INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NPTEL
NPTEL ONLINE CERTIFICATION COURSE

Refrigeration and Air-conditioning

Lecture- 19
Vpour Absorption Systems-2

with
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Hello I welcome you all in this course of reflection in air conditioning today we will continue all discussions on vpour, vpour absorption system refrigerant systems in vpour absorption the efficient systems there as to be the refrigerant.

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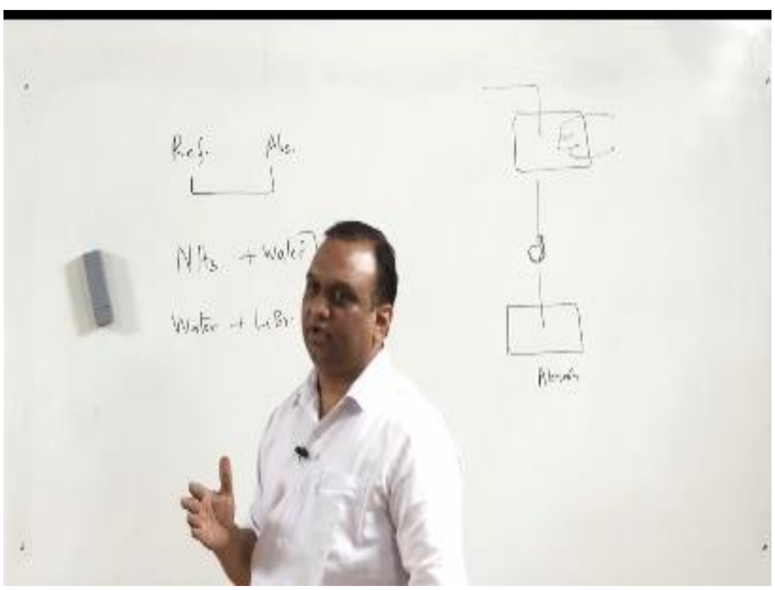

And one absorbent the refrigerant is absorbed by the absorbent at lower temperature and then the absorber and then it goes to generator where the mixture is heated and refrigerant is elaborated during this process the pressure of mixture is also increased pressure on the mixture is also increased with the help of a pump and sometimes difference in evolution also used for increasing the pressure in that case the generator will be below the absorber now they are certain combinations of different compounds like Ammonia water Ammonia has very good affinity with water.

So ammonia is refrigerant and water is absorber that is another type of combination can be which is very popular is lithium sorry, here water is an refrigerant and lithium provides is absorbent so these two type of combinations of vpour come absorption refrigerant there may be other combinations also but these two combinations are very popular now we will take them one by one let us start with ammonia water system.

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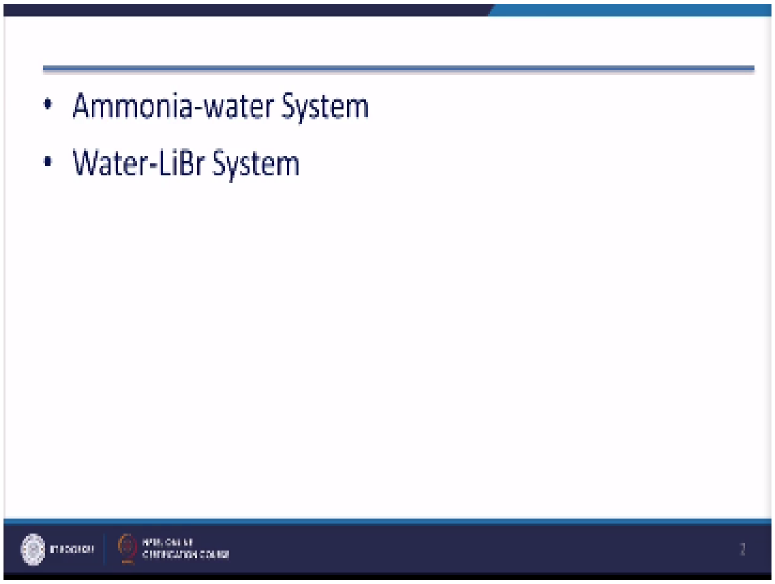

In Ammonia water system the amount because it is this combination is taken because ammonia is refrigerant and water is an absorbent.

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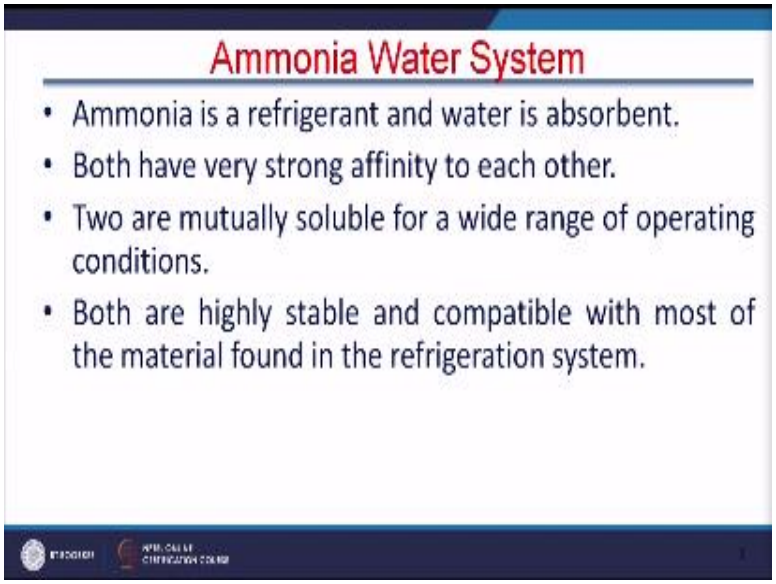

