INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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NPTEL ONLINE CERTIFICATION COURSE

Refrigeration and Air-conditioning

Lecture-21
Introduction to Air-conditioning

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Hello I welcome you all in this course on refrigeration and Air conditioning, refrigeration part we have already covered in the previous lectures; today we will take up introduction to air conditioning. Now in refrigeration the temperature is controlled at a certain level but in case of air conditioning not only temperature humidity is also controlled.

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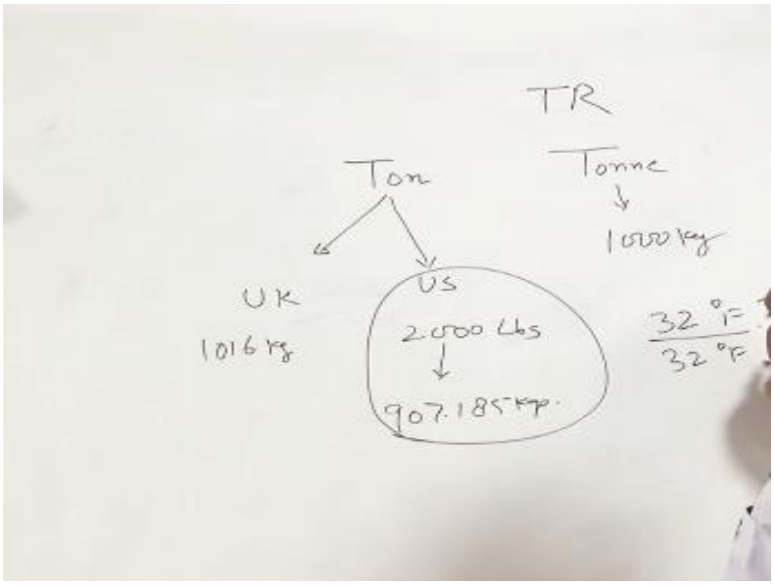

Temperature, humidity in addition to these two the quality of the air is also controlled in air conditioning, so air conditioning is not only about controlling temperature and humidity it also

involves the controlling the quality of the air, it is possible that you sitting in a room temperature is ideal temperature, in India the ideal temperature is 25^0C humidity is 50% this is ideal case but you will not feel comfortable. You may not feel comfortable because the quality of air in this room is poor the quality of the air includes everything the dust particle in the air or cleanliness of the air, second is presence of carbon dioxide in the air because is there is a high level of carbon dioxide then there are symptoms like you will be start feeling headache or body pain and you will not feel comfortable at all.

So it has been witnessed specially in the case specially in the classrooms which are air conditioner air condition or the computer centers where the population density is high the level of the carbon site carbon dioxide shoots up and this shooting up of level of carbon dioxide cause this state of discomfort among the occupants it happens like this you are sitting in a air condition environment temperature is 25^0 you are not feeling comfortable but when you go out, outside temperature maybe 40^0C but you feel very fresh, that is due to access of carbon dioxide in the close environment.

So air conditioning I am repeating air conditioning involves not only control of temperature humidity but also quality of vapor, now as in the case of refrigeration if you remember we express in terms of cooling, in air conditioning also we express the capacity of the system in the forms of tons of cooling tons of refrigeration or tons of cooling and again I will like to repeat here. Because I have largely told you in the first lecture that there two terms one is TON another is TONEE this TONEE is 1000 kg.

Now this TON it is UK tom and US ton now UK ton is 1016kg this is 2000kg and this sorry this is 2000 pounds an these 2000 pounds when it is converted to kg it comes around 907.185 kg and when we talk about 1 ton of cooling the cooling it involves this ton, so one ton of cooling means. The conversion of one ton of water an level at 32^0 Fahrenheit into one ton of ice at 32^0 Fahrenheit within 24 hours, so that heat will move a rate is known as one ton of cooling and I have told you earlier also.

