MARINE ENGINEERING

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Lecture57

Refrigerants

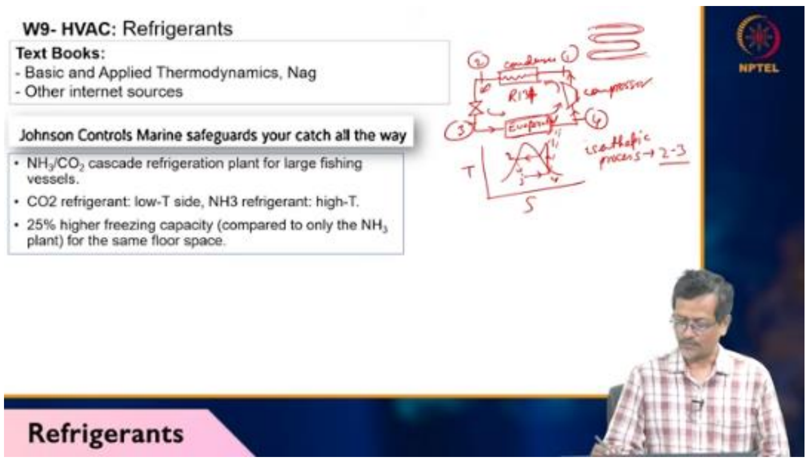
good morning everybody. Today lecture is on HVAC. It is continuation of previous lectures. previous lecture we started HVAC system and you have seen there is one compressor. Normally it will be a vapor compression system but there are other types of systems also there.

from compressors, hot vapor will go to condenser. Condenser to unthrottle valve or expansion valve. from expansion valve there will be evaporator so from evaporator again the gas will be going to compressor okay so fluid will be flowing like this okay normally the refrigerant will be like r134 or different type of refrigerants later we will discuss in details now this one if you want to put in TS diagram it will be like this initially you are compressing gas after compression you are cooling down this refrigerant then there will be throttling throttling process is actually isenthalpic process I will be putting number also 1 2 three four uh after compression one two three four okay so two to three is uh your isent eyes uh your enthalpy constant isentropic process isenthalpic two to three there i said enthalpy is not changing but entropy is changing and it is irreversible process

Okay, so we have seen this two to three is your throttling process or expansion process. So condensed liquid, will be passed through a narrow channel, and then evaporation will be happening. So the evaporator will be inside your room or inside your refrigerator and the condenser part will be outside your refrigerator. If you see any refrigerator system at your home also or any organic system, backside there will be one serpentine pipes. Normally it will be copper pipe.

and it will be releasing lots of heat and if you touch it it will be temperature will be very high actually so condenser will be releasing heat so temperature is high and it will be releasing heat to atmosphere and evaporator will take heat from your food vegetable meat fish whatever item you are putting inside refrigerator or inside from your room if you are using for air conditioning system for same system same mechanism will be used for your refrigerator or your condenser system okay Now, 4 to 1, we are assuming this is entropic process. So, that is why this line is vertical. If it is not isentropic, then the line will be deviated. For example, it may be like this.

So, it will be consuming more energy. 3 to 4 is an isobaric or constant pressure process. 2 to 1, it is again a constant pressure process. While 2 to 3 is your enthalpy constant, entropy chang and pressure also changes. Now I got some information from this Johnson control website.



So ammonia and carbon dioxide cascade refrigeration systems they are using actually for fishing vessels. So later we will discuss what is cascade refrigerator system. Cascade system is like you have one system refrigerator and you have two refrigerator systems as you have done. So for your nuclear power plant I said like two system will be there for greater cycle. One cycle will be giving some power and another cycle will be giving power. Here refrigerated system also will have like one cycle will be reducing certain heat.

Then again another cycle will be there to reduce further heat. that is normally used for your cryogenic application or very low temperature application. So this Johnson control for marine systems they have already ammonia and carbon dioxide based system. Ammonia also can be refrigerant. Carbon dioxide also can be refrigerant.