Because they are very strong affinity to each other water and ammonia two or mutually soluble for a wide range of operating conditions is specially existing inside the system both are highly stable and compactable with most of the material found in the refrigeration system except copper, copper is not compactable with ammonia so wherever ammonia is used copper fittings are not used.

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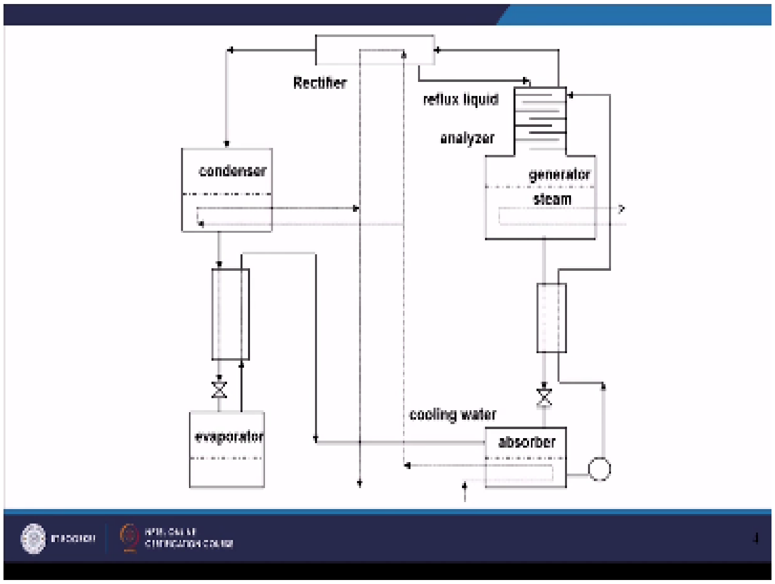

Now I will draw arrangements in a ammonia water refrigeration system so we will start with the absorber.

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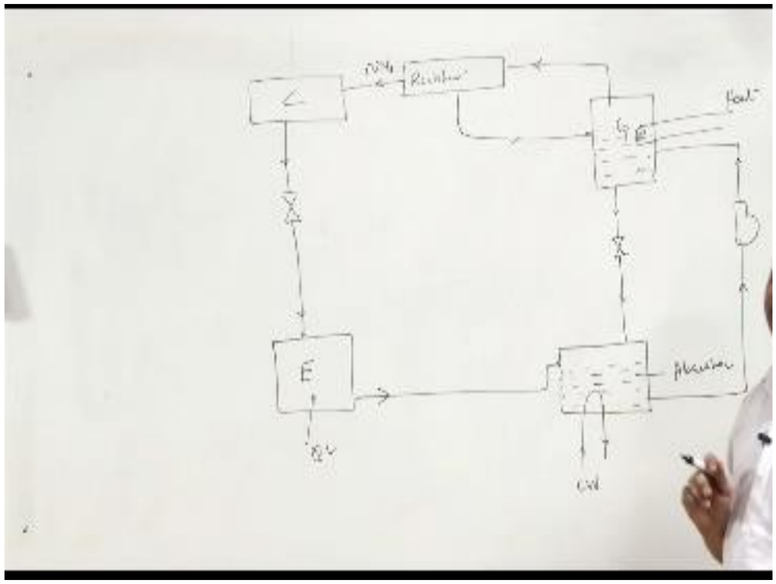

The system has one absorber we are weak ammonia solution exist so this is an absorber were absorption above mini takes place in weak ammonia in weak solution and it becomes a strong solution during this process heat is librated that is why cooling water is circulated in the absorber now the vpour from to absorber it comes from evaporator it is a normal evaporator from evaporator the vpour goes to absorber okay, and vpour gets absorbed here now this absorbed vpour the pressure of this absorbed vpour has to be in piece normally 10 times with the help of a pump and there is A generator.

There is a generator in the system now refrigerant is pumped to the generator with help of small pump now when the refrigerant comes to the generator I mean the absorb this ammonia water mixture when it comes to the generator the heat is supplied to the generator now this heat may be waste heat or heat from blood pressure domain or waste heat of any process some waste heat from the gas any waste heat we will do so this waste heat heats this mixture in generator and ammonia is elaborated and in fact it has traces of water also so the trace ammonia with the traces of water.