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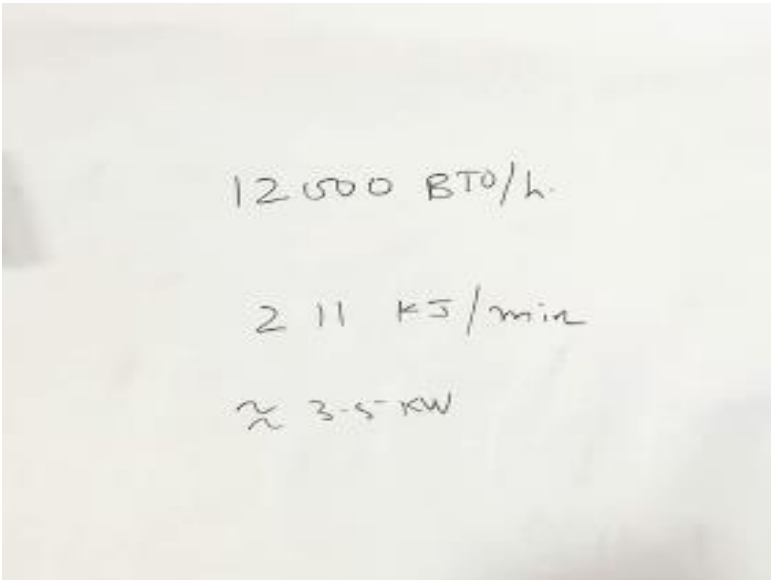

That one ton of cooling is equivalent to 12000 BTU/hr and which is one ton of cooling is 211 kilo joules/minute or approximately 3.5 kilo watt, so wherever a cooling of the order of 3.5 kilo watt is provided we say that the cooling is of the order of one ton of cooling.

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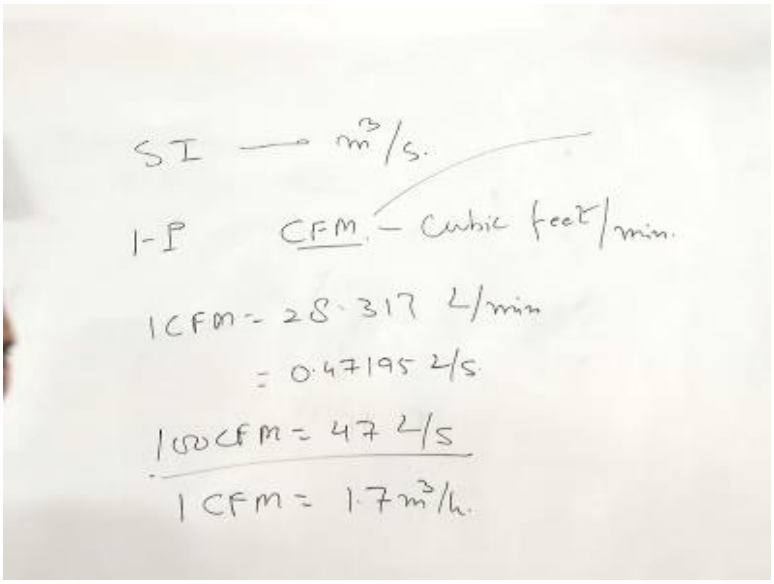

As a mechanical engineer we should be very conversant with the units, for example volumetric flow rate, in volumetric flow rate in each in SI system is expressed in terms of m^3/second however you will find in both of the cases in air conditioning the volumetric flow rate is expressed in each pond system and that is CFM, CFM is stands for cubic feet permanent, cubic feet per minute.

Now if you convert this CFM into the liters per minute it turns out to be 1 CFM = 28.317 liters/minute because we are have said with the SI units but in and you will find the number of the books on air conditioning also they are using mixed units they are using mixture of IP and SI units but here in this course we will be covering only SI units so we will cover convert all the IP units into SI units.

