INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NPTEL
NPTEL ONLINE CERTIFICATION COURSE

Refrigeration and Air-conditioning

Lecture-18
Vpour Absorption Systems-1
with
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Hello I welcome you all in this course on refrigeration and air conditioning today we will start with the vapor absorption systems in this lecture I will been covering faraday's experiment absorption refrigeration.

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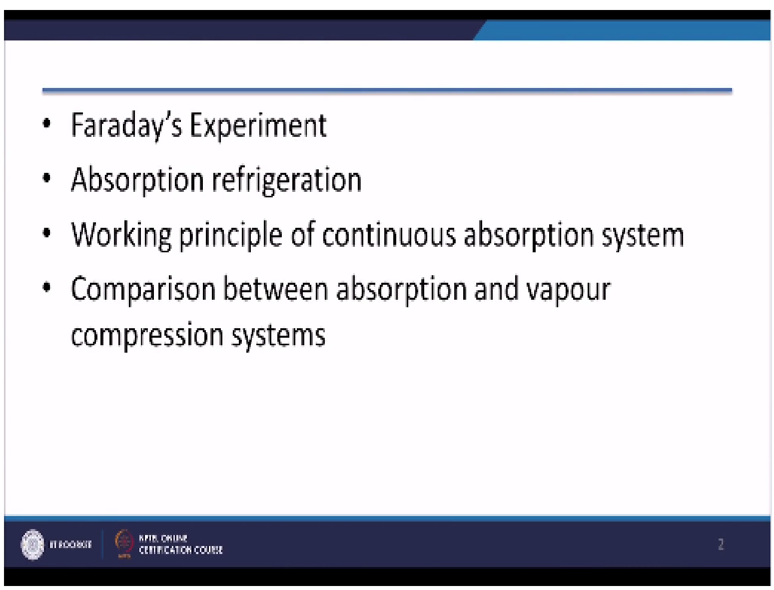

Working principle of continues absorption system compression between absorption and vapor compression systems. Now 1824 faraday was conducting experiments regarding the liquefaction of the gas so one of his experiment he took silver chloride power AGCL power.

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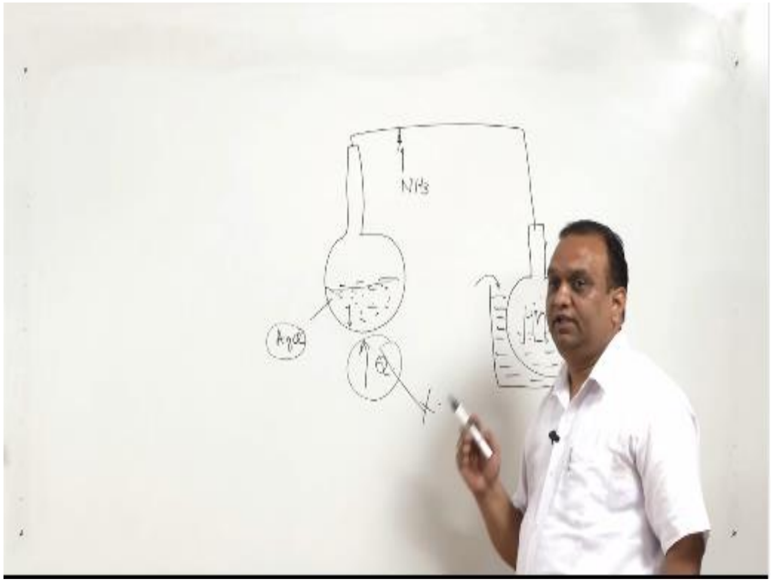

In one flask and he took another flask crated a vacuum and connected these two flask and this flask was placed in pool of water I am repeating he took a flask filled with a silver chloride power this flask was connected to another two flask which placed which was placed inside the water and there was continues supply of water and this arrangement was made for the liquefaction of amnion he injected ammonia here somewhere here through a wall ammonia vapor this ammonia vapor was absorbed by silver chloride water sorry silver chloride powered.

Then he heated this Ammonia he supplied heat to the flak heated the ammonia oh sorry the silver chloride water power and the ammonia was lapidated and it was conducted here it was collected so here so liquid ammonia was collected here and vapor was conducted and the heat was carried away by the water cooling water circulated here but when he started this his absorption after some time and this heat was removed because it was no longer required because all the ammonia collected here.

