MARINE ENGINEERING

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Lecture9

Radiation

Now, we will see radiation formula. Radiation formula heat transfer equals Q equals epsilon sigma A T S power 4 T O power 4. surface temperature and other body temperature. The Stephen Boltzmann constant sigma is equals 5.67 10 power minus 8 watt per meter square and K power 4 Kelvin. Absolute temperature on surface T s Kelvin, so Kelvin is capital T, capital K, so do not write small k, small k means kilo, we write small k, but when we write temperature Kelvin, we write capital K, that is standard notation from SI unit.

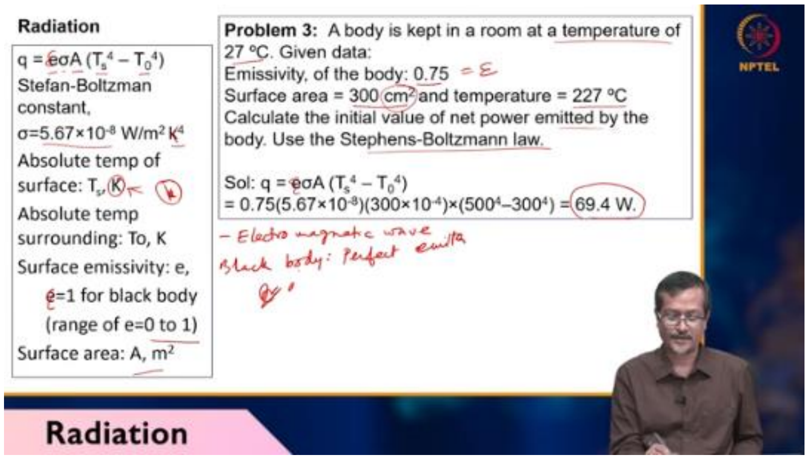
Absolute temperature surrounding temperature like T o, again Kelvin, surface emissivity, emissivity you can write E or epsilon, 1 for blackbody, Black body means the perfect absorber or perfect emitter. epsilon equal to 1 for black body range 0 to 1. Surface area A meter square. Now, you see the problem.

A body is kept in a room at a temperature of 20 degree centigrade. Data is given. Emissivity is given. Surface area given 300 centimeter square. You should note down this unit.

Temperature 220 degree centigrade calculate initial value of net power emitted by the body use Stefan Bozeman law. So, this law you have to use actually. Q equals epsilon sigma 8 Ts power 4 To power 4. from that you can get 69.4 watt. The electromagnetic actually radiation is actually electromagnetic wave, electromagnetic wave known as radiation.

Thermal, this is electromagnetic wave, I will write it. Electromagnetic wave. Thermal radiation is emitted by every particle having a temperature greater than or absolute, greater than the absolute zero. as absolute zero, it will not be emitting any radiation, but greater than absolute zero, all particle will be radiating some energy. and mobility of particle inside the body what causes the thermal radiation.

The motion is wholly stopped at absolute zero, the particle will not move at absolute zero, which is why the body at absolute zero does not admit any radiation, whereas anything above absolute zero does. And black body, so black body is a perfect emitter or absorber. or absorber and you can write absorber. Now whenever talking about heat, there are few terms you have to remember. Latent heat, sensible heat, super heat.



Those terms we will be using when I will be teaching you steam engine. boiler systems so if i take water at constant pressure let's say you have one vessel and again you have one chula okay and you are boiling water what will happen initially you are boiling but there is no steam coming out actually you cannot see any steam so after certain time only you can see steam coming out bubbles are getting created and lots of steam is coming out right so you are boiling actually in one atmospheric pressure you are not increasing any temperature. But if you have any pressure vessel, let us say pressure cooker, you have any pressure cooker. in that case, you will have one vessel that high pressure system.

in that case, you are increasing pressure actually. normal open vessels, it will be working at one atmospheric pressure. initially you are giving heat, it is not creating lots of bubbles and not creating lots of steam so that is that time it is increasing temperature let us say initially you are taking water at 20 degree and it is reaching to 100 degree centigrade temperature right so that temperature is called uh sensible heat you put one thermometer thermometer will show temperature a thermometer will show temperature increasing from 20 to 100 okay so this is called sensible heat Use thermometer okay if the thermometer be showing your temperature at 100-degree centigrade you get you to give lots of heat your fuel is burning your coal or wood or gas burning but your temperature will not increase the thermometer will show 100 only what is happening at 100-degree centigrade your phase change occurring means water will be steam okay so this is called latent heat so some heat latent means hidden some heat will be hidden in in the steam water 100 degree centigrade whatever energy was there when it is becoming steam its energy will be higher so some energy is hidden but you cannot capture in thermometer okay that is why it is called latent heat okay so boiling water is happening so latent heat will be there so that time you are giving lots of heat but nothing is happening i mean temperature is not shown in thermometer then After that, one condition will be coming called superheat. And liquid, when you are reducing temperature, let us say 20 degree to 10 degree, 5 degree, 0 degree, 0 degree again phase change will be occurring. It will be solid. Again, that is called latent heat.

