Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

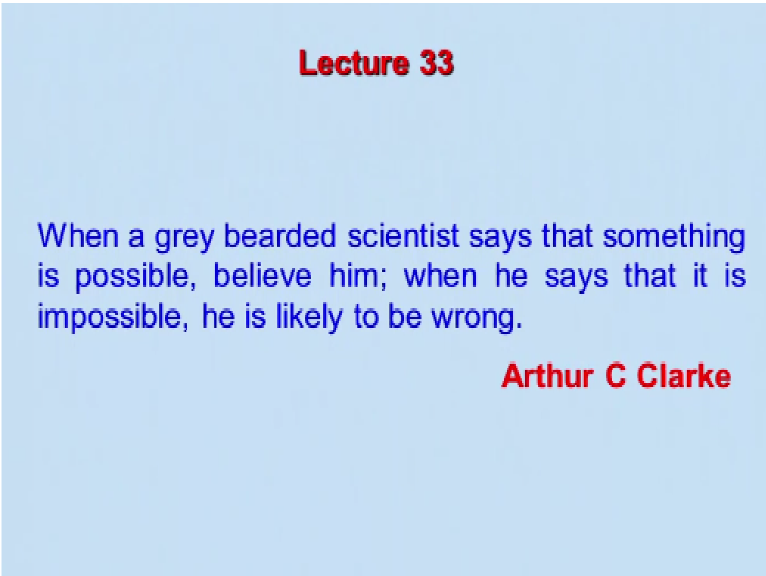
Course Title
Engineering Thermodynamics

Lecture – 33
Refrigeration Cycles

by
Prof. D. P. Mishra
Department of Aerospace Engineering

Let us start this lecture by quoting a thought process from Arthur C Clarke.

(Refer Slide Time: 00:21)

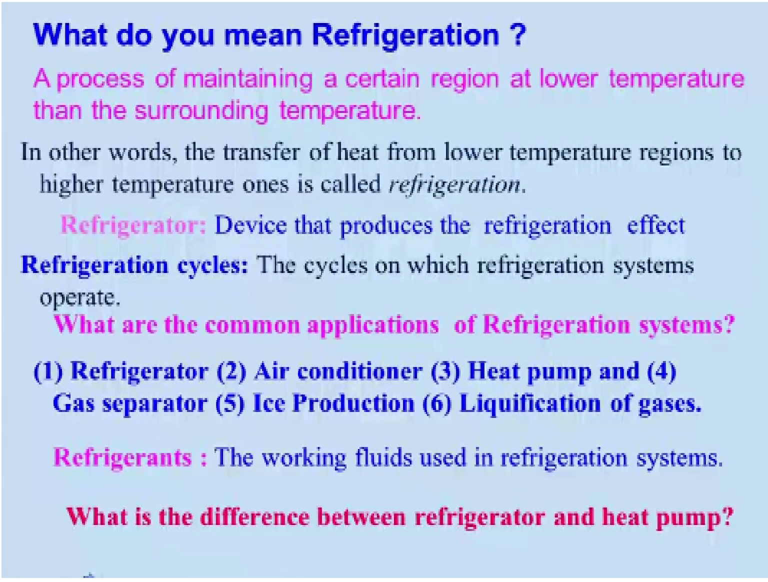


He says when a gray bearded scientist says that something is possible believe him when he says that it is impossible he is likely to be wrong that means when you need not to follow anybody blindly and I remember that Swami Vivekananda stole impossible is a word found in foods dictionary, so therefore one should not just accept you know that kind of things then only the science can progress also the engineering.

So if we look at we have discussed a lot about the heat engines you know us by various thermodynamic cycles we have discussed starting from the Rankin vapor cycle and then of course we have looked at a regenerative reheat and then what we call super heated steam the superheated Rankin cycles later on we moved to the gas power cycles under.

That we had discussed about auto cycle, diesel cycle, dual cycles and also the Brayton cycle like which will be catering to various heat engines developed by us for you know meeting our power requirement today we will be discussing about the other one is that is the refrigeration cycle which is just a posit of the heat engine and so if you look at question arises.

(Refer Slide Time: 02:15)



What do you mean by refrigeration is we all use you know refrigerator in our home and in particular and summer we use air conditioning systems and that is basically a process of maintaining certain region at low temperature as compared to the surrounding temperature or the ambient temperature for example in summer it is very hard, so we need to keep our room old and then you can use the refrigerator we need to use the air conditioner but suppose you want to keep some food at the lower temperature or the vegetables are the fruits then we will have to use the refrigerator and other things.

And in other words basically what is being done here the heat being transfer from lower temperature region to the high temperature region of course you need to provide some amount of work and when we do that we call it as a deviation and it is a basically if you look at a refrigerator is a device that produces the refrigeration effect or the cooling effect you can say that way and air conditioning is little different it is not only the what you call produce the cooling effect but it also the condition the air means you know quality of the air it has to control.

So we will be discussing about basically refrigeration cycle the cycle which is used for analyzing in our or the cycle which is used for the refrigerant system right we call it as a refrigeration cycle in other words basically the refrigeration system operates on this cycle right, so if you look at what are the common application of the refrigeration systems of course as I told you that your what you call the air conditioning systems refrigerators we use for cooling the food and other materials like which are easily get spoiled by the vector E and other things and any other things we use.

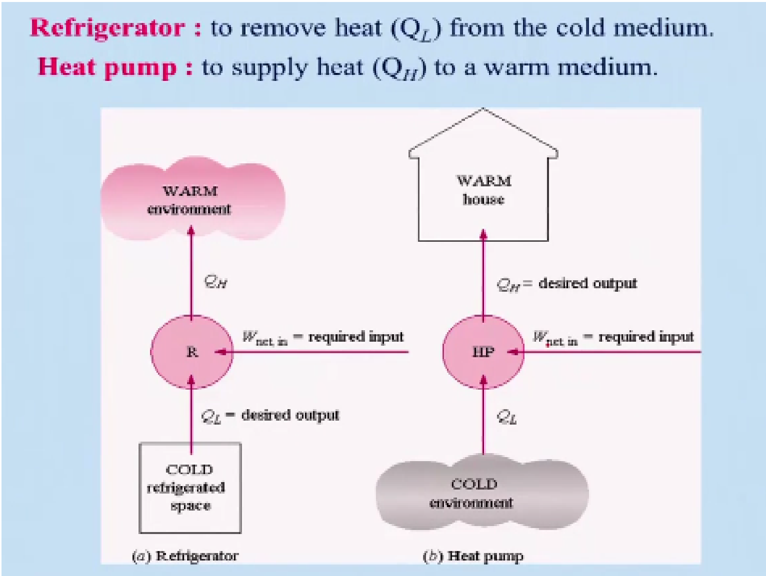
So there is you know you might have seen on the way to our academic campus that there is a nitrogen liquid nitrogen plant right and liquid hydrogen plant you must have seen right and they are also used the refrigeration system and I would suggest that you can go and check what is happening here and what is being covered in that plan, so if you look at the common application of the refrigerant systems are refrigerators and air conditioner heat pump gas separator we want to separate the gas.

Let us say you know from air I want to separate nitrogen or the oxygen you know I can go for low-temperature convert into liquid and then I can separate and ice production is a very a soul thing right and liquefaction of the gases we do that for example like we use you know liquid hydrogen and liquid oxygen in our spacecraft asps you know rocket engines cryogenic right so and several other places we can use that so it is a very important you know application and in this all this thing we use a you know fluid which will having certain properties.