So we have to be very conversant with the conversant so cubic feet per minute shall be 28.317 liters per minute which will turn out to be 0.47195 liters/second, so if I say half 100CFM, 100 CFM will turn out be around 47 liters/ second so it is almost half, normally a you will find in air conditioners when we design EC's for the large building certain minimum fluoride has to be maintained.

And the thumb rule is for one ton of cooling it has to be around 400CFM but normally you will find in a extremities, extremities are the window type of AC's the CFM is lower than this, it is kept lower than this because it is used for the confine space otherwise for the large system normally the CFM is 400 CFM per ton of cooling so immediately we can take even if you take 100 CFM = 50 liters/second.

Then that will also do but normally we consume we assume that 100CFM = 47 lit/sec in some of the cases CFM is also expressed in m3/hour and once CFM one CFM is 1.7m^3hour, sometimes area is given in feet's square in air conditioning also you will find.

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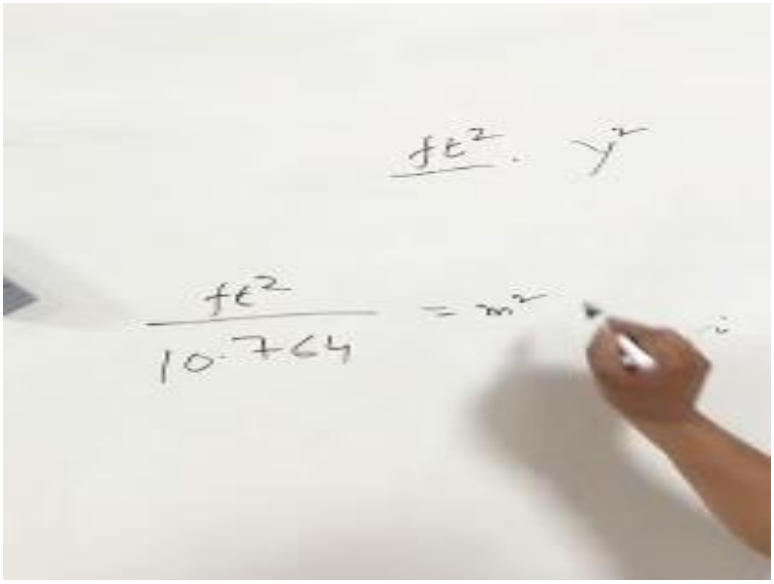

That area is given in feet square or area is given in square yards in this case if you want to convert square feet into the meter square then square feet divided by 10.764 this conversion factors you have to remember area in square feet divided by 10.764 will give you area in meter square this stands perhaps all of you may be knowing and that one mile for = 1.61 km.

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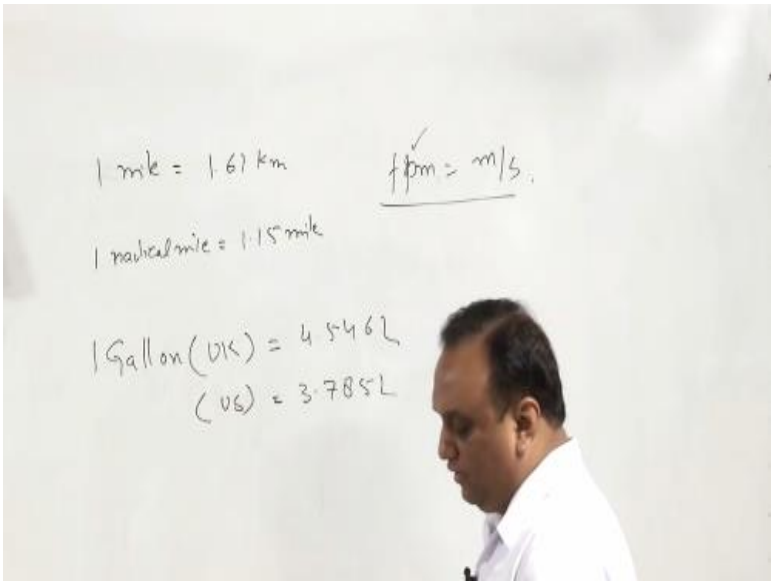