When he started his absorption he found that this pool of liquid started boiling it started boiling of and after certain period of time all the amnion was again reabsorbed by ammonium chloride sorry this silver chloride this gave bar through the concept of absorption refrigeration system it means the solubility of ammonia differs at different temperatures at lower temperature the solubility of ammonia in sliver chloride was high but when it was heated solubility ammonia reduced and the vapor where generated which were subsequently condensed in this flak however when the heating was removed all the temperature silver chloride reduced.

It is tendency to absorb ammonia increased and it started absorbing ammonia in the high level in the flask pressure started reducing pressure inside the circuit reduced and that pressure became corresponding to the tempura saturation temperature of this liquid and liquid starting boiling of and vapors where generated and they enter to this side and after certain time period all the liquid available here was shifted to this flask this gave birth to the concept of absorption refrigeration system now what happens in normal vapor compression system.

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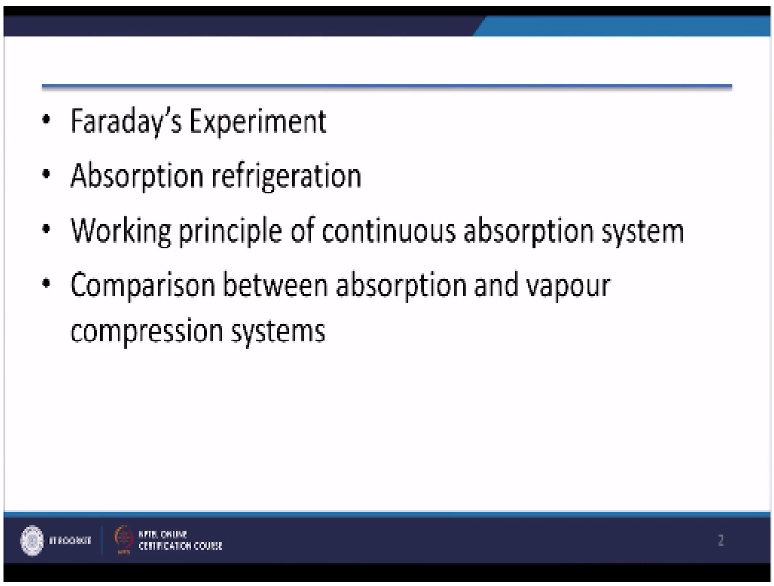

In a normal vapor compression system if we look at the pressure.

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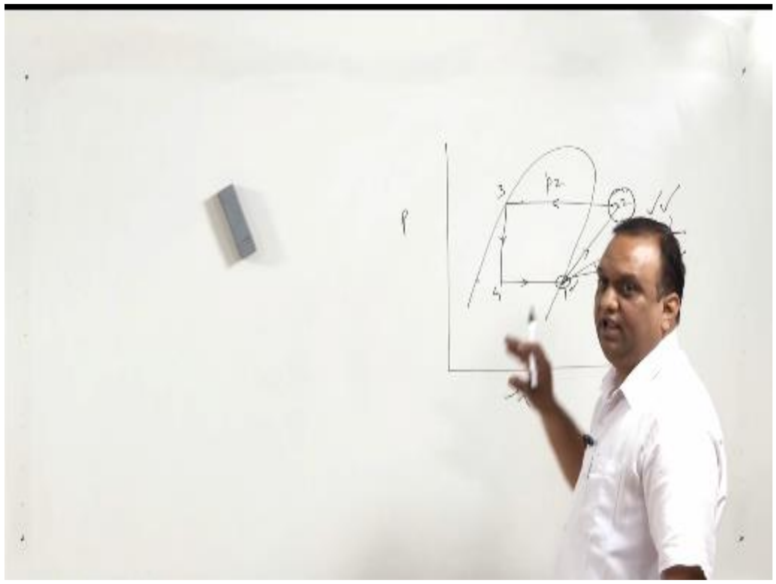

Diagram after the evaporator the vapors enter the compressor now at this point the size of the compressor is decided by the volume of the vapor at 0.1 if the capacity of the system is large definitely volume of the vapor saturated vapor or super hearted vapor available at a state 1 will be large for a very high capacity plane suppose I want to have a plant of 1000 of refrigeration capacity or 3000 tons of refrigeration capacity you can imagine the size of a compressor you must have seen the compressor for 1 ton , 2 ton, or 5 ton 0r 10 ton plants now if I want to have plants of this order the size of the compressor is going to be very large and there will be some a light problems also suppose.

