Surface Facilities for Oil and Gas Handling

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Thermodynamic Laws

We have seen radiation conduction and convection. Now, we will discuss a little bit about radiation. So, radiation means you do not need any medium actually. If it is coming through medium also medium will not be heated. For example, I said already example that airplane moving at 10 kilometre above the earth surface, their temperature minus 40 degree, all the sunlight will be there. So, air is not getting heated up that is why temperature minus 40 degree, but near earth temperature is higher because of convection, earth surface will be heated up because of radiation.

So, that radiated heat will be heating up the nearby air molecule. So, that is why this earth surface temperature 30, 35 degree, 40 degree will be there. But if you go up up up from the earth surface, the temperature goes down. Although sun solar radiation already there.

So, solar radiation is not heating the air, it is heating this earth surface ok. So, it is not heating the medium ok, it is passing through the medium, but not heating. So, it vacuum also it can transfer. So, it is actually electromagnetic energy. So, radiation basic formula is that Stefan Boltzmann formula Q equals epsilon or e sigma A T s power 4 T o power 4.

So, the sigma value sigma actually Stefan Boltzmann constant 5.67 10 to the power minus 8 watt meter square K 4. So, those units also you have to remember and constant because this is universal constant. So, you should remember, you should not forget these values and units ok. Absolute temperature of surface T s in Kelvin.

So, this temperature is given Kelvin actually ok not Fahrenheit or Rankine. So, here it is Kelvin temperature. Absolute temperature for surrounding T o ok, let us say this is heated up, this is T s and surrounding temperature T o ok. Surface emissivity surface how much emissivity is there. So, you can give some value if it is black body is 1 ok, if it is not black body.

So, in problem sometime I will give a black body if I write, then actually you have to assume 1. So, in that case I will not give emissivity value, but if I do not give that black body term, then I should give emissivity value ok. Emissivity value should be 0 to 1, it perfectly white body reflecting. So, in that case actually emissivity should be 0 and if it is absorbing black body it is 1. Surface area A meter square ok, it is everything given in SI unit not in your field unit.

So, see one problem a body kept in a room temperature 27 degree centigrade room temperature given data emissivity of the body 75, 75 surface area 300 temperature 2 to 7. Calculate initial value of the net power emitted by the body using the Stefan Boltzmann law ok. So, this directly you can use the formula Q e sigma A T s power 4 T o power 4. So, e value is given 0.75 sigma value given and T s value sigma value is there and what is 300 A area centi ok area is centimeter.

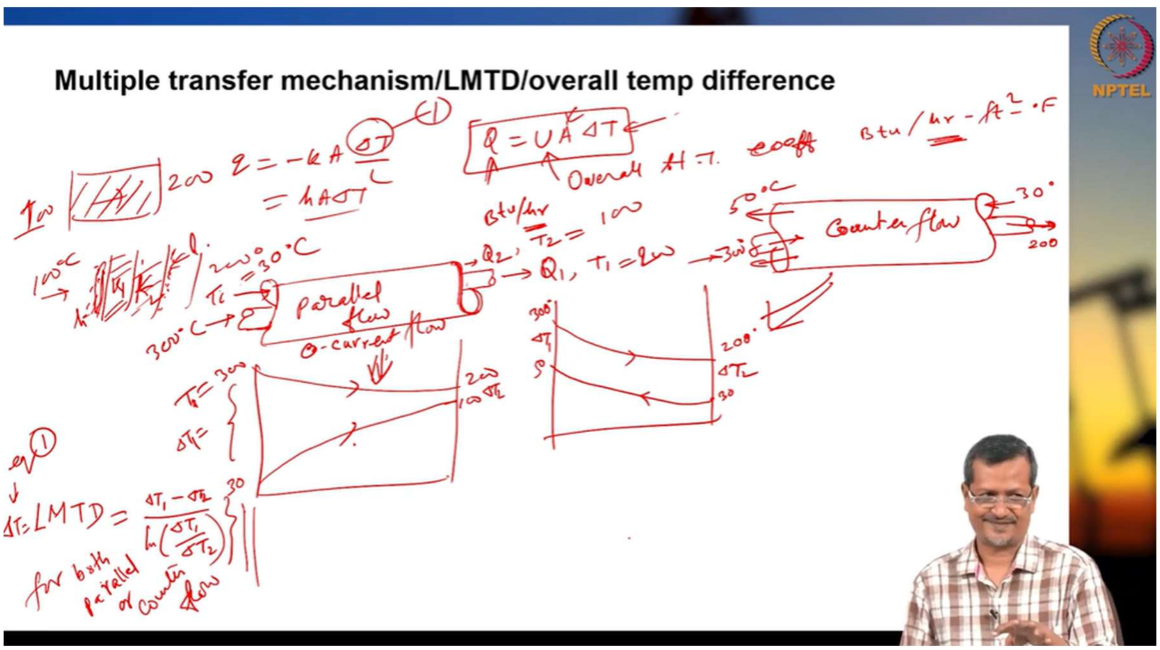
So, you have to convert into meter ok, 300 divided by 100 power square ok. So, it is becoming 300 into 10 power minus 4 ok. So, that value is given here fine and centigrade temperature is given. So, 27 degree centigrade is given plus 273. So, it is being 300 and 227 is given.