And one nautical mile = 1.15 mile likewise there are many conversion factor like if I take I gallon of UK that is equal to 4.546 liters, if I take 1 gallon (US) it turns out to be 3.785 liters like wise you will have to convert by yourself the velocity feet's/minute 2 m/s this you can do by yourself you do not need my help here this feet/minute you can always convert this into m/s so mechanical engineer you have to very conversant with the units especially in air conditioning because in air conditioning books in some of the books I have found that we are using mix units, right. And here we will be following only SI system of measurement.

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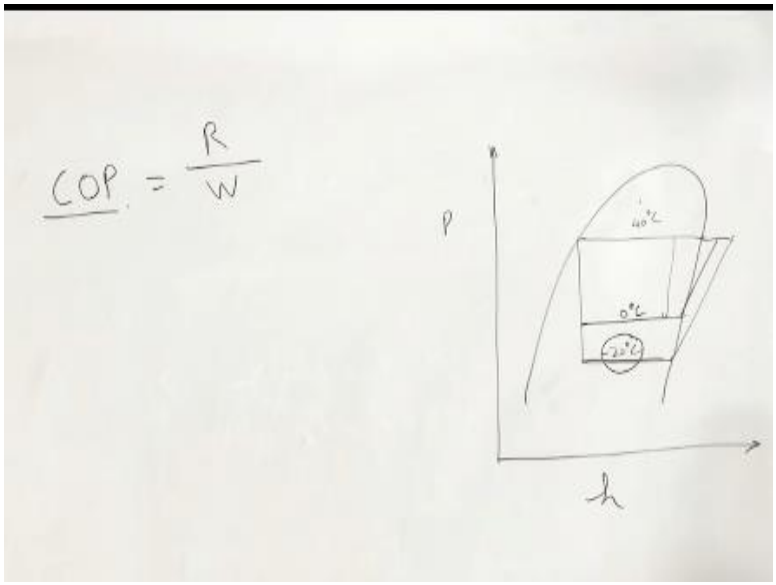

Now efficiency of air conditioner, now in a refrigeration system you where using CoP co-efficient of performance, co-efficient of performance was refrigerating effect divided by energy spent for this refrigerating effect that is energy consumed by the compressor, the same CoP is used for air condition also every year the conditional has certain CoP, now in air conditioner normally CoP is air than the refrigeration system.

The reason being if you look at the Ph diagram, in refrigerating system the evaporator temperature we are assuming around -20^0C and condenser around 40^0C, right. Condenser temperature can be have on this it can go to 50^0C because if the heat is dissipated to the

surroundings anyway here the evaporated temperature is -20^0C condenser temperature is 40^0C but in air conditioning system in most of the cases this for decision air condition we have to maintain 25^0C temperature of the room for that purpose the air coming from the air conditioner may be of 13 or 14^0C in that case this temperature shall not remain -20^0 C it may be around 0^0C or 1 or 2 or 3 ^{0} C, in that case you can see here there is more refrigerating effect and less power consumption that is why the CoP of air conditioning system. Is often or in most of the cases is higher than a refrigerating system, it is a general conclusion.

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Now efficiency of a air conditioning system is not expressed in terms of CoP if you go to the market and purchase AC for yourself you will never find this CoP or the data sheet, now in air conditioning system the efficiency is expressed by energy efficiency ratio, energy efficiency ratio is nothing but the ration of heat transfer in BTU/hour and energy consumes it consumed in watts.

Now here itself you can see that there is a mix unit, BTU/ hour is energy transfer rate in each pond system and W is the heat transfer rate in SI system, now here we will convert this in each port system unit into equivalent of SI system unit, now British thermal unit that is BTU = 1055

joules now If I write BTU per hour that turns out to be 1055 / 3600 J/ sec or this J/ s is nothing but watts so in dominator and numerator we will have same type of unit now here BTU / hour cam be calculated as 1055 / 3600 that turns to be 0.293 so we can comfortably write that COP = 0.293 energy efficiency ratio multiplied by 0 energy efficiency ratio so if we have energy efficiency ratio of any equipment it can be easily converted into the COP for example EER available in the market as energy efficiency ratio of 10.5.