I am using reciprocating compressor in that case reciprocating compressor are not fully balanced reciprocating machines are not fully balanced some unbalanced force will be there that will carte the variations strong foundations will be required in addition to that if I am rotary compressor normally to handle large volumes rotary compressor are used so rotary compressor will also require very strong foundation size of the compressor will be very large and the cost of the plant will also be high now if we look at a point 1 the vapor is saturated vapor or super heated vapor when coming out of the evaporator.

The volume of the vapor is large for example if we convert this large volume of the vapor into the liquid the volume into the liquid the volume of the fluid can be reduced by 1200 time parts even more or it ranges between 15 or 200 so if I have suppose if I have 200 liters of vapor here if I conduce this vapor approximately the conduced root will have a volume of approximately 1 liter this is I am talking the refrigeration if you go into the case of water it is more than 1000 times.,

So I ask to handle 200 liters of vapor and 1 liter of liquid definitely you will prefer to handle 1 liter of liquid because much less energy will be speed in handling this liquid now here we can use the concept of absorption systems what we can do we can absorbed this vapor in an absorbent and this actually being done in vapor absorption systems this vapor available at after the evaporator it gets absorbed in an absorbent and this absorbent.

So it is mixture of two liquids and this mixture of two liquids is pumped is instead of compressor because it is liquid and in order to handle one liter of liquid the size of the pumps will be very small if I have t0 handle 200 liters of vapor per second I am talking about per second then the size of the compressor will be very large so this liquid we can increase the pursuer of this liquid up to this stage p2 and when the pressure is increased the we can heat the mixture as we heat the mixture solubility of the vapor in the mixture will be reduced and we will get high temperate high pressure vapor at state 2.

So this is what exactly happens in vapor absorption systems in absorption refrigeration system all the process are same they have conduces exposition values and evaporators only this part compression of vapor instead of increasing pressure of the vapor in a compressor the vapor are absorbed in an absorber then this mixture pumped to the high pressure and here again the heating is done and vapors are liberated in the absorption system.

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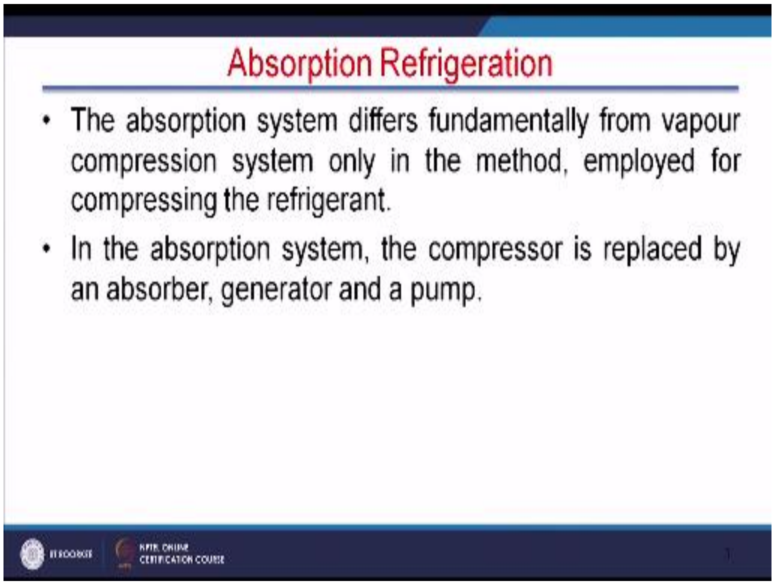

The compressor is replaced by an absorption generator and pump so where the vapors are generated.

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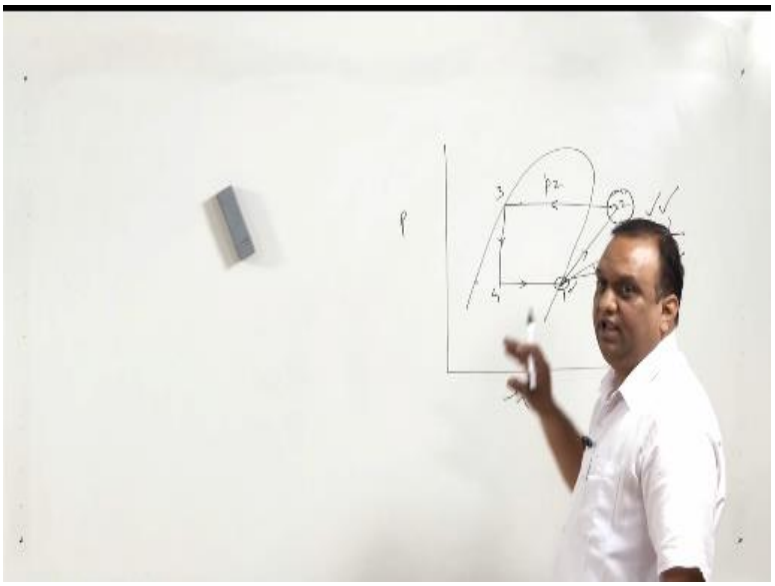

It is known as generator I will defined them one by one the absorber.