And that we call refrigerants there are various kinds of represent will be discussing about that but it will be having certain properties which is not same as that of the other fluids right as we had seen that certain fluids are being preferred for the heat engine similarly the certain fruits are preferred for the refrigerant system or every generation system and that we call refrigerants and.

So if you look at what is the difference between the refrigerator and heat pump if you recall we had already discussed about it basically you refrigerate will be taking the heat from the cold region right and giving to the hot regions where as the it is other way around right the heat pump will be taking the heat from the hot regions and then giving to the cold regions like in winter we use the heat pump right.

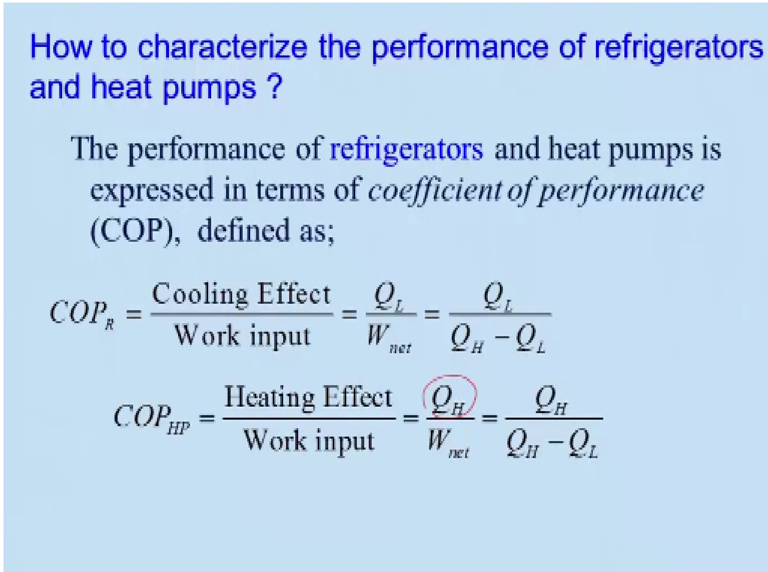
(Refer Slide Time: 07:24)



So as I told that already that refrigerator is basically to remove the heat ql from the coal medium or the cold region and a heat pump is to supply the heat to the warm region right and because the winter we use and that is warm and we will be giving some heat to the one region so if you look at this is the diametric you know schematically shown here that is in the cold region in case you know space we take some amount of 8 ql and that is the desire output and then we will give some work input here and then we will what you call a reject Q_H amount is a warm region in case of refrigerator.

But whereas the heat pump it is other way around it takes certain amount of heat OL from the cold region and it supplies the Q_H amount of heat in the one region which need to be maintained properly in the winter season right and of course you will have to give some work input to the heat pump.

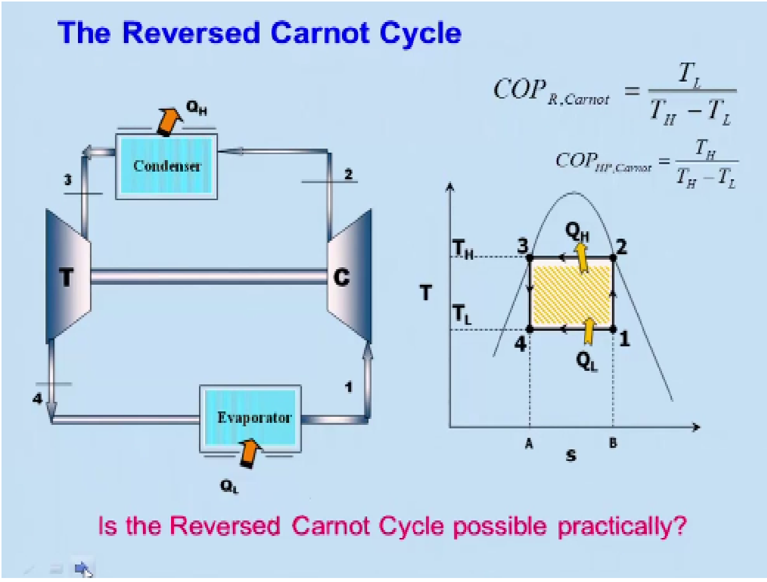
(Refer Slide Time: 08:32)



And of course how to characterize the performance of refrigerator and heat pump in case of the heat engine we use the thermal efficiency or the of course we can also use the second lap of efficiency just to check whether how good or bad it is are or what are the scopes of enhancing the thermal efficiency of waiting in but in this case we will be using the coefficient of performance right and that coefficient of performance for the refrigerator is nothing but your cooling effect and / the work input right and of course if you look at this the net and work input will be basically Q_H - Q_L right.

And similarly for the heat pump it is other way around we take the heating effect right that is nothing but your Q_H right and work net work done that is the ratio the coefficient of performance for the heat pump is the ratio of the heating effect divided by the by the work input right and if you look at the difference between the refrigerator and the heat pump is that one in one case the desired effect in case of refrigerator is the cooling effect Q_L and for the heat pump the desire if it is the heating effect that is Q_H .

(Refer Slide Time: 10:08)



So what we will do will have to look at our you know Carnot cycle in the reverse way in this case what is being done is that you know you compress the course the you know through it coming from the evaporator and then you will have to condense and reject Q_H amount of it to he what you call in the hot region and then you will have to you know like the efficient will pass to a carbine where it will be expanded and then it will be going to the evaporator where it will be observing certain amount of heat from the cold region.

So if you look at this is basically your cold region right and keep in mind that we do not really use the turbine but here I have just sent saying that is expansion and in real situation will be using basically or to call capillary tubes or the other throttling balls we have already discussed let us look at here what is happening in this case if you look at 1 to 2 is your compression this is the two-phase you know flow kind of things and 1to 2 and here 2 to 3 is your heat rejection in the condenser.

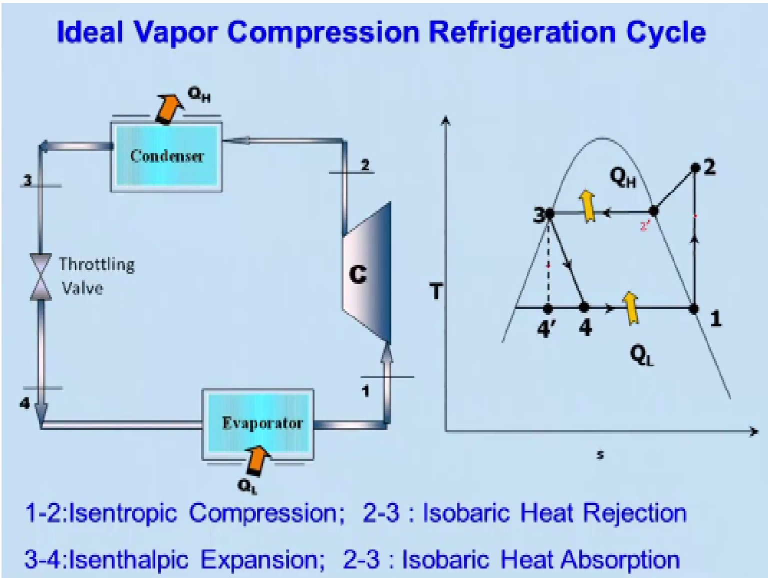
And 3 to 4 is your expansion of course we are considering isentropic expansion 3 to 4 and then 4 to 1 is your heat being what you call taken from the cold region and you know by the evaporators kind of thing, so if you look at 1 to 1 and 3 to 3 are isentropic process and of course this is the two-phase fluid so therefore the heat you know he observed by the evaporators and it rejected by the condenser our isothermal you know our isothermal in nature the process heat transfer is isothermal.