During solidification, liquid to solid, ice formation will be there. that time also, reduce temperature reduce temperature but thermo it will not show it will show only zero degree centigrade temperature so that temperature is again called latent heat hidden heat okay ice is there increased temperature zero degree centigrade ice zero degree centigrade water amount of energy inside ice and inside water will be different water will be more energy actually okay because this zero degree centigrade lots of hidden heat water has taken from okay from surrounding that is why ice will be melted because ice water particle will get more resonance and it will be having more heat inside. And ice specific heat capacity 2.1 kilo joule per kg, melting ice latent heat.

these values actually you have to remember. Liquid water specific heat capacity 4.2 kilo joule per kg per K. boiling water when happening latent heat you have to remember two to six five kg per kg now open vessel you boiled and you got 100 degrees centigrade but after that you cannot measure because water temperature will not increase right pressure also you are not changing but in case if you have one pressure cooker so pressure cooker if you put inside one thermocouple inside pressure cooker.

temperature will increase, it will cross 100, 100, 1, 2, 3, 4, 120 it will go. Your pressure cooker whistle will be, noise will come. Then what is happening? Inside pressure increased. Inside pressure increased, so boiling boil also increased.

normally inside pressure cooker, pressure will be 2 bar or 2 times of atmospheric pressure. and your boiling point will be around 120 degree centigrade. how to show this one on a graph? Then in that case, we draw one TS diagram and this was saturation line. Saturation line means the left side, this side, this side has a liquid zone.

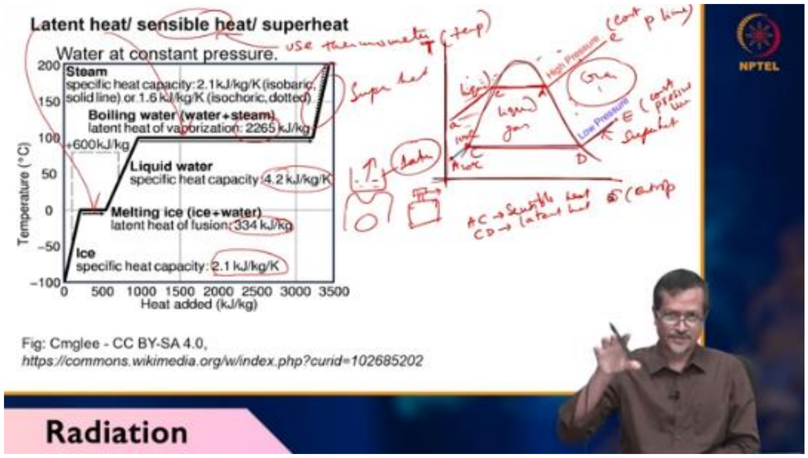
this side gas and inside gas will be there. What is happening? Initially, you take water at 20 degree centigrade temperature, let us say here point A, you increase temperature, it will reach to 100 degree, this temperature left side. 100 degree centigrade, it will reach 20 degree centigrade, then phase change will be occurring here. C to D. So, A to C your latent heat and C to D, A to C your sensible heat, C to D your latent heat and D to further if you go up that will be calling as a superheat.

It will be gaseous state, but it will be having a little bit more energy than in AC or DC zone. DE may be. Now, this is normal, your normal vessel, A to C, C to D you can check. But if you have pressure cooker, so pressure cooker, pressure will be increasing. in that case, your curve will be like this, upper curve.

Let us say small a, small b, small c, small. A, C. I have not given B. Then A, C. Then D, E. So, if you have pressure cooker, then your temperature will be increasing, the boiling temperature. You can see this boiling temperature increased. this line A, C, D, E is constant pressure line. Constant pressure line.

Constant pressure line. a c capital a capital c capital d capital e this line is constant pressure line okay so if you are increasing temperature If you are increasing pressure, your boiling point will also increase. But if you are reducing pressure, boiling point will be also reducing. So, pressure cooker uses this philosophy.