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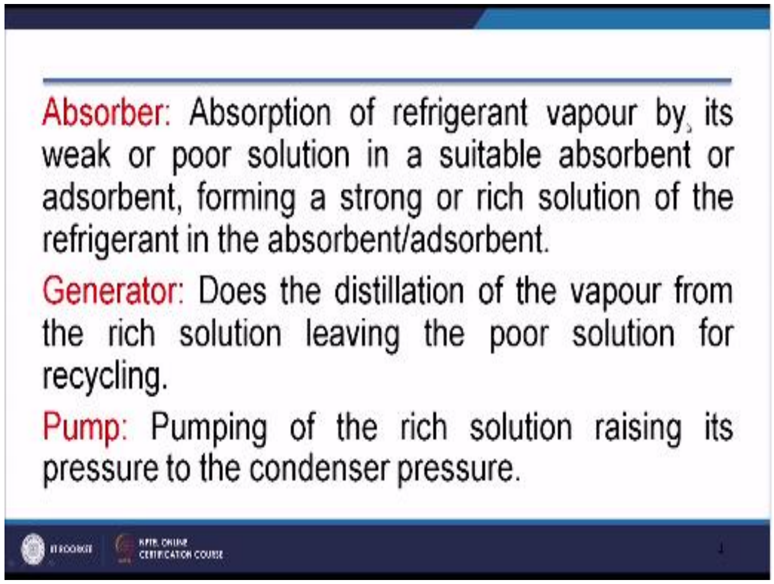

In absorber the absorption of refrigerate vapor by it is week or poor solution in a suitable absorbent or absorber forming as strong or rich solution of the refrigerant in the absorbent adsorbent so here in the absorber. The vapor is absorbed in an absorber it is no absorber now second part is generator now in generator the heating is done heat is given and vapor is liberated and third is pump the function of pump is to increase pressure of low pressure liquid to high pressure liquid so vapor absorption unit are.

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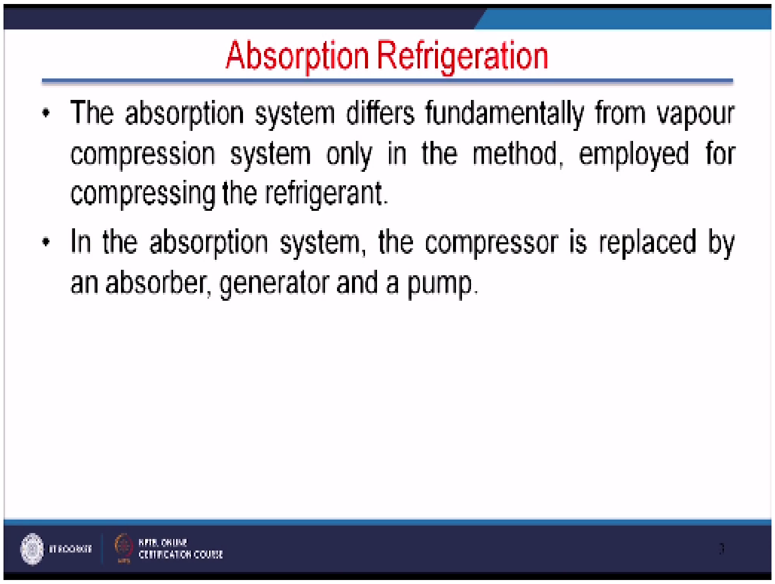

So vapor absorption unit are really heat operated units and the movement of refrigerant into the absorber is done by the pressure depression in the absorber now I will take a typical example of continues refrigerant system because the faraday system was intimidate system in intermediate refrigerant system one flask you're giving heat.

