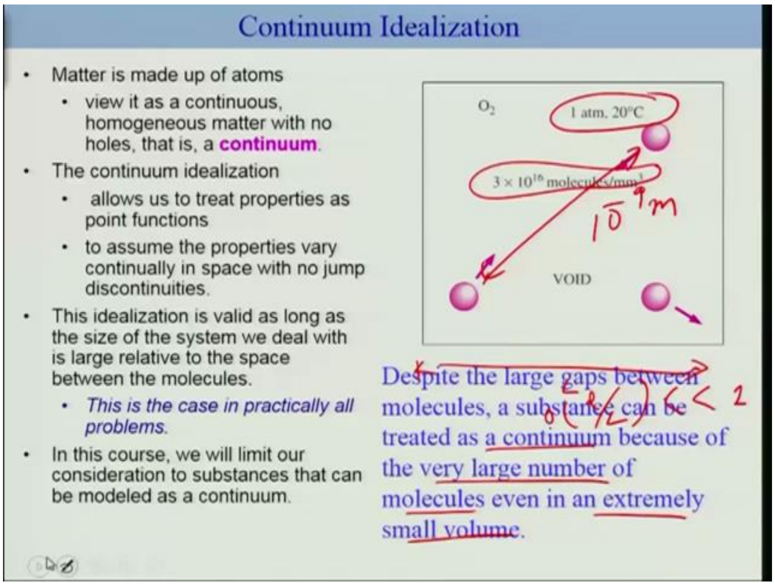

Now in the typical matter what the matter if you know of this contains of many different atoms that falls we do not see these molecules or atoms around for us it is looks like a homogeneous. And this is what we are going to use as an approximation we are going to use this system as continue and this is idealization. But it is not so on and it is so bad approximation because if you look at the distance between these two atoms here in this case this will be of the order of 10 to the power - 9 meters okay. And for example this is a oxygen in certain volume at atmosphere 20 degree Celsius and there are these many molecules in the system.

So, if you look at this distance and divide by this distance the order of L by L is going to be extremely small and in such case this matter will look like continuous and this is not the approximation we are going to use. So, despites the large gaps between molecules a substance can be treated as the continuum because of the very large number of molecules even in extremely small volume. Now this allows us to do consider that the properties are also continuous.

So, it allows as their property vary continually in space with no jump discontinuity. And considering the system which we are going to look at the because of the size of the atom which are extremely small this would be their practical case for all our problems okay. So, when I have to going to take sand particles or grain or asteroids which are extremely large or large in size. So, in this course, we will limit in our consideration to substances that can be model as a continuum.

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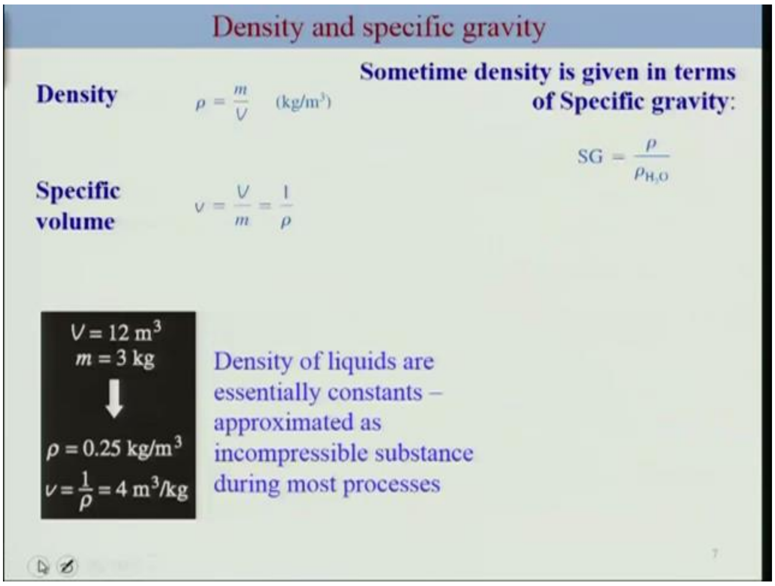

We will consider this kind of definition so if definition of density is very well known mass by volume specific volume is going to be volume by mass or one by reverse density. Now you have this specific gravity also which is the ratio of the density of the substance with a density of the water, now this density of water will be considering at 4 degree Celsius where the density of the water is maximum.

Now you can look at the specific gravity for various different substances some are greater than one some are less than one those which those having specific gravity that is let us then one will float on top of the waters layout okay. Now density of the liquid typically constant and we will be considering to be constant, so that is why they are part of called incompressible substances though there are slight change if you increase the pressure substantially, but otherwise we will be considering a constant density in this particular constant. So, furthers defined few things what is a definition of state in thermodynamics.