It goes to the rectifier in rectifier the water is separated out and it is drain back to the generator so that at the exit of the rectifier we get pure ammonia so I am repeating the process this is as the operator absorber, generator now we have come to the rectifier now this ammonia after rectifier it goes to the condenser, condenser and condensation takes place so at this point we have at the exit of the condenser we have high pressure liquid with low temperature that normally happens in vpour compression system.

And after that expansion of this ammonia takes place this is an hydros ammonia and then after expansion it enters the evaporator and the cycle is not complete yet cycle is not complet6e here because liquid is pumped from absorber to generator after certain period of operation all the fluid from absorber will be shifted to the generator and generator will be full so there is a drain back arrangement again and the valve is provided to the meet the pressure law pressure difference so pressure is dropped and cross the one and the weak solution it is called weak solution because the ammonia has already been liberated from the solution but it is still consist of is consist some part of the ammonia so this is weal solution from generator enters the absorber, absorber gets ammonia from evaporator and it makes the solution rich and which solution is bound back to the generator so this is one cycle which keeps on going and after that the vpour after rectifier they go to the condenser as in the case of vapor compression system.

And then after the expansion the vpour goes to the evaporator where refrigerating effect takes place now in order to increase the efficiency of the system because we can provide one or two heat exchanger which can improve the efficiency of the system the system efficiency can be improved say this suppose this condenser vpour.

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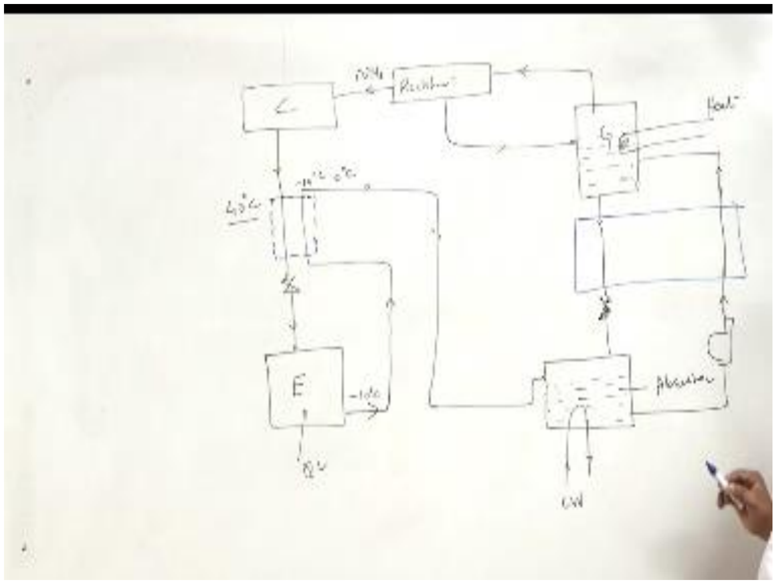

This is expansion or I will put somewhere here this condenser vpour let us say it is at 40°C and this evaporator vpour may be around let us say - 10°C and in a any case it is going to get heated here during this process so heat exchanger can be provided so instead of directly going to the to the absorber it passes through heat exchanger and then it goes to the absorber and this heat exchanger is provided for to facilitate heat exchange between these two fluids this is at 40°C this is at let us say – 10 or 0°C heat exchange take place vpour get super heated and the liquid gets cool.

When so cool liquid is expended we get more refrigerating effect at the same time this heated by suppose after attaining heat it becomes 0°C ammonia so this 0°C ammonia or super rated ammonia vpour it goes to the absorber it gets absorbed here now in this side of the system also this is go for improvement because the fluid which is going up and fluid which is going down there are at different temperatures so here suppose I shift this expansion wall to here and pump somewhere here heat exchange can be arrange between these two fluids because in absorber in any case heat has to be removed so if heat is removed here right.

Heat is removed here so here load will reduce this heat this high temperature fluid we will this heat will be used for heating this fluid this is solution of absorber and absorbent or so which is pump to the generator so any case it is going to get heated here so with the written line if we takes heat that will also improve the efficiency of the system so this is a typical arrangement for ammonia water system which is the presentation it is shown here now I will take one example again.

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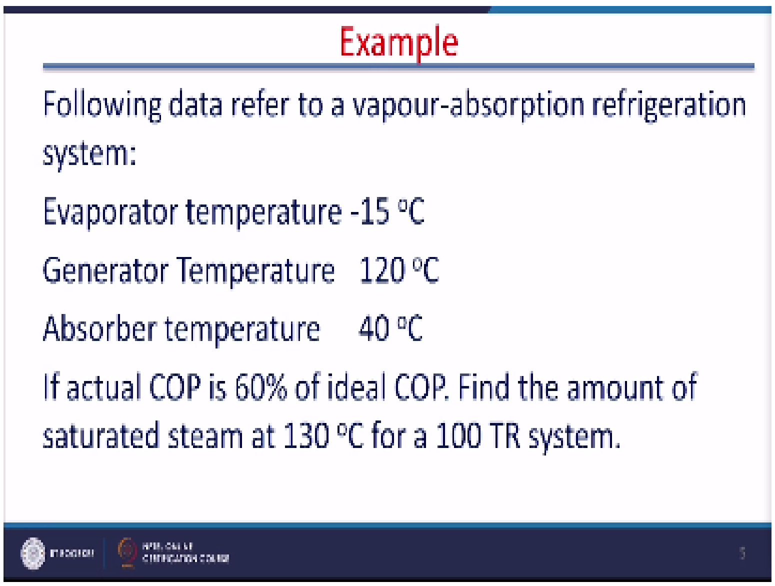

Suppose for absorption refrigeration system the following data referred to vpour absorption refrigeration system where.