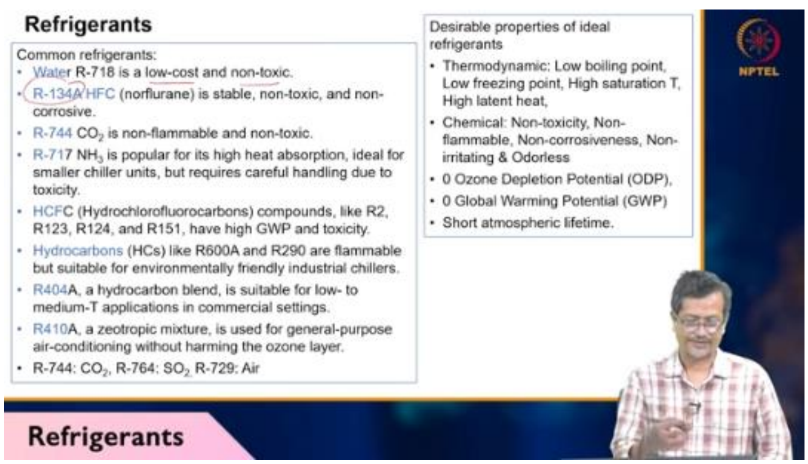
H2 also can be refrigerant. Other than your Freon and fluorine and chlorine based refrigerant systems. So carbon dioxide refrigerant, low temperature side it will be used. For example if I have cascade system like this. One cycle, another cycle.

So one cycle is like this for example. Then another cycle will be like this. I am not drawing properly so it should be normally like this. It should not go so long. So it will be like this.

So 1, 2, 3, 4, P, Q, R, S. So CO2 and NH3. So similar way you can design your refrigerator system. So the casket system is 2 systems or 3 systems or multiple systems will be there. So CO2 will be low-temperature side.

So low-temperature side means this one will be CO2 and this one will be NH3. At 25% higher freezing capacity so as per the company document they are saying freezing capacity is higher for same space if they are using. And if they are using only ammonia based system it will give less amount of freezing. okay so to increase system performance they will be doing so many different mechanisms they will be applying one is that cascading system and several other system will be there we'll discuss later so here we see the common refrigerant for example what water also can be one refrigerant okay it is a low cost non-toxic so it is very popular in many cases r134a also very popular refrigerant so These are called refrigerants.

Refrigerant is a working fluid flowing from the compressor, condenser, or evaporator. That fluid is called refrigerant. In thermal propellant, you used only water and you change heat from condenser, evaporator, not evaporator, you can say boiler. in the Rankine cycle case. But in this case, we do not have boiler, you have evaporator.



So, water, you should remember the name also like R7, R means refrigerant. R means refrigerant and 718 some nomenclature is there. So we will discuss later. So R134A, R744, carbon dioxide also can be there, ammonia can be there, hydrochlorofluorocarbons, HCFCs also will have refrigeration properties, hydrocarbons like R600A, so several refrigerants are there then ample names are there but we normally for you our case will be studying only the common part okay so you should remember the refrigerant name that chemical that

refrigerant is the designation R144, 718, 744 those things you should remember. So, R744 carbon dioxide, R764 SO2, sulphur dioxide also used as a refrigerant, R729 air, air especially for aircraft engine they use air as a refrigerant. So, desirable properties of ideal refrigerant, so thermodynamic low boiling point it should have, If it is a very high boiling point, then temperature requirement will be very high. So, it should have very low boiling point, low freezing point also, high saturation temperature, high latent heat also should be there.

Why latent heat should be there? When evaporation is happening, so small amount of fluid should take lots of heat. So, it should have higher latent heat. Even condenser side also, if you have higher latent heat, latent heat is the amount of energy it is absorbing to change phase from liquid to gas or gas to liquid. if amount of heat is higher so it will be beneficial for us chemical like non-toxicity should be there non-flammable if there is any leakage let's say if refrigerator you are using at home and flammability there it can be dangerous normally we use it for kitchen also right so in kitchen if some flammable gas is coming so that may be very much dangerous so non-corrosiveness must be there non-irritating health related point also should be there

and zero ozone depletion potential zero global warming potential we'll discuss later all these things and short atmospheric lifetime so quickly it should be depleted and it should be creating a separate molecule if it is staying for longer time that's also not good for your ozone depletion potential okay so okay so now see this refrigerant definitions Global warming potential or GWP, it is measurement of how much heat a greenhouse gas traps in the atmosphere over a specific period, usually 100 years and it will be compared with respect to carbon dioxide. So carbon dioxide they will be saying 1 as global warming potential. this is baseline. all other refrigerants should have more than that normally.