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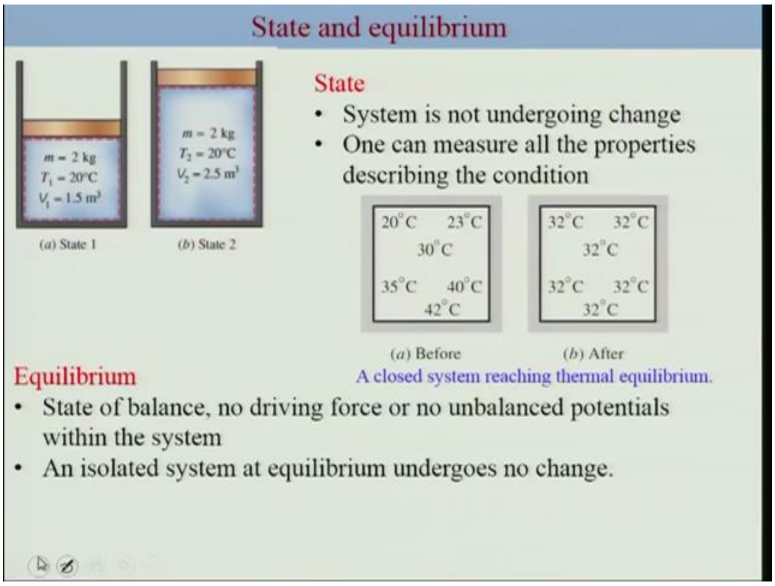

So, let us consider a system which finally stops change in at all in our, so it undergoes the change and then reaches a point, where no change is in the properties are same. In such case the one can measure the properties all kind of properties. So, a specific step means a specific value of the properties, so if you fixed the values of the property you achieve as press particular state and this is an example you have a state one or with the mass 2kg 20 degree Celsius 1.5 meter cube you change the volume to 2.5 you change the state. You are changing just one property of the state and you are changing the state of the system.

So, that is how we going to define a state having a fixed set of properties. The other expect of thermodynamics where going to deal with is equilibrium the where is different kind of equilibrium. So, let us look at what is definition of equilibrium, so equilibrium is a state of balance there is no driving force or unbalanced potential within the system. So, let us take a case where you have variable temperature within the system okay. And after isolating this course system it reaches continuous constant value of the temperature throughout the system. So, a closed system reaching thermal equilibrium this is an example for that. Now if you take a system in isolated at equilibrium there will be no further change. So, as after this particular system if you isolate it there is going to be no change.

So, even if it a close system let say if at all isolated let it equilibrates to a specific temperature and then you isolate this isolate, then there will no further change in a system because there will be no interaction with this surrounding okay. So, that is how we are going to define the equilibrium there are many from of equilibrium or system it is state to be at equilibrium, when all kind of equilibrium conditions are met (())(10:22). The equilibrium conditions are thermal equilibrium, mechanical equilibrium, and chemical equilibrium.

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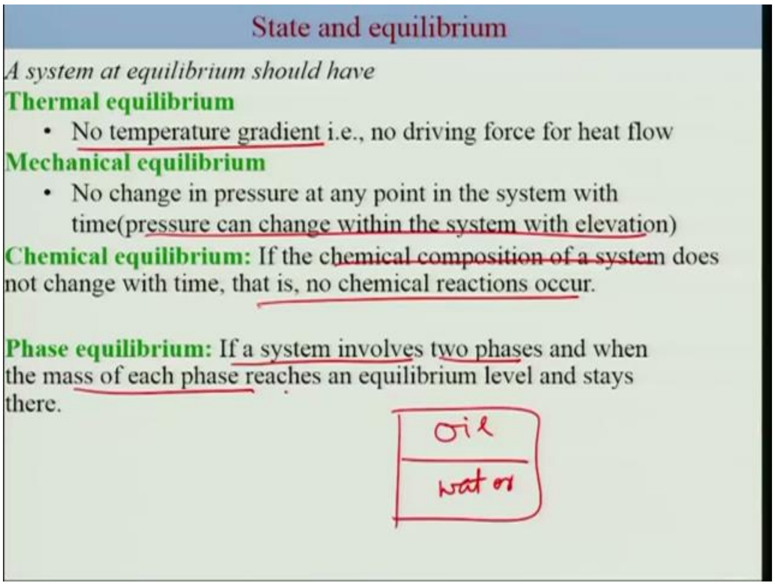

So, let us look at one step by step in thermal equilibrium will be where there is no temperature gradient that means there is no driving force for heat flow. A mechanical equilibrium is, when there is no change in the pressure with time. So, there is no driving force for a fluid to flow, so a pressure can change within the system with elevation but in such case the forces will be balanced, then you have this chemical equilibrium. So, if there are no changes in the chemical composition of a system, then the system is at chemical equilibrium. So, for example we can consider like sugar dissolved in water and there is no changes in the chemical composition throughout the system and it will be say that chemical equilibrium. Now there is something called phase equilibrium. Now this is relevant, when you have more than one phase so phases such as liquid, gas, and solid.

So, if you have for example two liquids let us say oil and water, after you shake and you let it stay for while oil separates and water separates and there is no change in the composition of the oil and as well as in the composition of water after a while and there will be consider to be at equilibrium because they will need the thermal equilibrium they will need the phase a mechanical equilibrium as well as they are at two different phases.