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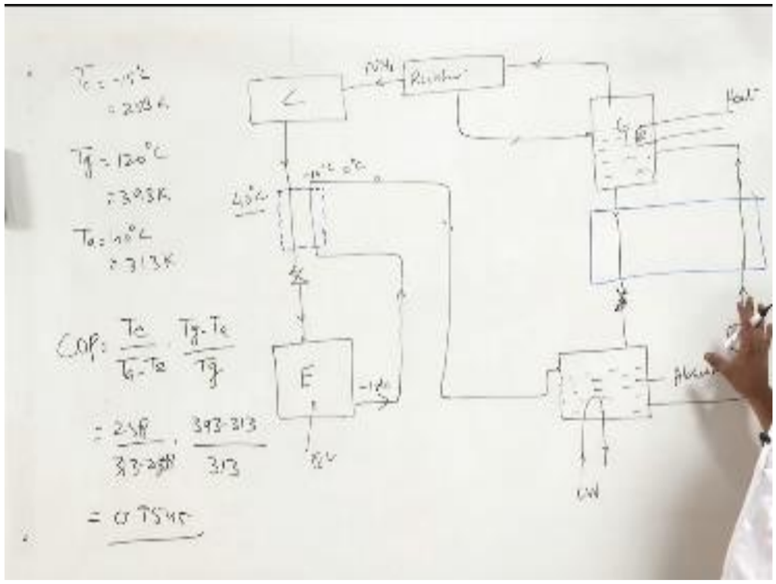

Evaporated temperature is - 15°C and that is 258 kelvin generator temperature is 120°C that is equal to 393 kelvin and absorption temperature is 40°C or 313 kelvin now with these temperature suppose in this ammonia vpour system so this heating temperature in generator is 120°C evaporated temperature is - 15°C so we will let us make a 50 and the absorption this absorber temperature is 313 kelvin if I want to find COP of the system Cop of the system will be evaporated temperature T absorber – T evaporator T generator – T absorber by T generator if I put the respective values.

It is going to be equal to 258/313 – 258 multiplied by 393 – 313/313 and the COP I am going to get a 0.9545 COP of absorption system is close to one I mean 0.7 0.8 1, 1 is very good if you compare the COP of the vpour compression system the COP system the COP is 3.53 3.5 and COP 3.75 so it does not mean that COP of the absorption system is very, very low in fact what happens in absorption system we are using only heat in vpour compression system energy input is in the form of work which is high grade energy and this high grade energy is converted from the low grade energy.

Perhaps the efficiency of the device or may be some engine or turbine is steam turbine the efficiency of the conversion may be 30 40 or 50% so that we do not take into the count if we take that into a count then these COP of one of absorption system is comparable with the COP of 3 in case of vpour compression system and the benefit of absorption system is if the v way street is available then we are getting the refrigeration effect with almost negligible expense of energy so here this UPS 0.9545 but the actual copy is 60% in actual cycle.

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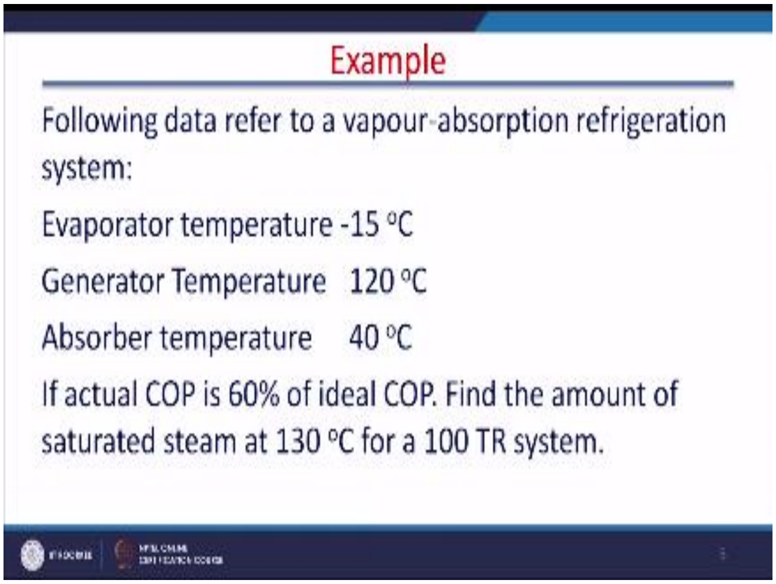

40% losses are there so actual copy is 60% so actual copy.