So, 227 plus 273 equals 500 ok, you are converting into Kelvin centigrade to Kelvin. So, this is Kelvin actually. So, do not forget ok. If you are putting another unit it will be completely wrong. So, it is becoming 69.

4 watt ok. This is very simple problem you should remember this especially this Boltzmann constant how to solve the problem what the data in required. So, you should remember the formula also ok and for further study you should go to any undergrad textbook ok. So, when ah you take certain amount of ice you increase temperature let us say ice minus 1 degree centigrade temperature ok. You increase temperature then it will be liquid after after certain time. Then again you increase temperature it will be evaporating or it will create loss of steam ok.

So, what happens? You minus 1 degree temperature is there you increase temperature. So, that time it will be ice only till it reaches to 0 degree centigrade temperature ok. So, 0 degree centigrade temperature although you are adding heat x axis if you see heat added although adding heat, but temperature not increasing ok. So, what is happening that time ice will be melting ok some solid to liquid. So, it will be taking loss of energy and molecular change will be happening ok physical change not chemical change ah.

So, that time temperature not increasing. So, you are doing everything in constant pressure. So, you are assuming a normal atmospheric pressure ok. So, that heat is taken during melting is called latent heat ok. Latent heat latent means ah hidden ok hidden heat is there.



So, some amount of hidden heat it will take. So, it will not you cannot sense using your thermometer ok, but if you have anything to measure like heat how much you giving. So, if you have any instrument. So, then you can measure heat is giving you are giving heat and you can measure that one, but temperature thermometer will not show any increasing temperature it will show only 0 till it completely melts ok. Then again it will start increasing thermometer will show increasing temperature.

So, increasing temperature temperature temperature it will reach to 100 degree centigrade ok. So, again everything is happening at one atmospheric pressure if you changing pressure then store will be different. So, assume initially one atmospheric pressure ok. So, at 100 degree centigrade it will be start boiling again temperature will be fixed although you are adding heat ok. No change temperature no change although you are adding heat.

So, this is called latent heat again latent heat of boiling. So, previously it was melting of ice it was latent heat of fusion or melt yeah fusion or melting you can say that a head of melting that is a fusion or latent heat for solidification in opposite way you can say 0 degree water you take and you cool down remove heat ok. So, some amount will be heat will be it will be taking, but will be kept hidden. When it is boiling also it will take certain amount of heat. So, liquid means more molecular cohesiveness more molecular attraction when it is you are making it is steam.

So, that means, you are giving so much energy. So, that they will not be able to touch each other whereas, they will be moving randomly when steam or gas when you are talking about molecular motion will be higher ok. So, Brownian motion will come, but you are reducing temperature you are making liquid. So, Brownian motion will be will not be playing such role because liquid more viscosity will be there. So, fluid will not be moving rather if you are changing 0 degree to 100 degree centigrade water temperature molecular resonance will change ok.

Molecular resonance or molecular will be vibrating more, but when it is crossing 100 degree. So, that the vibration will be so high. So, it will not be touching each other or it will not have any attractive force other it will be moving away and randomly moving here and there ok. So, that will call latent heat. Again after 100 degree centigrade temperature if you are increasing giving more heat.

So, it will be going to superheated region heated ok superheated region this 100 degree at what atmosphere pressure you are giving more heat than the then the steaming temperature or 100 degree centigrade ok. So, that is why it is called superheated region. So, if superheated some steam is there if you want to make liquid. So, first you have to reduce temperature to 100 degree centigrade then it will be starting creating liquid ok. And some values are given so you should try to remember latent heat of fusion 334 kg per kg then liquid heat capacity 4.