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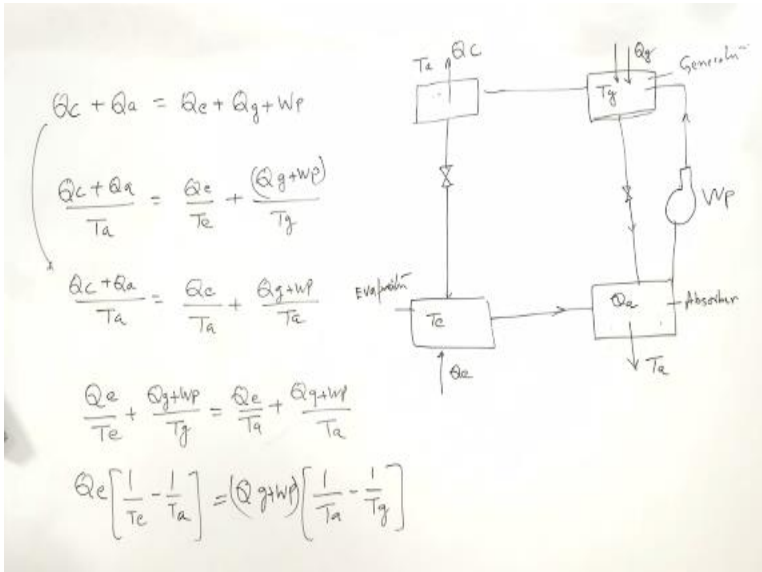

And another flask you're collecting liquid and then heat is removed and this fluid boils of and you get refrigerant effect now in order to reap cycle again the heat as to be given then liquid will be formed and then again liquid will be evaporated so this is n intermediate cycle and for actual practice we need continues cycle so in order to have a continues cycle there as to be one absorber where will vapor will be absorbed absorber were vapor will be absorbed evaporator.

This is evaporator and absorber as temperature sorry evaporator as temperature Te and it is taking heat QE now vapor from emerging from the evaporator they are entering the absorber now here absorption takes place during this process of absorption heat is liberated and heat is sent to the surrounding at A so this is QA after the absorber if pump is used a pump is used to pump the fluid to the generator this is generator where heating takes place and heating can be done from external sources normally in absorption systems they are very useful where waste heat is available.

So waste heat can be used for heating in then generator it has temperature Tg and the heating is heat transform is Qg now after genitor it goes to the air in the case of vapor compression system it goes to the evaporator sorry the conductor and in condensation also the heat is rejected Q conducer and outside temperature is TA temperature and this is and we assume here there is assumption that temperature difference between this and this and condenser outside is inhalable.

Now after the conducer it goes to exposition wall as usual and to evaporator now fro continues operation of this unit this is absorber and this generator in absorber there is a rick solution of refrigerating into the absorber it is pumped and here because the vapor is librated this become limed solution so limed solution is again send back to the absorber and that I how the cycle is completed now in this cycle in continues operation of absorption system if I want to do the because for analysis purpose.

So if here I want to have coefficient of performance first of all I will do the heat balance so heat balance is QC condenser and absorber plus Qa is equal to because it is heat rejected and heat supplied is Qe + Qg + worth of the pump this is energy given to the system. All the processes are idela processes so change in entropy of a system is 0 so Qc + Qa/ K = Qe/T + Qg + Wp/T, so we have taken that entropy sum of change in entropy 0 and this is heat balance, now if we divide this equation by Tl then we will be getting Qc+ Qa/ Ta is going to be equal to Qe/Ta + Qg + Wp/Ta.

Now we have two equations these two equations this term is common so we can always write Qe/Te + Qg+ Wp is work of the pump divided By Tg = Qe/Ta + Qg + Wp/Ta, now if we further arrange these terms we will be getting Qe(1/Te-1/Tv) so Qe/Te – Q sorry here this is K, Ta now this trem is taken to this side so Q will be common so Qe / [1/ T – 1/Ta] = Qg + Wp[1/Ta – 1/Tg], now I am repeating I have taken heat balance, right.

Heat coming to the system is Qe + Qg, Qe means heat is taken in the evaporator heat coming to the generator worked by pump is equal to heat rejected it is condense heat rejected in the condenser heat rejected in the absorber because during absorption process there is a heat rejection, we have considered the change in entropy respected in the respective process we have taken the change in entropy.

Now this equation of heat conservation is again divided by Ta it is divided by T, now we have these two equations, now in these two equations you can see this is equal to this they are same, so this is equal to this so this equivalence we have taken here we have rearranged the term this is in bracket, so we have rearranged the term.