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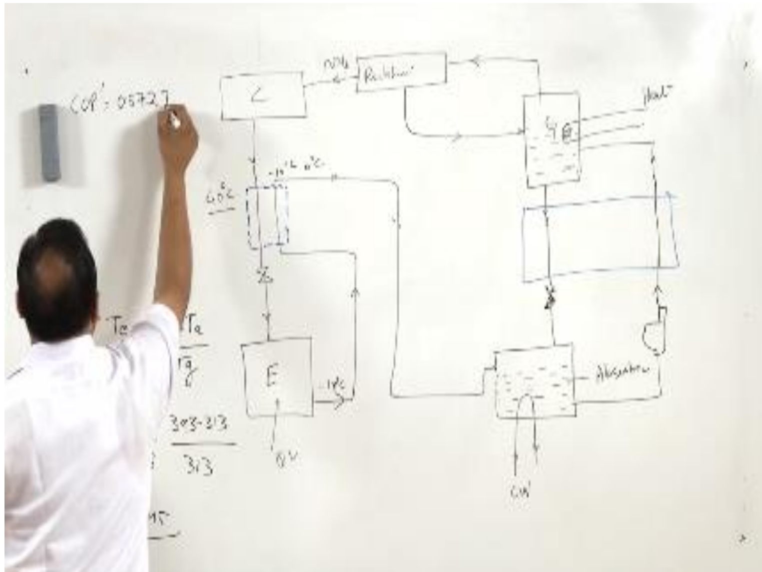

COP′ it is 60% of this it becomes 5727, here 10 TR of refrigeration system has to be given so 10 TR means sorry, 100 tonnes of refrigeration so 100 tonnes of refrigeration means 100x3.5kW this much of energy is required and this much of energy is required for this steam at 130˚C suppose steam is used for heating at 130˚C we can assume that steam is condense here and mass of the steam is the energy supplied and that so mass of the steam can be calculated as.

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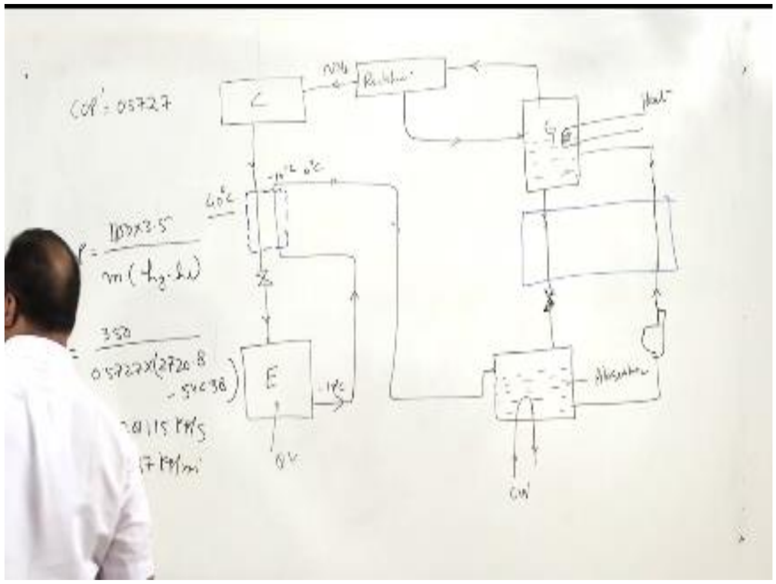

You know COP is refrigerating effect that is 100x3.5 and mad mass of the steam multiplied by hg-hl I mean enthalpy of saturated steam so m=350/COP is 05727 multiplied by 2720.8-546.38 this is 2720.8 is the enthalpy of saturated steam at 120˚C and this is enthalpy of saturated liquid water at 120˚C and this gives the mass value has mass flow rate as 0.28115kg/s or mass flow rate is 16.87kg/m. So this is the amount of a steam which is required here to produce -15˚C temperature here.

Now after this there is another combination of absorber and refrigerant that is water and lithium bromide. In this system water ammonia system water is absorbent ammonia is refrigerant. Now here in this system the water is lithium bromide type of system the water is refrigerant and lithium bromide is absorbent. Now this system lithium bromide water system works on a very low pressure and in different books you will find different type of arrangements it has four term arrangement, one term arrangement, two term arrangement is also there.

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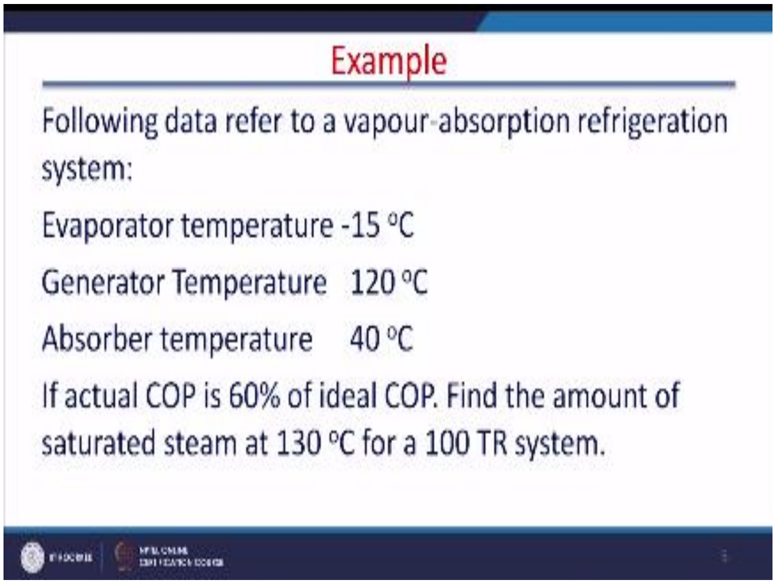

But in order to understand the system this lithium bromide water efficiency system tow term arrangement is best suited, because in two terms arrangement.