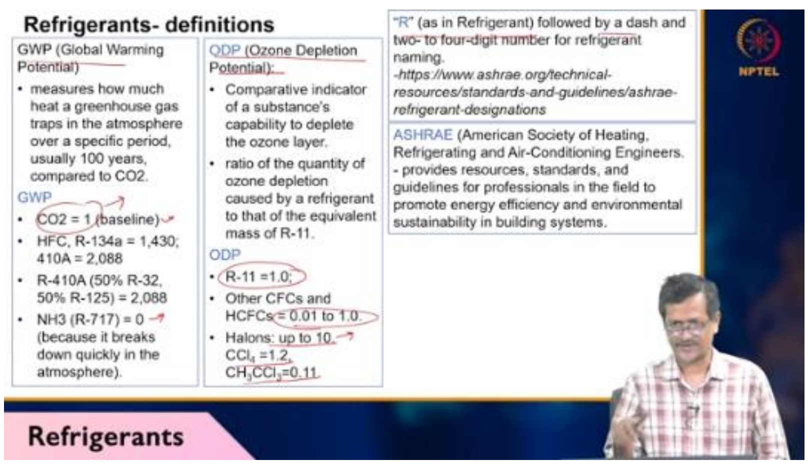
Ammonia will have zero. non-halocarbons refrigerant will have zero. For example, water. Water is not having a greenhouse gas. water will have zero value.

ODP, ozone depletion potential. If some refrigerant is depleting ozone layer, so their potential will be some, there will be some values and it will be compared with R11. R11 normally it will be 1, standard value they will be saying 1. Other refrigerant values will be like 0.0121. if I say R12, then it will be less than 1.

within that range, the values will be there. Hallons will have CCl4 1.2, CH3, and CCl3 1.11, so less than 1. Hallons will be more than 1. here it is written R as a refrigerant, followed by a dashed line or some other points will be there. those refrigerant name will be like this, R dash some number.

that will be the refrigerant name. Normally the naming and ozone depletion potential, ODP, GGWP, all these things will be decided by ASHRAE. ASHRAE website if you go, they have all these criteria, naming of refrigerant and lots of information will be there. American Society of Heating and Refrigerating and Air Conditioning Engineers, they are basically regulatory bodies you can say. they will be putting all the regulation digits and naming, GWP potential, all the digits, it will be there in their website.

They publish in many books also. if you want to know more about refrigerant and their effect, you should visit their website ASHRAE. naming of refrigerant are already told, it is refrigerant, followed by 2 or 3 digits. The methane, ethane, propane, series like X, number of carbon atom, minus 1. X equals 0 CH4.



But 0 is ignored. R12 and R22 it is having one carbon atom. it should be R012. similarly other naming also you should just you go through it. maybe some question I can give based on this naming structure.

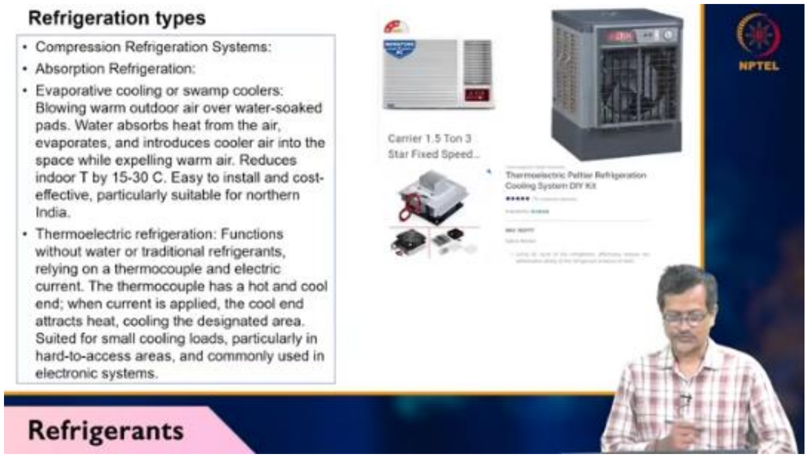
refrigerant regulations so if you see a refrigerant the refrigeration system started long back and 1930s around it was r12 it is having very high odp ozone depletion potential if 10 000 they have written okay so 1950 1900 2025 you see this ozone depletion potential gradually going down okay so they have target like 2024 or 25 onwards there will be no ozone depletion okay greenhouse Global warming potential also will be lower than 700. And this will be coming under again ASHRAE's classification A to L. So they have one document

34 specification. So there they have specified all this greenhouse potential and ozone depletion potential like GWP and ODP in their document. So which refrigerant will have higher potential, which have lower potential is there in their document.