2 kg per kg. So, these values are important that is why I have given this picture I have given from kept I have taken from this this picture from Wikipedia ok because of these values are important ok 2265 latent heat for vaporization and this is every time we have to

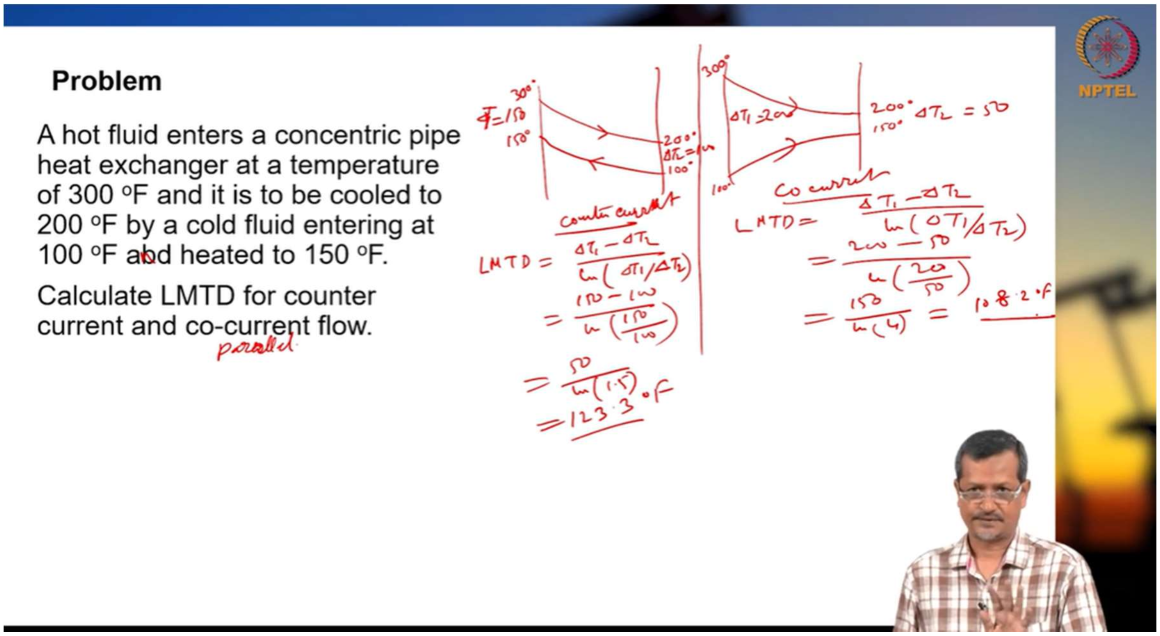
say in atmospheric pressure. If you are changing at pressure then story will be different for example, your pressure cooker pressure cooker normally it will be working at 2 bar pressure then it will create that high steam that the sound will be coming right. So, the temperature will be 120 degree centigrade about a 2 bar pressure. So, if you are changing pressure then your boiling temperature will change your melting temperature will be changing ok. So, if you are applying pressure on ice so it will be melting a normal temperature also.

So, for example, you take 2 ice and pressurize it will melt again release the pressure it will be joining actually. So, joining means the normal temperature you melted again you release pressure that whatever water you melted. So, that one will be ice again. So, it will be fusing together ok. So, if you change pressure so your melting and boiling temperature boiling condition also be changing ok.

So, already we discussed about viscosity in the whole whole course actually we have used the term viscosity several times almost every lecture there will be term viscosity viscosity density because oil and gas when you are talking about. So, you have to play with viscosity density temperature pressure right. So, because it is lecture on heat transfer. So, you have to know that viscosity related to temperature. So, if you are changing temperature viscosity will also change ok.

So, viscosity definition also you must remember it is resistance to flow. So, part if you have higher viscosity particle will not try to flow easily ok. Viscosity in gas molecules transferring momentum because this Brownian motion will be there. So, if you are increasing temperature what will happen particle will be moving more. So, actually when it is moving more viscosity will increase ok, but in liquid it will be weakening the molecular forces.

So, in that case viscosity will be going down if you are increasing temperature, but in gas it will be happening of any opposite this molecular randomness will be increasing it will be colliding more. So, there will be more viscosity ok. So, gas in temperature increases gas molecular interchange viscosity goes up ok. So, molecule will be transferring momentum and viscosity will be going up in gas, but in liquid just opposite will be happening because molecular attraction forces will be reduced because of temperature they will be forcing do not go to nearby. So, in that way viscosity will decrease ok.