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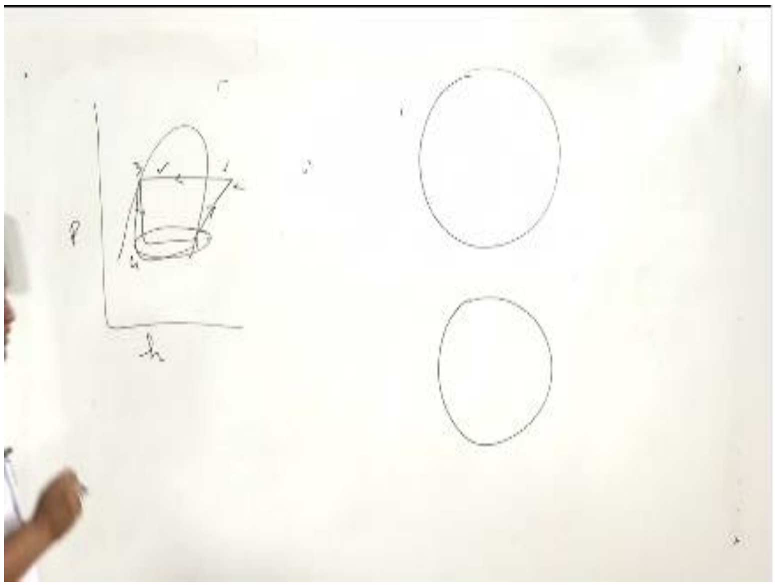

We take low pressure term and high pressure term, because in any in vapour compression also if you know kind of vapour compression system there is always a high pressure side and low pressure side this is low pressure side evaporate after expansion it is a low pressure side and this is high pressure side and this condenser and then after the compressor it is a high pressure side and pressure increases in compressor, pressure reduces in expansion device. Now here in absorption system lithium bromide water absorption system.

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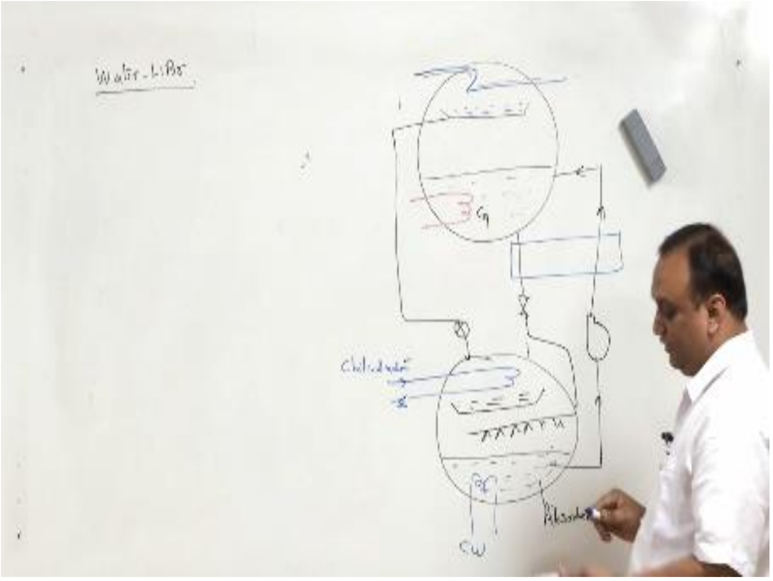

Water lithium bromide absorption system where water works as a refrigerant, now this is the high pressure vessel this is the low pressure vessel. In high pressure vessel suppose water vapour is condensed in high pressure vessel we will start from condenser so there is a pooling water I will show with a blue ink so it will be easy to understand, so this is water chill water which flows here and water vapour is condensed and water vapour is collected in this tray.

After collection in the tray the water vapour I will shift this little blue, the water vapour goes to the evaporator through expansion mole. Now after expansion as we know we get low temperature low pressure vapour that is water vapour and there is a pipe line for chilled water, so this is the pipe line for chilled water and chill water this is chilled water, so chilled water is circulated in this pipe line so the low temperature water vapour where it comes in the contact with this pipe, right heat is taken away by the water and that is how the temperature of chilled water is of the water circulated in this pipe is reduced.