So of course this is the ideal case which is not really you know possible to implement it because of as I told that it will be two phase flow it is very difficult to compress the two-phase fluid and also the conserve that it will be reaching the saturated vapor line right and also similarly the expansion from the state 3 to 4 is also difficult because it is passing through basically two-phase fluid of course he started with the saturate liquid but after that it became a two-phase fluid which will be very difficult to do that and it will be spoiling the turbine blades and everything.

So of course you can get the Carnot efficient basically coefficient of performance for the refrigerator that is T_L / T_H - T_L and for heat pump it will be just you know T_L here in the you know refrigerator system coefficient of performance will be replaced by the T_H it and rest is the T_H - T_L therefore the you know the difference between the COP of refrigerator and the heat pump is that only the your you know desire things are different in one case it is T_L other case T_H so as a role that reverse Carnot cycle is not really possible practically.

Now we will have to change the components or the processes that it is you can implement it very easily and if you look at as a poll earlier that this turbine can be replaced by a throttling wall and we use capillary tube in case of refrigerator and other devices also.

(Refer Slide Time: 14:25)



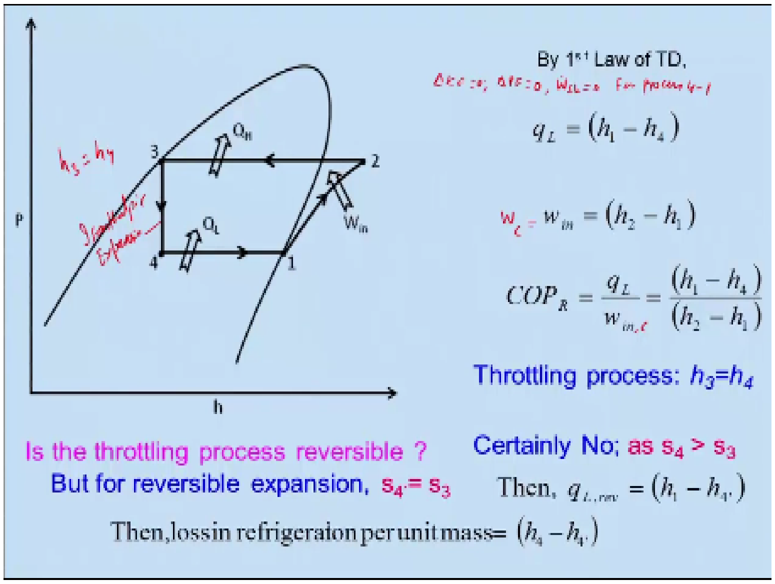
So the ideal you know lake way the vapor compression refrigeration cycle because here we are basically compressing the vapor and once it is passing through the evaporator you know like kind of things so evaporated is the vapor one and then ideally we can say that it is you know saturated vapor condition and then you can what we call compress it isentropic related to and then heat will be you know rejected in the condenser that is a condition 2 to 3 it will be rejected to the warm environment and that is Q_H and then after that what will happen like we can call basically 3 to 4 that dash is isentropic expansion right.

But however in the real situation this will be isenthalpic process that is 3 to 4 right which is will be taking place, so this is the ideal what you call vapor compression cycle and if you look at the if you compare the ideal vapor compression refrigeration air cycle it is heat rejection you know and what we call in the 2 to 3 is the same constant what you call temperature heat rejection and only thing is that difference what you could see it is the superheated vapor here in the station 4 and then of course it comes to saturated condition but however the what you call in this region right what you call the cost temperature remaining constant but however you know if you look at the it is the isobaric heat rejections.

Right the pressure will be remaining constant this is the line and the heat absorption by the evaporator is basically also the isobaric 4 to 1 and it is if you look at if I could manage to keep I there in this two phase flow so this will be also isothermal in nature right so incase of heat rejection it is only 3 to you can say this is the 2' you know like it is only goes from this isothermal but it is not because temperature is changing but however this what you call it rejection and they heat absorption are isobaric process.

And 3 to 4 is your isenthalpic process right and that is the difference but whereas it is 3 to 4' is basically incase of Carnot engine that is entropic process and of course 1 to 2 is also the isentropic compression but in case of Carnot engine it is basically you know two-phase fluid to the saturated vapor condition it is a case of reference system it is going from the saturated vapor to the superheated vapor no state during the isentropic compression.

(Refer Slide Time: 17:55)



So if you look at the same thing we can see in the P and H diagram right it is a will be very clear I am like the 3 to 4 is basically isenthalpic in expansion rate because Y h_3 is equal to h_4 and of course 2 to 3 your heat protocol rejection that is the Q_H is a constant pressure you know it rejection and 1 to 2 3 isentropic compression and 1 to 1 is your again isobaric heat absorption so we can analyze this thing what we will have to do wheeler to use the first law of thermodynamics and we know that is Q_L amount where for the process 4 to 1 right which is nothing but your $h_1 – h_4$.

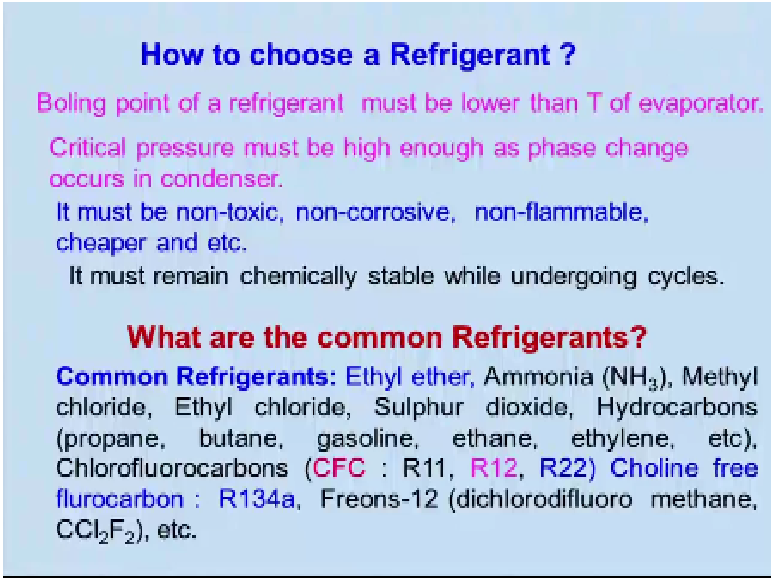
And we do the same assumptions here that is the flow is steady process and there is a change in kinetic energy and you know lake is equal to 0 and change in potential energy is 0 and there is no SAP to work here in this case 0 so for process you know 4 to 1 and it is the steady flow process all the things so we will be using that so QL is equal to h_1 - h_4 and similarly we can get a W in or the what we call the compressor work this you can say this basically work input to the compression right and which is equal to s_2 - h_1 right.

And COP of refrigeration if you look at Q_L / Wc that is you know you can say this is basically input to the compression weight that is equal to h 1 minus h $_4$ / S $_2$ -h1 and we have seen that there is no you know work being produced by the expansion process there I because of throttling process right S_3 = H $_4$ and questioning is this startling process you know reversible certainly no we have already seen that you know entropy is increasing during the throttling process.