So, for that it is go through your any book of viscosity under textbook ok. And now some more thing you have to remember thermodynamic laws. So, in class also many time I asked this one how many laws are there many students will be saying 3, many students will be saying 4 actually there are 4 laws you see the 0 first second third. So, zeroth law first law second law third law ok. So, zeroth law says the thermodynamics thermodynamic equilibrium A equilibrium is B, B equilibrium is C.

So, C will be equilibrium with A. So, this is the rule of zeroth law right. First law first law thermodynamics says work and energy definition work can be converted into energy ok. Second law says entropy concept they are saying work and energy can be convertible, but there will be certain energy loss every time ok. So, there will be no perpetual motion machine perpetual machine machine machine means you design any machine. So, there will be running automatically continuously without supply of any external energy.

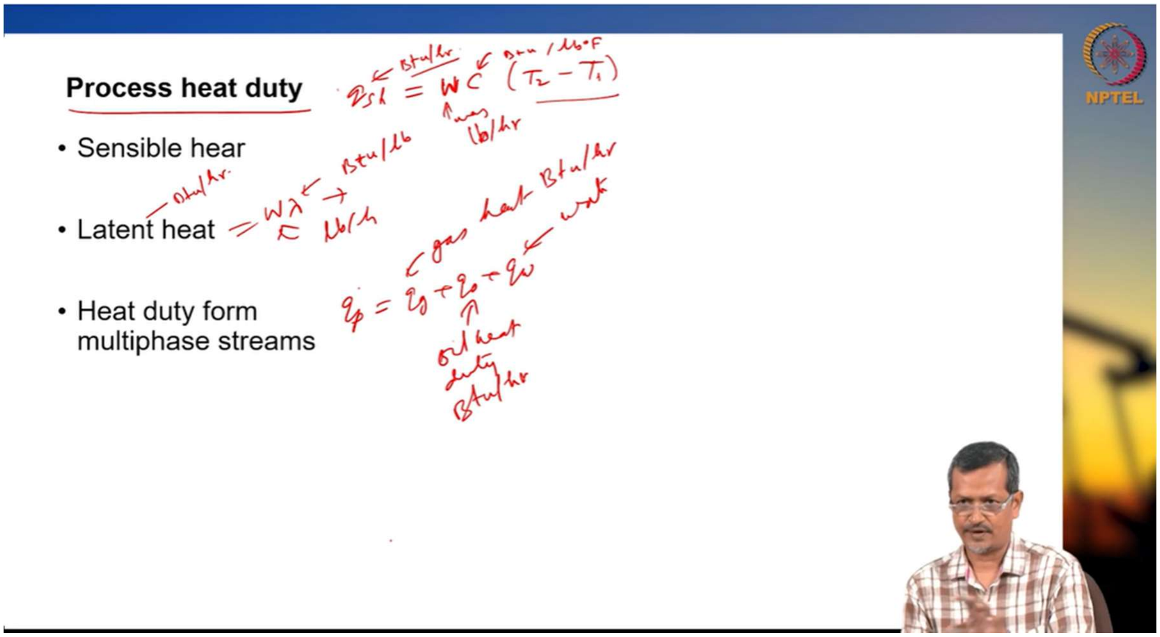
So, there is not possible never possible. So, this is perpetual motion machine is never possible ok. So, you transfer heat from your heater heater to another system and you you are thinking same heat will be taking back and you will be giving to feed. So, there is not possible external heat supply of some energy you must be giving input every time because there will be certain losses which you cannot get back from the system ok. So, second law says that entropy concept and irreversibility ok. When a whatever machines we are running normally there will be irreversible some energy will be lost ok.

So, reversible means some process is going A to B. So, B to A again you are coming there will be no energy loss, but normal machines like say air conditioner running or your camera running or TV running computer and anything. So, there will be certain energy loss you cannot get back never ok. So, that is called irreversibility of process. Third law says entropy of perfect crystal at temperature of 0 Kelvin absolute 0 is equal to 0 ok.

So, this is absolute 0 definition will be coming from third law and there are two statement from for second law actually clauses statement the heat can never pass from colder to warmer body without any work ok. So, that is why this your refrigerated systems are there. So, some mechanical energy must be giving input. So, then you can transfer heat from lower body to higher body high temperature body. So, Kelvin flux statement is impossible to construct a device that operate in a cycle and produce no other effect than production of work and the transfer of heat from a single body.