Now again that absorb this part is absorber, now absorber and generator the two things, now water gets absorbed in the absorber this is the absorber from the absorber there is a pump and this rich solution is pumped to the high pressure side, is pumped to the high pressure side where heating takes place now heating here can be done with the some external means now heating takes place here and after heating the water vapour is generated and this vapour gets condensed here at the condenser and this condensed vapour is expended through the valve.

It goes to the evaporator where chilling of water takes place the remaining water is absorbed in the absorber so in absorber also we have provide some pooling cooling water in absorber after absorber a pump is used the function of the pump is to pump the low pressure liquid to the high pressure liquid this is rich solution, rich solution goes to the generator, this is generator and in generator the vapour is generated.

Again here, we have to take care that if we do not provide drain back arrangement then all the rich solution will be shifted to the generator so a drain back arrangement is again provided here through an expansion valve per lean solution of water in lithium bromide is expended and it comes to the absorber and it is, it does not come from here it has to come from below in the form of spray this is the actual way.

Now further in order to improve the efficiency further in order to improve the efficiency because here anyway it is going to get heated if we can and this is a, if we can heat here by providing a heat exchanger so this is the high temperature fluid this is the low comparatively low temperature fluid if heat exchange takes place here in that case the temperature of lean solution before the expansion vale will be less so we be getting less and less temperature here at the same time when the fluid is pumped when the vapour is going to the generator anyway it is heat is going to be added here, but we get some addition amount of heat here this is arrangement for further improving the performance of the system.

Now here in this system water is used in three modes water is used as a refrigerant in entire cycle water is used as a secondary refrigerant, water is used as a secondary refrigerant because this chilled water goes to the building or some cooling place takes heat from there and comes back to this place so water is also a secondary refrigerant water is also a main refrigerant and water is also used as a coolant.

So water in this cycle water is used for three proposes now in this cycle the best part is in the ideal cycle in ideal combination in ideal mixture combination the difference between the boiling point should around 200˚C but here it is much more in case of lithium bromide and water system in case of if you compare the normal boiling of ammonia and water the normal boiling point of water is 100˚C, normal boiling point of ammonia is -33.33˚C so difference is 133 that is why when the vapour emerges from generator in case of ammonia refrigerant system it has some presence of water.

But in lithium bromide type of system when heating is done they are no traces on lithium bromide pure water we are getting and here in the condenser which gets expended here. Now the limitation of the system is because water is a refrigerant it should not be operated below 0˚C or this system is not useful for to operation below 0˚C. but high temperature applications it is extensively used.

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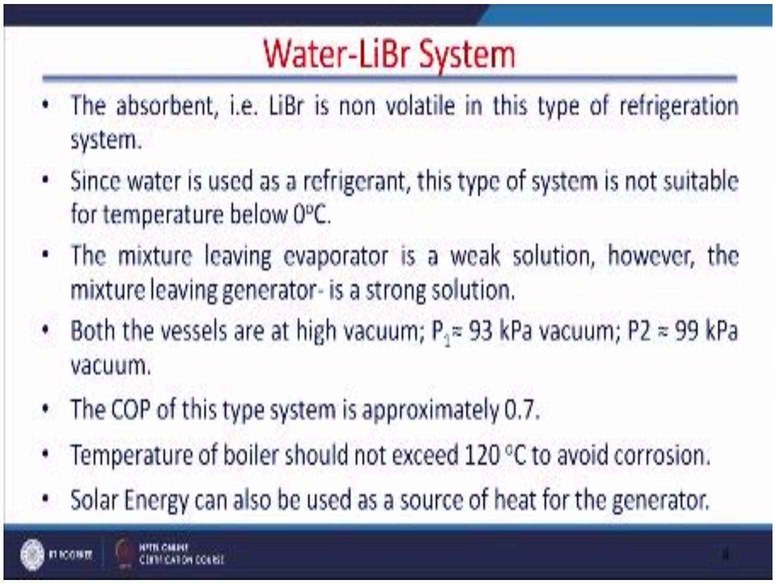

And the pressure inside the vessel here the pressure is approximately.

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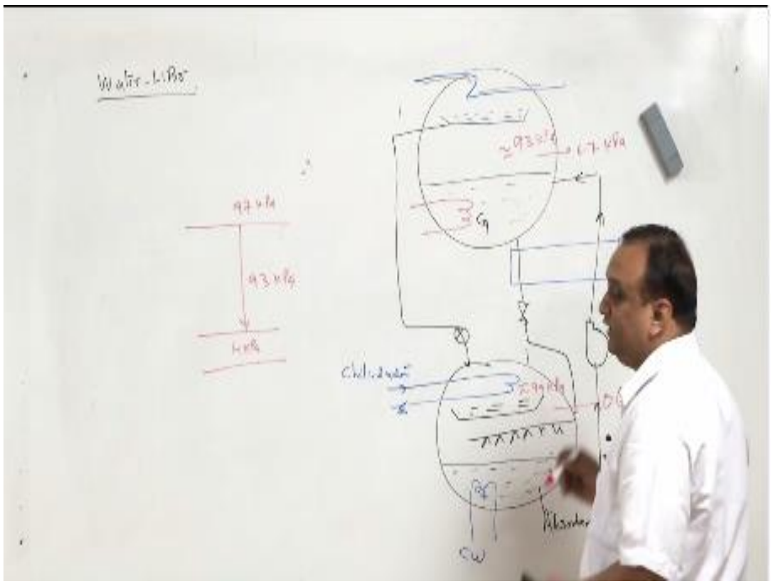