So as the $S_4 > S_3$ so therefore it is an irreversible process but for the reversible process S_4' is equal to s 3 that we have seen right of course you cannot see in PS diagram and TS diagram right one so therefore the amount of you know heat which is observed during the reversible process is equal to $h_1 - h_4$'.

So if you look at that will be what you call higher as compared to the irreversible process that is the throttling process so therefore loss in your face and per unit mass will be nothing but you have $h_4 - h_4$ dash right that will be the loss in refrigeration per unit mass due to the isenthalpic process in it what you call throttling valve or a capillary tube what we use in.

(Refer Slide Time: 21:54)



So question arises how to choose a refrigerant right because that means we need to look at the properties what it should have then only for example you can say can I use a water as a refrigerant can I use you know air as a refrigerant right can I use because these are the two fluid which we are very familiar with but of course that can be used and we will see later on that we will be using air for the as a refrigerant you know as a fluid for the refrigeration system which is being used particularly for a or air craft applications we will see that.

And for a refrigerant the boiling point of represent must be lower than the temperature of the evaporator because you know like that is the should be there otherwise you cannot really absorb the heat right and critical pressure must be high enough such that the phase change occurs in the condenser because the condenser the phase change you will be occurring you know otherwise it is not possible to give the heat you know to the out like heat rejection is very important.

So suppose you are having a refrigerant whose critical pressure is very, very you know low then what will happen it cannot it will be remaining in the vapor state, so therefore particularly the vapor compression cycle you cannot use it right and it must be non-toxic and non-corrosive also because it will be passing through the various you know components it will corrosive means it will be eroding the material and the life of the refrigerant system will be refrigeration system will be very less or very low.

And it will be nonflammable because if there is a leakage you know then there will be you know you know problem of getting what you call burnt or the some fire will be there so therefore it will be nonflammable and of course it will be cheaper and there are other properties one can look at it so it must remain chemically stable while undergoing the cycle because in the cycle various processes are taking place like you know it is getting evaporated it is getting condensed.

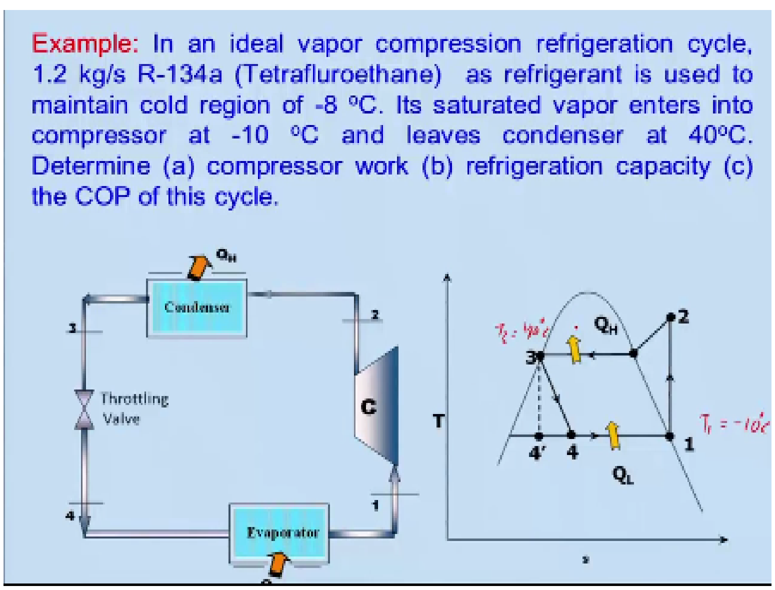
So it will be stable chemically if it is you know changing its chemical you know properties then it will be problematic and it will knows the refrigeration referee over to call refrigeration properties. So what are the common refrigerants you know if you look at like there are several of them I will be discussing few of them only because you know like if you look at the oldest of refrigerants is the ethyl ether you must have used a ether in it evaporates very easily and push down right that we use and but of course later on the ammonia and methyl chloride ethyl chloride sulphur diocese several of them you know are being used and generally the ammonia is although toxic in nature.

But it is very much preferred in industrial applications because of fact that it will be having higher co p right coefficient of performance will be higher so that the cost will be lower you know like that is the, but of course one can use hydrocarbons like propane butane gasoline ethane ethylene several of them one can use as a refrigerant but those are not being used because most of them are bill in nature you know like.

But this CFC we which are being used earlier days which we're rather being used earlier days that is the chlorofluorocarbons and if you look at there are three of them which are being used R 11 R 12and R22 and several others also R115 and then other things will be R105 so there are several of them I have just given three example R12 is being used basically for your domestic applications and R 22 is dominim is refrigerant to kind of things refrigerator it is being used and R22 is being used in your air conditioning system.
And these are the causes of this what you call the ozone layer depletion so therefore that is being banned across the wall and then of course nowadays people are going for chlorine free fluorocarbon that is R134a and of course there is the other varieties like a Freons - 12 that is dichlorodifluoro methane and other things which are being used right, so now those people are using basically R134a and there are several variants are there and it is being you know sold in various places in a different names right.

So if you look at you know there is a orison need to have a referee developing a represents which will be benign you know kind of thing then also serve the purpose, so and it should not spoil the ozone layer not the pollution or the other aspects so that is the important one what you know research people are doing.

(Refer Slide Time: 27:59)

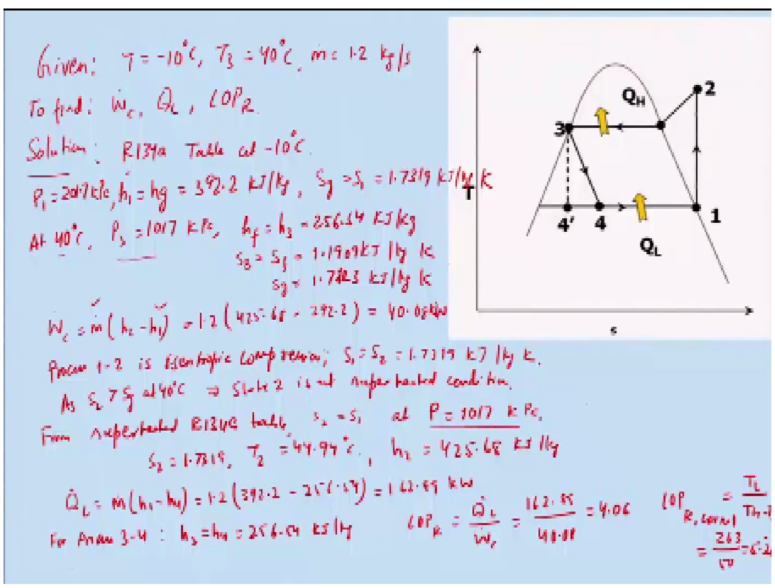


So we will take an example like basically to illustrate that how to calculate this is the an ideal in an ideal way / compression efficient cycle1.2 kg per second of this Tetrafluoroethane is used to maintain the cold region of you know - 8^0 Celsius right and it is saturated vapor enters into the compressor at - $10\ ^0$ Celsius and leaves the condenser at what you call 40^0 Celsius and determine the compressor walk and the refrigeration capacity and of course the co p of this cycle ideal cycle what we will be finding out if you look at like basically this is operating you know at the this temperature you know if you look at this is your basically the -8^0 Celsius kind of things here like.