So, actually these statements like perpetual motion machine not possible ok. So, this this basic definition you should remember because you are trying to learn fluid basically fluid mechanics and machines interaction. So, in that case you have to know definition of work power energy you have to know the thermodynamic laws you have to know viscosity you have to know density these definition those are basic things for your petroleum engineering related subjects ok. You cannot ignore ok. During interview interview also you should remember those basic things units definition of thermodynamics basic heat transfer ok.

So, you should recap I cannot teach everything in this course, but you should recap from other textbooks ok. So, one example is given was the difference between first law and second law. So, many time I ask many student about difference between first law second law they will be giving mechanical definition you can remember this 3 years movie . So, one mechanical definition one is practical definition. So, we expect sometime practical definition whether you understood or not many student will write like day less greater than equals 0 for universal entropy increasing in second law or Clausius statement as it is they will be remembering.



So, we do not want sometimes we ask whether you understood or not ok. So, some one simple example they have given like say if a cup is falling from the table it will break first law says it will come back it will be joining again second law says not possible second law says some energy lost you cannot get back. So, it is not possible to join again, but first law says like it will fall down it will break it will come up it will jump on the table and it will be again cup ok. So, that is the difference ok first law says convertible possible second law says 100 percent not possible fine. Definition of some definition like entropy enthalpy we use several times in your calculations.

So, you should know the definition. So, basic definition you should remember enthalpy like measurement of energy. So, how much energy is there in a body ok. So, a formula is that h equals E plus PV ok P is internal energy P is pressure V is volume ok. So, many time we use this enthalpy term to calculate. Entropy thermodynamic function used to measure the randomness or disorder this is also actually energy ok.

Heat heat definition is the energy transfer from one body to another body if del T is there ok. This is also energy heat is energy ok temperature is not energy this is measurement of heat or physical quantity to express the coldness or hotness you can say not measure of heat. SI unit of temperature Kelvin, but if you are using other type of unit system for example, field unit rather. So, you will have different units, but for SI we use Kelvin and joule for heat ok. Thermodynamic process few process you should know adiabatic process.

Adiabatic process means like you take certain system and heat is not getting going to transfer anywhere else ok. We are assuming all heater inside system. So, you are compressing something decompressing something you are not changing heat. So, that you call adiabatic process.

So, heat no heat transfer happening. So, heat is not changing temperature can change heat is not changing ok you are not going to waste your heat. Isochoric process no change in volume ok. So, the term you should remember isochoric ok. So, no change in volume volume is not changing, but other parameter may change.

Isochoric bar bar means pressure ok. So, isochoric when you are saying iso same bar pressure same pressure system means no change in pressure ok. So, temperature and other parameter may change, but you are not changing the pressure. Isothermal therm again you are saying therm is temperature. So, no change in temperature. So, no change in temperature means make process so slow that heat will be dissipated and you are maintaining temperature ok.

So, that Boyle's law you can remember PV goes PV goes constant ok. So, PV constant like if you are making very slow process. So, heat will get dissipated from the system let us say this is piston cylinder and you are compressing this one this is gas ok. This is piston cylinder ok and this is gas you are compressing.

So, you are changing pressure. So, volume changing ok. So, this is you are moving ok you are compressing. So, what will happen it will be getting compressed volume will be changed. Now temperature will also get up, but if you are making system so slow the temperature will get dissipated heat will be getting dissipated. So, temperature maintaining. So, in that case very slow process Boyle's law will be holding ok, but if you are making faster process.

So, one piston cylinder cycle pumper you are taking very fast you are pushing. So, if you touch this cylinder wall it will be very heated very much heated up ok. So, very fast process. So, temperature increased you did not maintain this isothermal condition.

So, Boyle's law will not hold. So, in that case formula changes like this p v p v power gamma equals constant ok. If system is faster then p v power gamma if the system is very slow you are making isothermal. So, in that case p v equals C fine. So, gamma value is actually specific heat constant gamma equals normally 1.

4 that value you take right C p by C p ok. Some values also you should remember actually freezing temperature, boiling temperature, absolute temperature C already know centigrade 0 degree 100 degree F 32 220 K R ok. This table you should try to remember this same value sometime you need these are because absolute fixed value. So, you should remember ok. Already you may be knowing centigrade Fahrenheit, but other you can use some conversion formula you can directly convert or you can remember. So, many student will be trying to remembering things many student will try to remember the formula. So, that they can convert any temperature to any temperature.