Vacuum is 93 kilo Pascal and here is vacuum is approximately 99 kilo Pascal, so system work in very high recruit vacuum means pressure below the atmospheric pressure if atmospheric pressure is say, let us say 97 atmospheric pressure so 99, 3 vacuum is it has only 4 kilo Pascal absolute pressure, 93 kilo Pascal vacuum and it has only 4 kilo Pascal absolute pressure and here you can see 99 kilo Pascal it is almost 0 vacuum is very high, here in this case it is not possible here the vacuum will be of the order of 96 so in the evaporator the pressure is approximately 1 kilo Pascal or 1.5 kilo Pascal.

Absolute pressure here turns out to be around 0.62 1.2 kilo Pascal and here absolute pressure, absolute pressure is approximately 6 to 7 kilo Pascal so system works in a very high vacuum.

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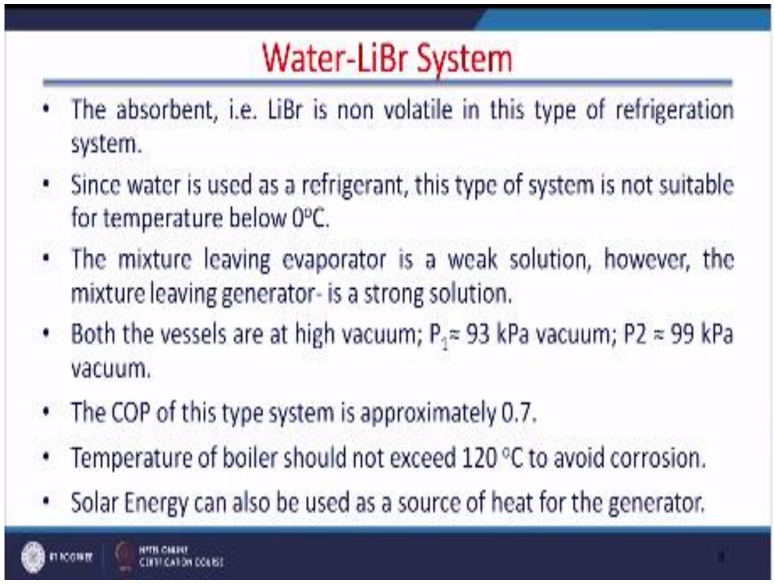

That is one thing we have to maintain but COP of the system is approximately 0.7 third you think is in any part of the system the temperature should not exceed 120˚C in order to avoid corrosion in the system. This system is well suited for solar energy because if solar energy is used as a heat source solar thermal energy is solar thermal energy. Solar thermal energy is used as a heat source then we can run this type of system in order to provide solar cooling normally a solar energy is used for heating systems.

But here with the help of absorption systems the solar energy can also be used for cooling purpose.

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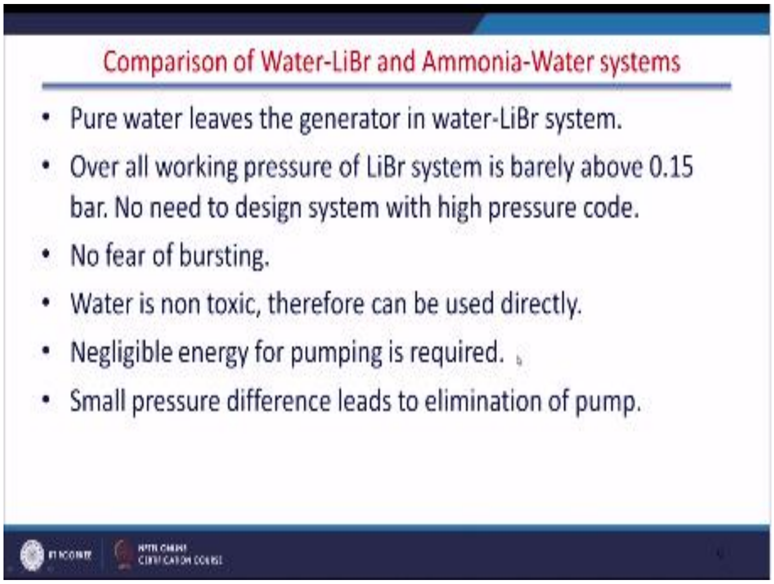

So overall working pressure lithium bromide system is barely above 0.15 there is no fear of bursting because the pressure is very low water is non toxic therefore can be used directly. Negligible energy for pumping is required here for the purpose of pumping negligible energy is required. Small pressure difference leads to elimination of pump, if the small pressure difference there we can swap these cylinders and in that case the pump can be eliminated.

So this is how this cycle has can be compared or has advantages over water ammonia cycle that is all for today in the next we will continue with the vapour absorption systems. Thank you.

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