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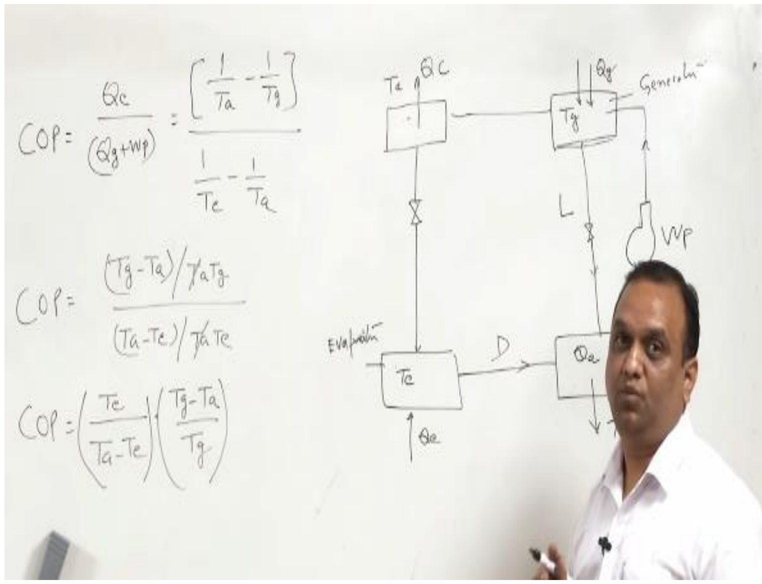

Now CoP of the system, Co P of the system is refrigerating effect that is Qe, heat transfer taking place in the evaporator plus energy input in the system, in vapor compression system it was two compressor now here it is Qg + Wp work of the pump, in some of the books you will find that work of the pump is neglected because if you compare this heat transfer and this energy and this energy this can be neglected.

But here in the expression we have considered it, so this ratio is going to be from this expression it is going to be equal to [1/Ta – 1/Tb]/1/Te – 1/Ta and CoP again, CoP is going to be equals to Tv – Ta/ TaTv, Ta-Te/TaTe, so this can be cancelled and CoP of the system we can write as [Te/Ta – Te]x [Tg –Ta/Tg] now this is the expression for coefficient of performance of any this vapor compression refrigeration system, now here if you look these expression individually.

Tg- Ta/Tg, means a carbon cycle working between this temperature and this temperature, the efficient of the carbon cycle can be expressed by this expression and multiplication of these two will give the CoP, now this temperature is difference between Tg and Ta, Tg-Ta is known as lift temperature between generator and absorber, temperature difference between absorber and evaporator is known as depression. Now for a better performance of the system the ratio of L/D < 1.

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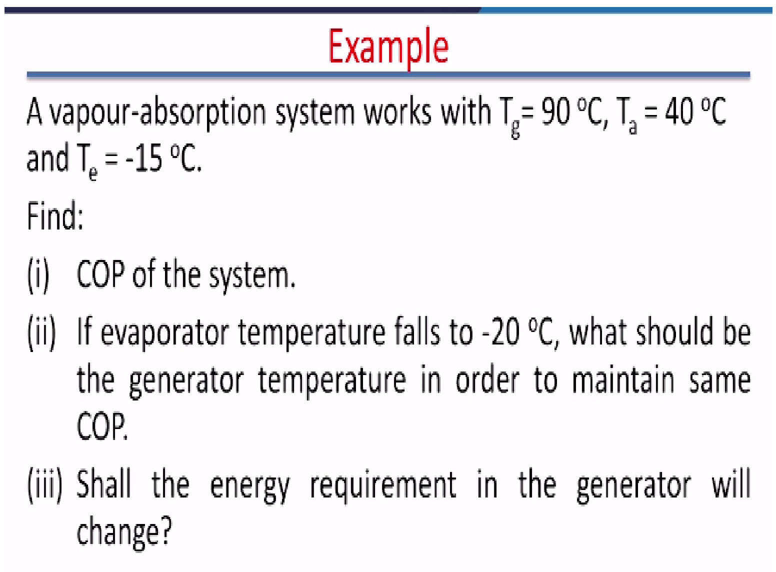

I will take an example here, in this example there is vapor absorption system working with Tg = 90^0.