Because it is refrigerant used to maintain old region that is 8^0 Celsius right and it the region is in a coal and then article saturated vapor enters into the compressor at minus that means this is t1 is basically -10^0Celsius and leaves the condenser right if you look at condenser is this 13 right at 40^0 Celsius right this is basically t3 you can say 40^0 Celsius kind of things.

So what we will do we will have to use basically refrigerant table you know like to get these properties and then try to solve this problem.

(Refer Slide Time: 30:06)



So if you look at what other things are given here like as I told thet1 is given as -10^0 Celsius and t3 is 40^0 Celsius and the mass flow of the refrigerant you know like is given 1.2 kg per second and we need to find out to find is the work done by the compressor and what you call the refrigeration capacity that is Q l & Co p of region.

So what we will do we will basically look at the refrigerant table corresponding to 2 – 10^0 Celsius, so we can use R134a table right at – 100^0 Celsius what will get we will get h 1 is equal to hg right this is at the saturated vapor line. So that I will get basically 392.2 kilo joule per kg and we will get SG which is equal to S_1 is 1.73 19 kilo joule per kg Kelvin and the pressure if you look at I can get the pressure p1 that is saturated pressure is 20 1.7 kilo Pascal.

Similarly at 40^0 Celsius right we will get basically this data's right p 3 is 10 17 kilo Pascal and h f which is equal to h_3 256.54 kilo joule per kg and $S_3 = S_f$ right that is equal to 1 . 1909 kilo joule per kg Kelvin and S_g I can get that is S_G = 1 .7 to 17 1 2 3 kilo joule per kg Kelvin. So we need to find out the compressor work and that is basically $W_c = m .S_2 - h_1$ right, so if you look at h1 we know right h1 is known.

So this is known right and a stone we need to find out and m dot already is given this is given this is given a stew we will have to find out so how will find out S_2 because the process is isentropic right here, so I know this entropy at this point right S_1 so the if you look at the process 122 is isentropic right that is the isentropic compression right. So therefore that means $S_1 = S_2$ right and we need to use basically what you call the what we will do we know this S_1 right that is equal to 1.7 319 kilo joule per kg Kelvin.

And from this what you call 40^0 Celsius right we can find out this S_f right this S_F we can find out also the S_G right and if you look at this S_G is basically less than the S_2 that means what that means it is basically the superheated vapor refrigerant right, so as the s2 is greater than the SG at 40^0 Celsius right okay, so therefore the state to is at superheated condition so from the superheated steam table sorry superheated refrigerant table right R134 a we can find out right I mean we can match this $S_2 = S_1$ and that is happening at the pressure right of 10 17 kilo Pascal's right.

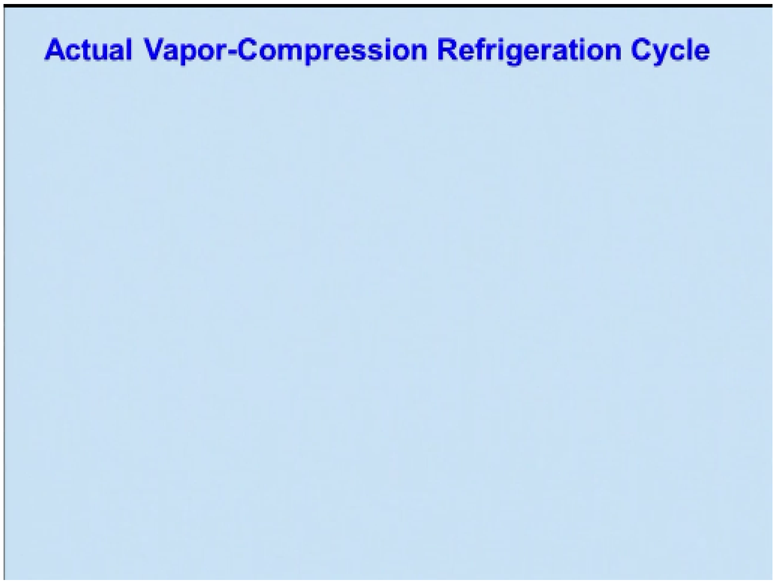
And once we can find out that then we can find out you know corresponding this table S_2 = 1.73 19 and right we can find out the temporary temperature also liked by interpolation that is 44.94^0 Celsius right and if you know like if you look at this pressure is already given like p3 this is the same constant pressure process so by that by mapping this S_2 S_1 you can basically find out what will be the temperature happens to be here 44.94^0 Celsius and correspondingly as to we can find out that is 425.68 kilo joule per kg.

And once you know this values what you can you can substitute these values here 1.2 x 425.68 – h_1, h_1 is your three 92.2, so that will be happening like in if we do that you will get something 40.08 watt kilo watt okay this will be giving you this much of amount of you know work has to be given to the compression. So if you look at like we have already seen S_3 is basically h_4 right and we need to find out basically the article a refrigerant capacity that is Q. l = m. x $h_1 - h_4$.
So we know that for process for process three to four is basically isenthalpic process so $S_3 = h_4$ so S_3 already and we know that is 25 6.54 kilo joule per kg right h_1 already we know so therefore you can you know very easily calculate that because m dot is 1.2, h_1 is basically 392 .2 -h_4 h_4 is 256.54, so that is equal to 162.89 kilowatt right so what now we need to find out basically COP that is coefficient of performance of refrigerant that is Q dolt / w c so Q dot l.

We have already found out that is 16 2.89 / the WC is basically 40.0 8 and you will get 4.06but if you consider between these two temperature you know they cannot reverse Carnot cycle then we will get the Coupon Carnot is equal to t l t h minus Twitch is equal to basically if you look at this is 263 / the 50 and that is equal to 5.26 so you can note from here that GOP of the Carnot you know refrigeration cycle is greater than treetop of the ideal vapor compression cycle .

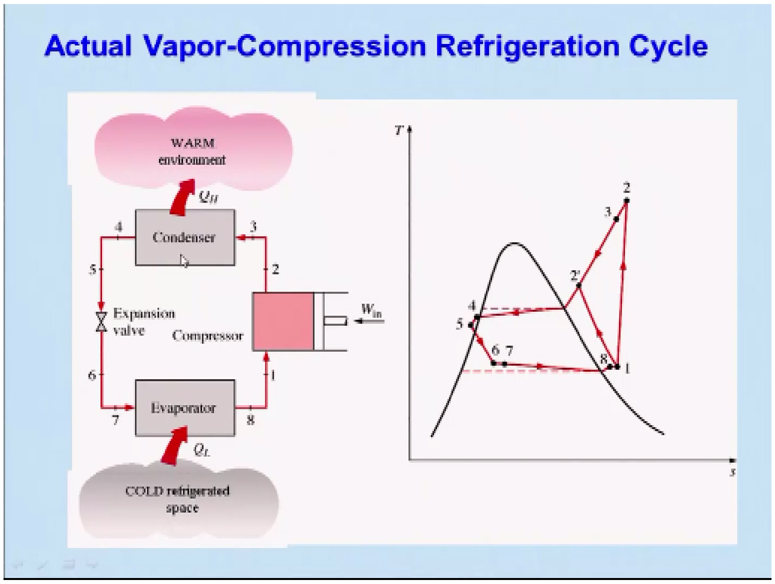
So I mean by this one can really learn how to calculate and how to do that and let us now discuss about actual vapour compression refrigeration earlier we had discussed the ideal vapour compression efficient cycle.