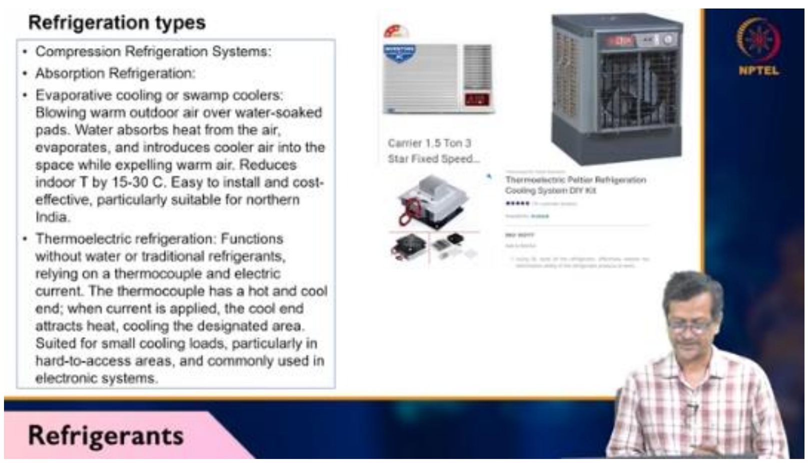
So A to L, you see this one, mild flammability, low toxicity, low GWP, hydrofluorine, HFO blends, safer than ammonia, ammonia actually toxic in atmosphere, hydrocarbon based refrigerant, energy efficient than R410A and transcritical carbon dioxide system. HFOs replaces older HCFCs, lower GWTP potential. So this ASHRAE A2L recommendation shows the list of refrigerants which people will be using actually. The companies, especially the big companies, normally they will be using this latest refrigerant and they are doing lots of research also like many big companies for marine applications or domestic applications in land use. They are developing new type of refrigerant, new type of technology.

If you see any refrigeration system, fridge or air conditioning system, every 10-15 years their technology is changing actually because they want to increase efficiency. They are making more energy efficient. They are making less noisy and they are working on the pump side. They are working on this refrigerant. They are trying to develop new type of mixed type or single type.

compound or mixed compound they are using and they are trying to develop new systems or new series of air conditioner or refrigerator systems. So it will this example they have given R32 and R54B. So there will be many others also. So many companies will have their own company name also and they will be putting some extra chemical to improve certain properties. So, we have seen air conditioner types like air conditioners will be split air conditioners, wind air conditioners and centralized air conditioners.



different types are there. refrigeration type also like similar way we can divide, but there will not be any split air conditioner sort of thing, but technology I will explain. vapor compression system I already explained like one compressor is there, then condenser is here, then one throttle valve is here. Throttle valve normally we specify like this. This is throttling.



This is you are creating restriction. So whenever you are drawing throttle valve just put this symbol. It will be looking good. Not this one. Like this.

Then it will be going to the evaporator. Then it is going to condenser. this is your simple vapor compression refrigeration system. Vapor compression refrigeration system, VCRs. And absorption system.

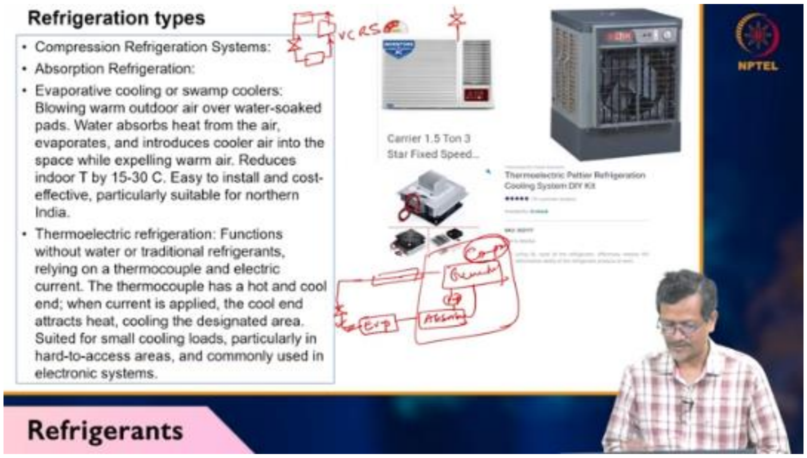
Another system is called vapor absorption system. So, there we can use water also as a refrigerant. How the system looks like? So, it will have evaporator system. So, refrigerant will go to one absorber.

then there will be one throttle valve okay from here it is coming evaporator absorber absorber 2 it will be going to generator and there will be one pump okay so what will happen this evaporate let's say water is there water will be absorbed by certain fluid or ammonia ammonia will be absorbed by water okay So, let us say liquid ammonia we have or gas ammonia we have and if you have water, so water will be absorbing lots of ammonia or water will be absorbed in some lithium bromide solution very high rate. So, when it is absorbing, it will create low pressure actually. When it is creating low pressure, so that low pressure will be evaporating more refrigerant. When it is evaporating, again it will take heat.