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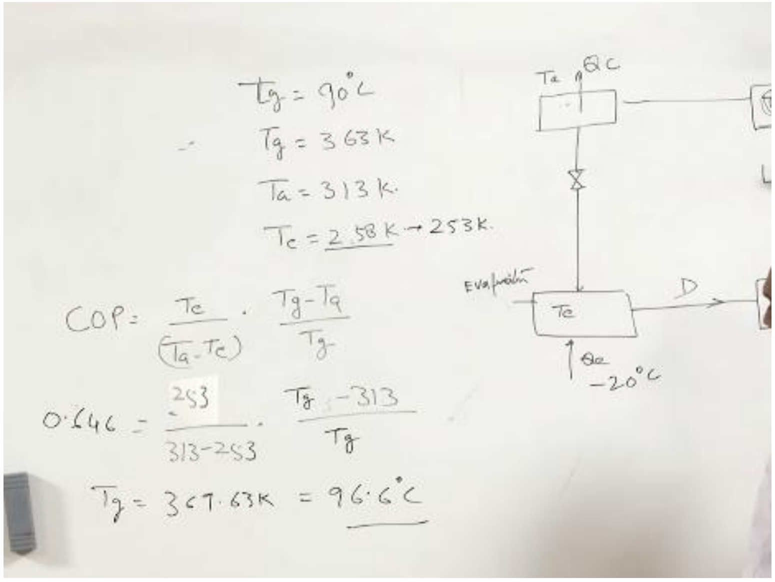

90^0 C is Tg an Te is equal to so 90^0 means Tb so absolute temperature is 363 Kelvin, now Ta is 40^0C so absolute temperature if Ta is 313 Kelvin and evaporated temperature is -15, so -273 – 15 is 258 Kelvin, now we have temperature here 90^0C this temperature is 40^0C and this temperature is $-15^0{}_{C,}$ CoP of the system now in order to find CoP of the system it is going to be Te/(Ta – Te) x Tg-Ta/Tg.

So if we take Te is 258/ Ta 313 – 258 multiplied by 363 – a, Tg – Ta, 313/363, if you solve this CoP of the system is 0.646, now second is if evaporated temperature falls to -27 suppose this temperature instead of -50 it is reduced to -20^0C, what should be the generator temperature in order to maintain the same CoP, now if this temperature is reduced such type of issue crates a lot of problem in vapor compression system.

But here first of all will solve it and then I will explain, so here now CoP this Te it falls to -20^0C so it becomes 253 Kelvin, so when Ta becomes 253 Kelvin, now Ta is same 313 is same 253 Kelvin now Tg we have to find now Tg is have to find, Tg and this is Tg and CoP is remains same 0.646, now if you solve this and try to find the value of Tg the value of Tg is 369.63 Kelvin or 96.6 ^{0}C.

So in this absorption system if we reduce the temperature of evaporator simply in order to maintain same CoP simply we will have to increase the temperature of the generator, so it can be easily compensated with easily the CoP can be maintained, this type of arrangement is not possible in case of vapor compression system, now 3^{rd} is shall a energy requirement in the generator will change?

The energy requirement in generator will change or not? The energy requirement in generator will not change, only temperature at because temperature of energy addition will only change, so in the generator C the amount of energy will required for Seem refrigerating effect, because if the temperature is going down we are assuming that refrigerating effect is the same, so if refrigerating effect is same.

In that case in order to maintain same CoP the energy at reset in generator will be at 96.6 ^0C, now we will make a comparison between absorption and vapor compression system. So if you compare the absorption system and vapor refrigeration system to quality of a energy.

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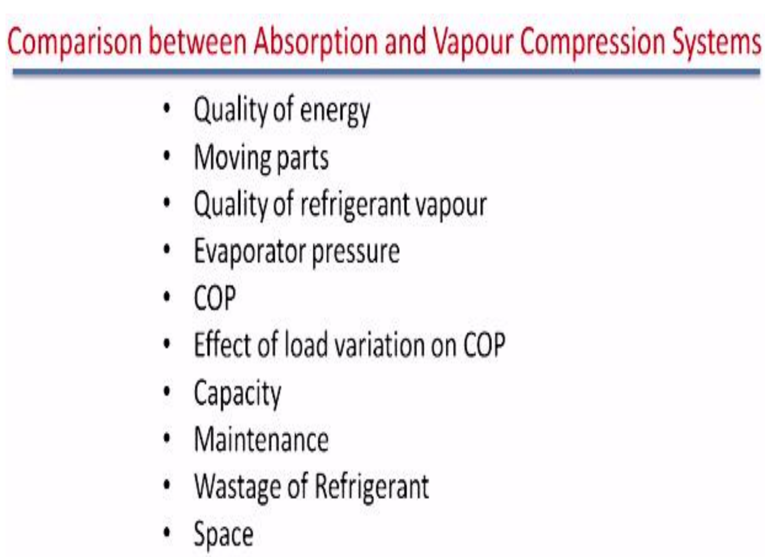

In vapor compression system a compressor has to run and compressor shall run with high grade energy a work will be required and here in this case only heat is required and that too if wasted is available that is I mean if waste if available then we get refrigerating effect almost free of cost, it has less moving part so fiction loss is less.