So, hence phase equilibrium is this is a system which involves two phases and when the mass of each phase reaches an equilibrium level they has stays there. So, this is an example of phase equilibrium or so then we know that the state have a series of the properties or set of properties and if you change one of the property the state will change. But it is not necessary that you have to define all the property to fixed a state there is a minimum number of properties which you must define or rest of the property gets fixed upon once you define this minimum number and that is how that is what the state postulates tells us.

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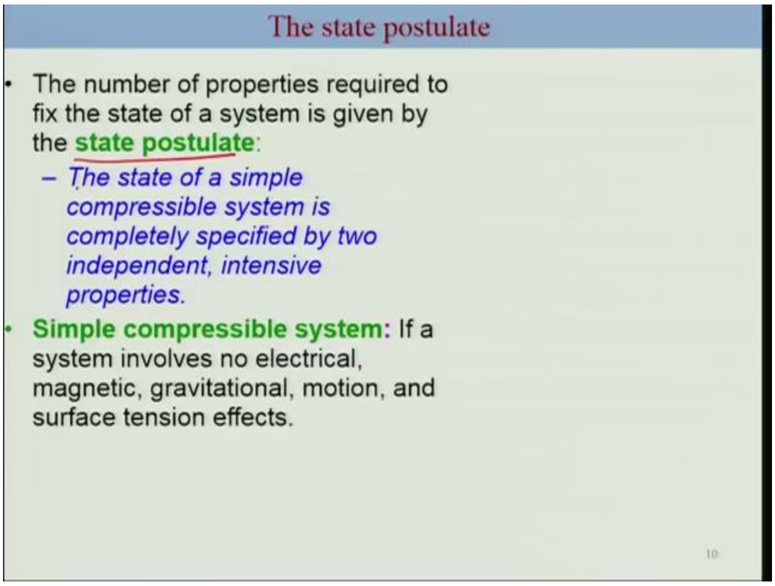

So, state postulates is the state of a simple compressible system which is completely specified by 2 independent, intensive properties okay. Now what is a simple compressible system which is a system which involves no electrical, magnetic, and gravitational and surface tension kind of component? If you have those then you have to include another variable in order to define the state. Now this is an example of a specific state where to just two variable is been define temperature and specific volume okay.

Now you can make use of temperature and pressure also or this is relevant only for single phase, for single phase temperature and pressure are independent but for two phases first for example where water a liquid is converted into vapor, then the temperature pressure gets related. So, this is kind of one example where you know that at sea level when the pressure is one atmosphere water boils at 100 degree Celsius write and when we go to mountain the pressure is less than **p** atmospheric pressure and the boiling temperature also gets reduced. And in such cases when there is the phase change temperature is the function of pressure. The temperature of the boiling temperature is a function of pressure.

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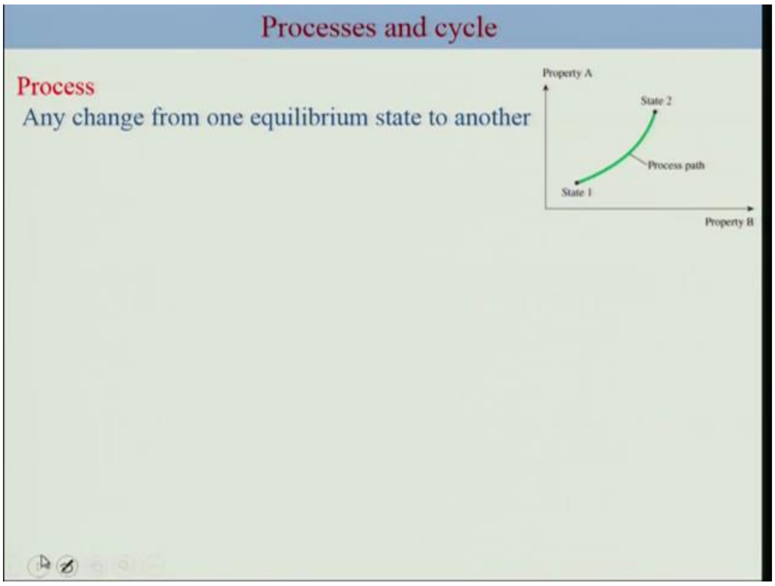

Many state you can change along do a process. So, we will be defining the process here that any change from one equilibrium state to another. So, this is an equilibrium state and this is an equilibrium state or this is a process path okay. So, the process path is the series of state through which the system passes through. So, essentially it means that each of them along this green line is a state. And this is this is a specific state, this is a specific state of our interest or they are processes which are very fast, they are process which are very-very slow, a slow process where the intermediate point along the path or at equilibrium or Quasi equilibrium It is called Quasi equilibrium process. So, this is an example where you are using the slow compression in order to reach in order to make use of equilibrium thermodynamics what you are doing here…