If you increase the pressure, boiling point will increase. at higher temperature actually cooking your food. And this diagram, TS diagram, S means entropy, T means temperature. later we'll be using extensively for refrigeration system design for your steam turbine steam system in boiler also we'll discuss okay so you have one sensible heat zone then latent heat zone then super heat zone super heat zone means your system what water or fluid any fluid whatever you take aniline or anything it will be boiled after that also we are adding heat okay you are containing pressure pressure constant and you are adding more heat so that area will be uh called uh the super heat thing we will be using later when again i will discuss during steam turbine design or refrigeration system design in previous



classes in previous week you have seen this entropy enthalpy definition again we will define a little bit so that later stage it will be easier to remember to calculate specific things so enthalpy formula is he means internal energy p pressure v volume if pressure and volume changing internal energy also be changing so enthalpy also will be changing so enthalpy we get from moliere diagram later we will see how to calculate using moliere diagram but not this week another week i will discuss and entropy the definition also you have seen the thermodynamic function used to measure the randomness or disorder and it is coming from second law of thermodynamics you already know heat definition also you know energy transfer from one body to another body this is actually energy temperature physical quantity to express the coldness or hotness so thermometer will not show heat it will show the temperature so temperature is the effect of heat okay Thermodynamics process. there will be several process in thermodynamics we already discussed actually.

Isochoric process, isobaric process, isothermal process, isentropic process. let us draw one figure. PV, that piston cylinder you can assume that pressure inside is there and this is my piston. you compress it or decompress it. So, if it is isobaric process, constant pressure, isobaric.

And if it is vertical line, this is point 1, this is called isochoric process, isochoric process. And if it is coming like this, isothermal, PV equals constant, you can remember, we discussed already and adiabatic. PV power gamma equals constant, adiabatic means heat transfer not happening, isothermal means heat transfer happening. So, you should remember all these terms, especially this isobaric, isochoric, isothermal, isentropic, isenthalpic, all these terms you have to remember.

where we see this phenomena in piston cylinder element we can see this phenomena in your steam turbine system a steam turbine system later we'll discuss actually in details again we have to draw this envelope ts diagram envelope this is called envelope vapor envelope and phase change will be occurring temperature increasing and superheated thing will be coming then there will be one turbine okay turbine and turbine after turbine there will be condenser from condenser one pump will be here from pump again you are giving heat so let's say one two three four process is there so what is happening pump will be pumping certain fluid and it will give to boiler okay it heating will be starting one one heating started heating is started then what will happen one to one dash one to one dash sensible heating in boiler temperature will be water temperature will be increasing to 100 degree or whatever required temperature then after the phase change will be occurring phase change where occurring one dash to one double dash phase change phase change occurring or latent heat absorption will be happening or

water will be converted to vapor. what is happening 1 dash to 1, 1 dash to 1 double dash, in between actually it will call 2 phase region, this whole inside this one, this area called 2 phase region, 1 dash to 1 double dash, this phase change occurring, then 1 double dash to 2, 1 double dash to 2, this is called superheated region, superheat. And 2 to 3, what is happening 2 to 3, 2 to 3, 2 to 3 turbine work. there entropy, ideally we assume entropy is constant, S equals constant, S equals constant, constant ideal, ideal case, but practically S will not be constant actually.

Again 3 to 4 what is happening, 3 to 4, Whatever water went, steam went to turbine, turbine took energy out. Then after that, the same steam will be having lower temperature, lower pressure. that one you have to cool down, you have to make liquid. So, phase change will be occurring in 3 to 4.

So, 3 to 4 phase change. Phase change, what will happen? Phase change. In 3 to 4, what will happen? Gas is there, gas to liquid.

at 4 point, you got liquid water. Then liquid water you got, then pump it to boiler again, 4 to 1. 1 again, sensible heat, latent heat, super heat, turbine, condenser, cooling or phase change, steam to liquid, again pump. this cycle will go on in steam cycle. similar phenomena will be happening in your refrigeration system, but that is completely opposite system.

here you can see isobaric, which one isobaric? condition is there 3 to 4 actually isobaric condition same pressure process will be happening 1 to 2 same pressure process will be happening but 2 to 3 pressure is changing ok so there is some isobaric some isochoric some isentropic process is there isothermal process also there 3 to 4 isothermal process temperature not changing you should later we will discuss further but you should identify which is isothermal which is isobaric which is isochoric