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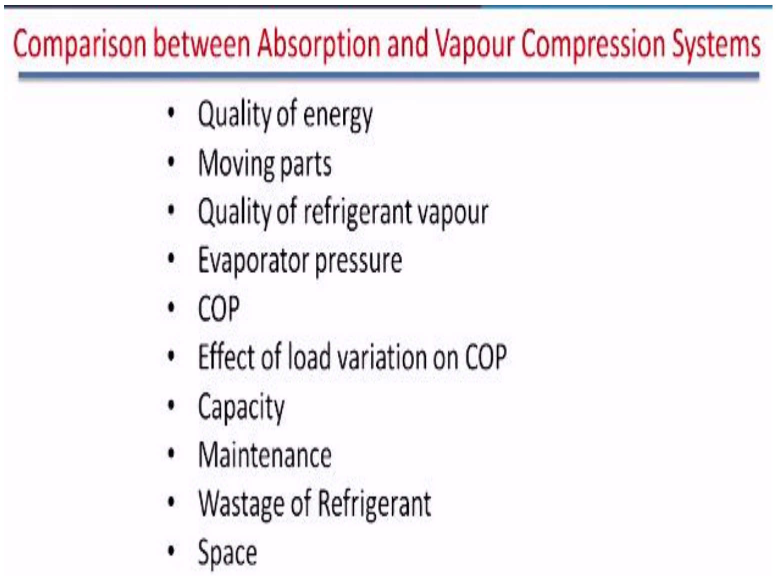

Quality of refrigerant vapor now in vapor compression system we have to ensure that the quality of vapor which is leaving the evaporator I mean it has to be super heated or atleast saturated but same is not the case here, evaporated pressure the in this case in vapor compression system is the evaporated pressure goes down, the performance of the cycle is drastically affected.

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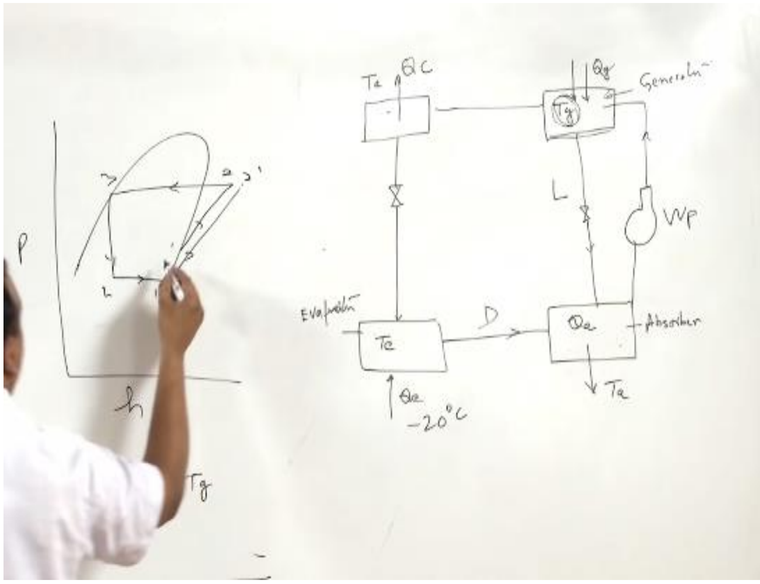

I mean in a Ph diagram is I reduce the pressure in the condenser, the performance of system will be drastically affected, right. Is will be because refrigeration effect will reduce and the energy consumption will increase but here we have seen in the previous numerical by slight manipulation of temperature in the generation the CoP can be maintained, Capacity we can go for very high capacity in case of a absorption efficient prod infact.

The plants of 3000 order of 3000 or 4000 tons of refrigeration capacity are recommend to be the absorption refrigeration plant, maintenance is low waste of refrigerant is not there because in vapor compression system they operate on very high pressure and leakage of refrigerant is always an issue so here the wastage of refrigerant is not there as you compare with the waste of refrigerant in vapor compression system.

And it occupies lesser space it does not require and Robbers foundation for compressor, and there many more I mean issues which make vapor absorption system superior to vapor compressions system strictly in the case of high tonnage of cooling these types of systems are not economically viable for low capacity systems like 110, 210 refrigeration for those capacity vapor compression refrigeration systems are recommended.

Now this is all for today's lecture tomorrow we will discuss some of the specific vapor absorption systems.

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