(Refer Slide Time 42:02)



Because of fact that the processes in the compressor need not to be isentropic in nature and so also in the during the heat rejection we have considered isobaric process and heat absorptional so brick process in case of ideal refrigeration cycle but that won't be possible in actual situation so let us look at the component wise the it will be having the similar like evaporator and a compressor condenser and the throttling valve.

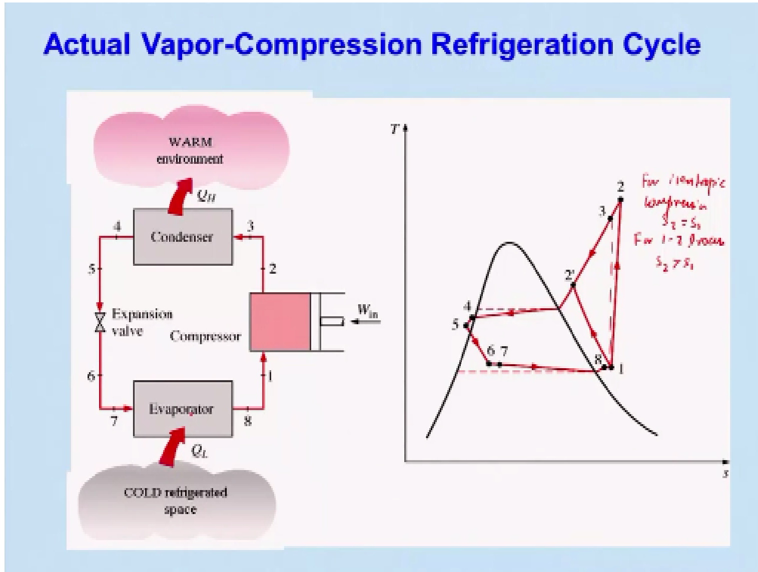
(Refer Slide Time: 42:40)



The what we call expansion wall but the process in the compressor basically will be no isentropic in nature that is 1222 if you consider this basically entropy as increase in this case act in the ideal situation the entropy will be remaining constant that means for isentropic compression that s 3 is equal to s1 and for actual compression for process 122right that s 2 is greater than s1 and in certain cases also we can intercooled the compressor says that entropy will change the process one to two dash of course that is to what you call enhance the COP coefficient of performance of the recreated .

And as I told that in condenser there will be lot of tubes will be there and I will show you may be actually refrigerator and so also in the evaporator there will be a lot of tubes will be there and then losses will be very high and generally this expansion valve is very closer to the evaporator.

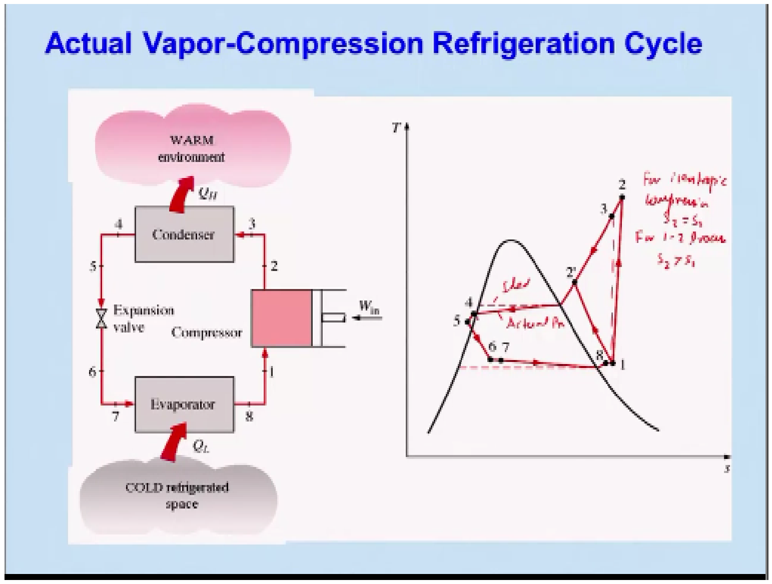
(Refer Slide Time: 44:14)



And then we will see me you know just after this discussion and as a result the pressure in the condenser only remaining constant and as the pressures not each you know changing in the condenser so also the temperature during this two phase flow will be changing that means it is be lowering down so pressure is lower down so also then the dashed line what I have shown here is basically ideal process this is ideal right and this solid lines actual process right so therefore the passes will be to the till four point in suppose to it but however it is very difficult to maintain the liquid article saturated vapor at the end of the condenser.

Therefore it is will be helpful to go for the sub cooled liquid till the state pipe which is the liquid and it is also a requirement for the expansion or the throttling process because of fact that if it is not saturated liquid.

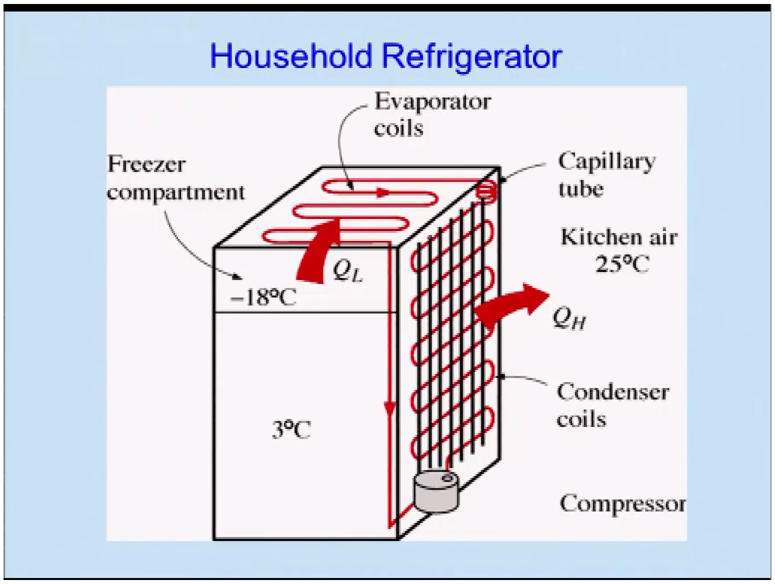
(Refer Slide Time: 45:30)



Then you know enthalpy will be change would not remain constant therefore if it is sub cooled liquid so that it will be remaining constant so h5 is equal to basically h6 in this case and in as a toll-like earlier that there will be what to call pressure change in the evaporator also so therefore the process is little bit extended from Essex to s7 so in this process what is happening basically you have ill up to give more work input to the compression and the cooling effect also being reduced as a result like COP will blower in case of actual vapour compression reference.

I cool as compared to the ideal one and which is expected we have seen also in the case of heat engine thermal efficiency of actual cycle is lower than the ideal site tape so let us look at a household refrigerator system so this is your compression which is shown right this is the hermetically sealed compression.