So you are creating indirect evaporation. In wafer compression system you create low pressure. Then you compressed, you expanded but here also you are doing same thing. So here condenser will be there. So this part actually it is mimicking your wafer compression system, your compressor.

It is mimicking compressor but this part will be same. This is condenser. okay this will be releasing heat then throttle valve then evaporator will be there okay so in this case h2o can be your refrigerant ammonia can be your refrigerant okay so basically these are common refrigerant used for vapor absorption system normally this will be used for your there's a cold storage or similar sort of where high heat requirement is there and big these will be heavy and bulky so that's why you cannot use for your small room application okay because you will have some extra mechanism absorber pump generator then condenser But if you have window air conditioner you can see simple one windows air conditioner this much of size will be there. So this one you can fit in your window or you can have split air conditioner you can use for your household.

And this one if you are from North India you are very much familiar with this type of figure. Lots of square will be there and water will be splashed over it. So water soaked thing will be there and one fan is here. Here I think four bladed fan. This is axial type fan. This is axial fan. So actually it will be taking air.



Air will be entering here. Then air will be going out from here. And it will be soaked with water. When you are soaking, air is going through the soaked cotton or the sieve. So the air will get lots of moisture.

When air is getting lots of moisture, so actually temperature will go down. Later we will discuss psychrometrics. So there I will explain how this temperature is going down. So when you are adding moisture in air, temperature will be going down and you are feeling comfortable, cool environment. And this will be working only in low humidity area, especially in North India.

and south india like say kolkata chennai this area we cannot use this type of thing because already humidity high so this purpose of this desert cooler is to increase humidity but if you have already high humidity you cannot use so that's why in chennai hostels are other nowhere is there but north india everywhere it will be it is very common also and very cheap also in roadside vendors also they'll be selling this type of uh desert cooler okay so evaporative cooling or swamp cooling so this is actually evaporative cooling okay so lots of moisture will be there and moisture will be evaporated and when it is evaporating it will take latent heat latent heat when it is taking so temperature will be going down okay that's why this is working so temperature can be reduced by 15 to 30 degree very high temperature reduction based on your ambient temperature and your humidity let's say temperature is very high humidity very low so in that case you add moisture your temperature will be down at very high rate moisture will be going up so finally you will feel comfortable room okay thermoelectric refrigeration system this is also there but this is very less use is there for especially electronic cooling you can use Okay, so when we write about refrigeration, so like R11, it will be like R011 as per the formula. Then you can represent in chemical formula like this, C, carbon, F, fluorine, chlorine, chlorine, chlorine.

Okay, so it will be C, F, Cl3. Okay, trichloro, monofluoromethane. That name also you should remember, trichloro. chloro mono fluoro methane so r12 r22 if you want to write then r so r22 means 0 2 2 so 0 means carbon in the previous slide you can remember c will be 0 plus 1 then 22 means H2-1 and F as it is 2.

So I can write like C1, 0 plus 1, C1, H2-1 is H1, fluorine 2, the remaining is chlorine. So, this formula becomes CClF3, CHFF2Cl. So, monochlorodifluorometHan. I think you are very much familiar with these chemical names, monochlorodifluorometHan. Okay, now R113, R113, so the formula is that, so 113, 1 means carbon plus 1, C will be like 1 is here plus 1 and 1 is for hydrogen, so 1 minus 1 and 3 is for fluorine.

Okay, so my carbon is, 2 carbon will be there, 2 carbon. So this formula becomes like F. F means 3F will be there. F, hydrogen, chlorine, chlorine, H. So chlorine number is not given. So remaining part will be chlorine. So C2F3Cl3.

F will be 3. F will be 3, then 1, 2, where is H? Because there is no H. So, there will be F, then C, F3, CL3, CL. Okay, so this will be a formula for R113.

So, if I give R113, so you can decode actually or if I give C2F3Cl3, then you should be able to write the name of the refrigerant. Thank you very much for today's lecture. Next class, we will start the formulation of the refrigeration system in the HS diagram. Thank you.