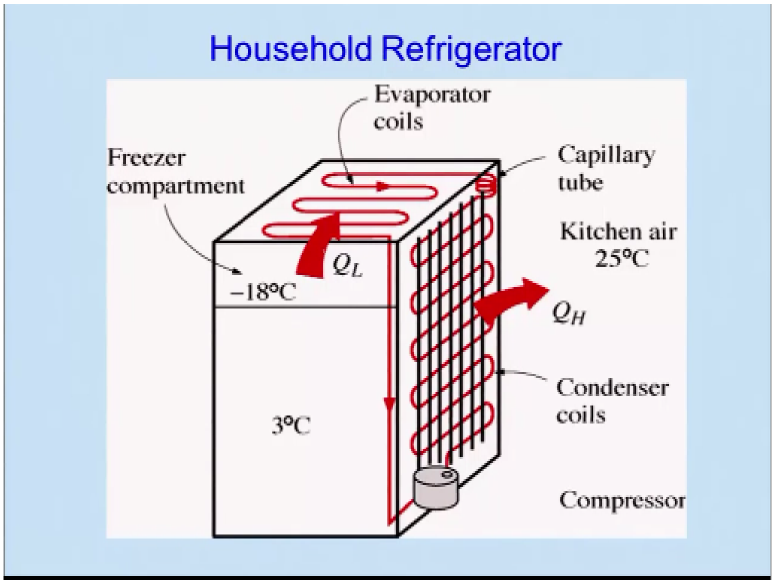
(Refer Slide Time: 46:47)



What people use it and there is a condenser coil if you look at you might have seen you know very old refrigerator system which is not covered nowadays they have covered if you put your hand it is very hot you might have observed right did you see any time go back to our even side and this lot of TV therefore the pressure losses will Bethe and this is your capillary tube what we call it as a throttling wall or expansion wall this is very simple very you know what you call hypodermic you can use as a small diameter tubes very simple one and which is closer to the evaporator coil and which will be remaining in your freezer compartment.

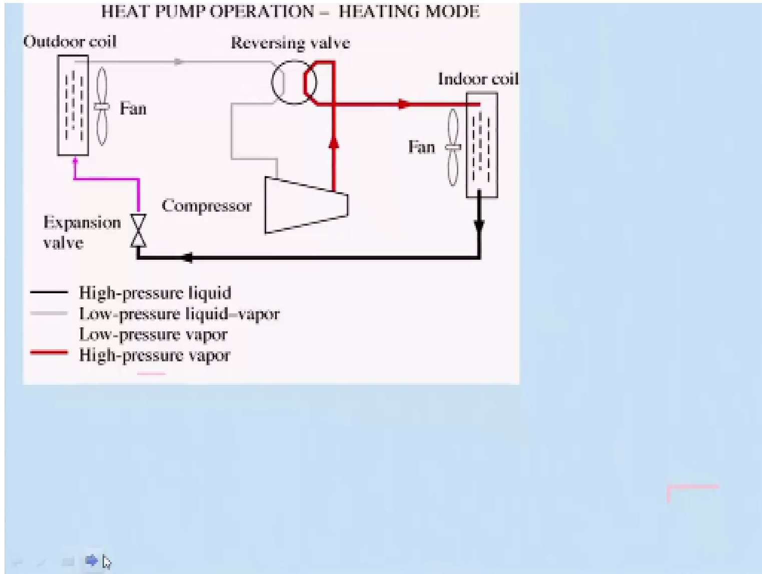
Right and that is maintained around -18 degree Celsius from where the heat will be absorbed and then you know it will be passing through and of course the other places the temperature maintained around three degrees Celsius in your household refrigerators okay not your other refrigerator where the low temperature is being used for keeping the ice criminal and therefore it is important to keep ice cream and other things you know like a freezer compartment otherwise it will be melt off.

(Refer Slide Time: 47:56)



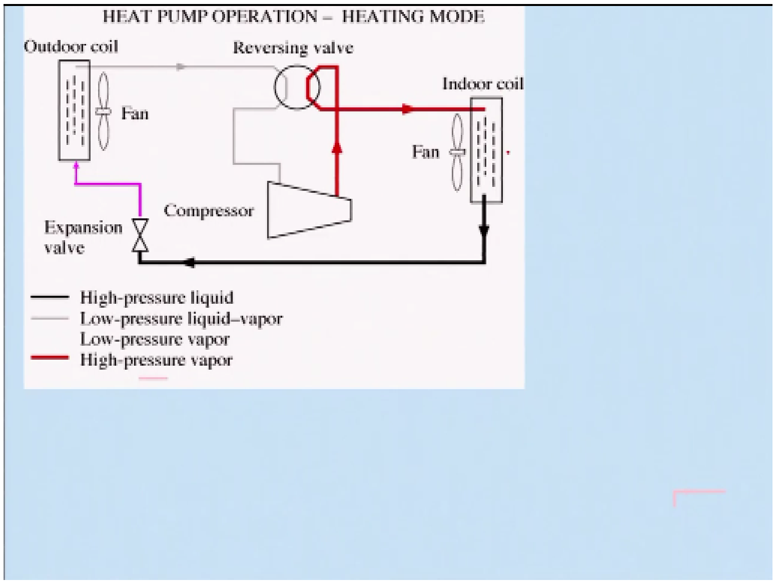
So this is the typical kind of things what will be you know being used of course the liquefaction systems another things will be you want to have a what you call the much lower temperatures and you may not achieve with the same refrigerant you may use some different refrigerants also together and that is known as cascading refrigeration system kind of things which won't be discussing but however if you are interested you can look at it but as I told that whether this air conditioner which is used can be used for heating in the winter season it pump .

(Refer Slide Time: 48:36)



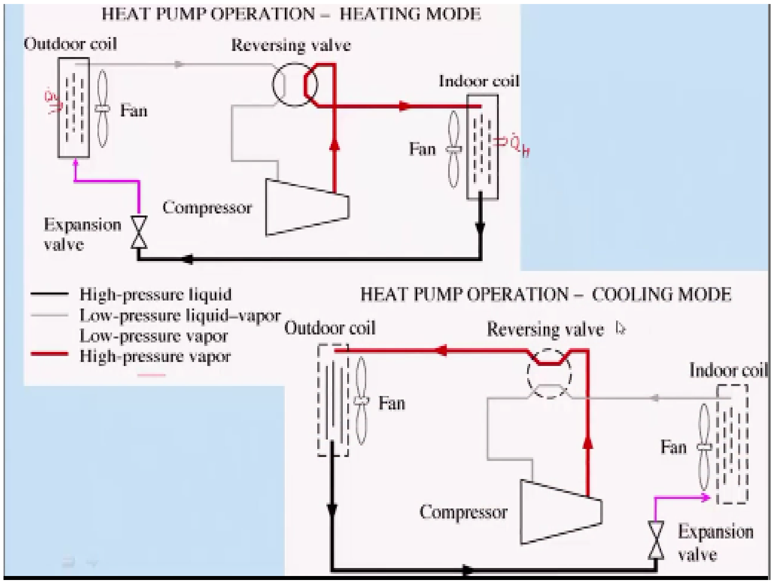
Because both the all the systems are similar you know like if you look at this is where having vertical expansion form wall and it is your compressor and this is your what you call the indoor coil kind of thing which is there and this is your outer you can say this is your you know sometimes it will beatings a condenser and it will be acting as also a evaporator so you just change this is one of them you know like this so in this case what is happening in this case we are using this as a heating mode that means we are taking out this is your hinder which is fixed in the room right .

(Refer Slide Time: 49:15)



And what is happening here it is compressed if it is compress here then it will be what you call higher temperature right and so that it will be taking or giving the heat out here right isn't it and then it will be coming and expanded it will be lower temperature and again it will go backend what you call observe the heat from outside ql and then it will go to again compress and goal that means it will be acting as a heat pump mode now if you look at the it is other way around that it will be acting as a you know cooling mode a heat pump.

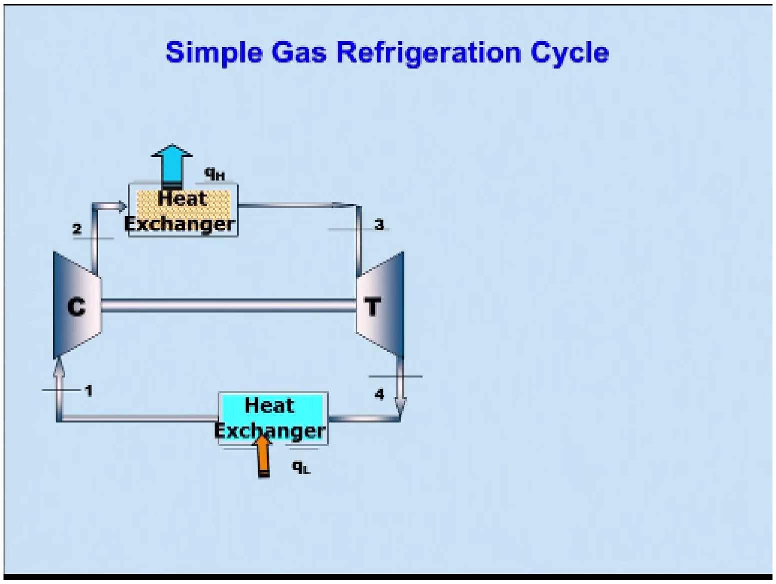
(Refer Slide Time: 49:59)



Will be acting as a cooling mode this air conditioner what do we say air cooler you can say and in this case it is the compression right it will be compressed and this ball will just reverse it is other one now instead of going to the indoor it is going to the outside row right in this case will be giving out heat here this will be acting like it what condenser here now right in this space it will be condenser right and then after that welcome and it will be expanded and it will be like a you what you call evaporator kind of things and again after that you know it will go to the again compressor and it will compress and cycle is complete so this will be if you look at it will be acting like a evaporator .

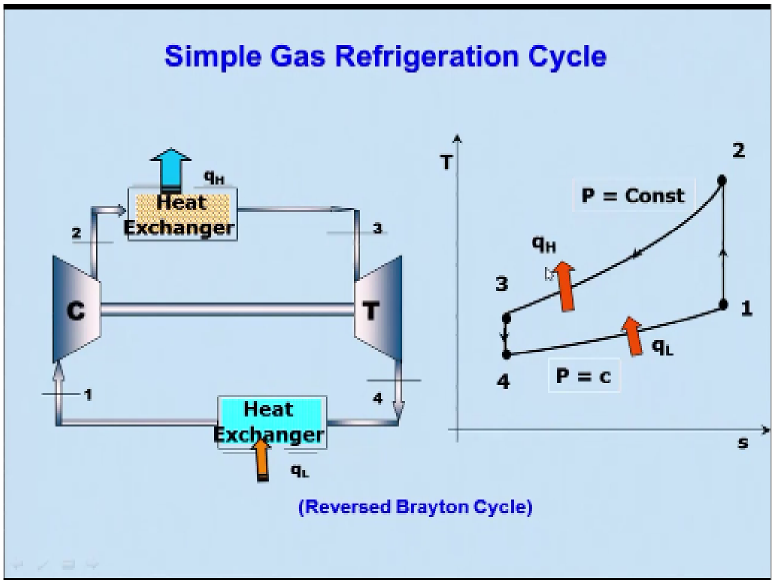
And it will be giving what you call taking heat from here you know ql amount right so you just change use this reversing wall and you can operate your air coolers a heat pump in the winter season and air cooler in the summer season so this is a very simple techniques which is being used one can go for it so if you look at we have looked at the vapor compression cycles of course there is vapor absorption cycle which we have-not discussed but there is a simple gas refrigeration cycle which is being used which will be using the gas not the vapor like your kind of things and in this case what is happening again.

(Refer Slide Time: 51:34)



It will be compressed 122 and there will be head exchanger heat will be going out and then it will be expanded in the turbine and then heat exchange so that amount of heat will be taking from the what you call colon Asian to that and then it will be it is rejected so if you look at the processes and this one is known as reverse Bray ton cycle we have already looked at Britain cycle for generating power it is just opposite of that that is if you look at 122 process basically isentropic right what you call compression and 32 sorry 223 process is what you call a heat rejection kind of things right.

(Refer Slide Time: 52:24)



And 324 is again isentropic expansion this is in the turbine and for21 is your high heat absorption from the coal medium right and as a result we are getting you just reversing the other way around you know and then using that so this is the ideal you know gasps refrigeration cycle even look at we will be discussing about ideal simple ideal gas-air efficient there is also complexity involved in it which you won't be discussing so what we are looking at here now.

Basically the ideal reverse Baryon cycle and we need to analyze it and we'll have to apply the first law of thermodynamics for each components for example for the processor 21 where it will be observed SQL which is nothing but is equal to h 1minus h 4 will be making the same assumption the steady flow process in this case and change in kinetic energy zero change in potential energy zero so therefore q le will be equal to h 1minus h 4 similarly.

qh will be equal toss 2 minus s 3 the same thing you know like so and the work is basically by the turbine see if you look at here the turbine is being produced some work right s 3 minus H for right and compressor is s 2 minus h1 and network will be w c minus WT and that you will have to you know like a is equal to s 2minus h 1 minus s 3 minus h ho and if you look at the co-pay coefficient of performance is nothing but q l / w net and you can find you know we are assuming that CP is remaining constant therefore you know we can express this enthalpy in terms of temperature because is remaining constant but is not it won't be for our assumption we are saying CP .

The constant not change changing with respect to temperature in actual situation it would be this is ideal we are taking and ideal gas also we are assuming so therefore it becomest1 the coefficient of performance of these gas refrigerators will become t 1minus t 4 divided by the what you call difference that is t2 minus t1 minus in the bracket t3 minus t 4 so that is the thing if you look at this COP of gas refrigeration will be less than the co pop vapor compression refrigeration cycle I mean you can do a simple calculation.

And you can see that whenever it is operating within two temperature this will build where so it uses for air captor you know cooling liquefaction of the gases of osteogenic systems and don't think that this is the use so simple cycles but there will be you know varieties are complexities will be involved in that in the sense regenerative and other things are being used so that GOP can be enhanced so if you look at we have given you an overall view of the refrigeration cycle kind of things and we stop over here and we'll be discussing in the next lecture basically about other how to handle this mixtures and how to handle the properties of the vertical air because air conditioning will be looking at so we will be looking at such that relearn thank you very much you.

Acknowledgement

Ministry of Human Resource & Development

Prof. Satyaki Roy
Co-ordinator, NPTEL IIT Kanpur

NPTEL Team
Sanjay Pal
Ashish Singh
Badal Pradhan
Tapobrata Das
Ram Chandra
Dilip Tripathi
Manoj Shrivastava
Padam Shukla
Sanjay Mishra
Shubham Rawat
Shikha Gupta
K. K. Mishra
Aradhana Singh
Sweta
Ashutosh Gairola
Dilip Katiyar
Sharwan

Hari Ram
Bhadra Rao
Puneet Kumar Bajpai
Lalty Dutta
Ajay Kanaujia
Shivendra Kumar Tiwari

an IIT Kanpur Production

©copyright reserved