So I want to convert this into the COP it is going to be equal to 3.x 2.293 = 3.08 so this is the conversation of ER into the COP in the air conditioning market you will find right that is the rating of AC systems 1 star , 2 star , 3 star 2 star not 1 star raise 2 star 3 star and 4 raise star and 5 star now 5 raise star is a the 5 star AC should have COP > 3.5 there are few manufactures in the market how give 5 star AC 4 star should have COP > 3.1 and definitely there is an > 3.3 and < 3.5 so in this range it is going to be 4 raise star or greater than or equal to.

Similar for 3 star you see the COP has to be greater than equal to 3.1 and it is to be less than 3.3 and I do not recommend that when you purchase AC for yourself you should go below 3 star it is always recommended that why you should go for a 5 star AC it is energy efficient and though they are slightly costlier but break in point come vet fast so untimely you remain in the profit zone when you purchase a 5 star AC they fixed cost is high but there running cost is low they consume less energy now if you go down star vise 5 star to 4 star to 3 star.

The fix cost may reduced but the running cost will increase so at the at end of the life of the AC normally it is assumed that the life an air conditioner is 15 years it goes up to 20 years also but average life is consider to be 15 years so in a 15 year's time this always a profitable buyer this is not profitable buyer for the span of 15 years now after this the star rating this I about the heat transfer but air conditioning involves not only heat transfer or maintain the temperature.

It also involves the movement of air in this room the movement of air in a residential building should be sized that in any part suppose this is the room so any part of the room the temperature difference should not be more than 1 degree centigrade or if the it is a 4 room or 3 room or 4 room set the temperature difference should not be more than 2 degree centigrade so air

movement in the building is very important right with the right kind of air movement you can maintain higher temperature of air conditioner.

And when you are maintaining high temperature of air conditioner in lot of energy can be saved so for the air movement first of all we should ensure that the air velocity in the system air conditioning system should remain between 0.1 to 0.3 meters / s especially in the summers it is recommended that a velocity should remain in the range of 0.1 to 0.2 meter / s in winters where air conditioner is used as a pump in market also some of the air conditioners are available these air conditioners you can use as heat pump.

So in the summer season they can be used as heating device and because when the cycle is reversed and air conditioner is used as a heating device is energy efficiency is COP +1 so suppose I want 1000 KW of heating 1000 w of heating and I use reviser cycle so 1000 W suppose COP of the system is 3 so 1000 W / COP will give you the power communed that is = 1000/ 4 and that's I 3+1 4 and that is 250 W so by spending only 2 it is abused to strange and it appears to be the violation of law of conservation of energy because at the expenditure of 250 W we are getting hearting equivalent 1000 W.

A same type of heating as to be done with a electrical heater I will be spending I mean I will be paying for in 1 hour run for this 1 KWh so if I run electric resistance heater for a period of 1 hour the unit of power energy consumed is 1 Kwh if I use reverse cycle type of or if I use the heat pump where heat is pumped from lower temperature outside lower temperature to inside higher temperature in that case the power consumed only 250 W or 1/ 4 Kwh may be straight way saving of 75% .

And you can save a lot of money on electrical bills that is why it is always recommended so heating purpose we should go for heat pump heating insisted of any resistance heating further location of air conditioner in a room is also important now cold air in summer the cold air as to come into the air as to come into the air so cold air should strike upper half of the body of an individual only then it will a state of comfort same way in winter heating the hot air should strike the lines.

If hot air is sticking the lines it will give very good state of comfort insisted of the fact one it is striking upper half of the body so cold air in summer should strike upper half of the body of an up to of occupants and hot air in the winter should strike possible should be made that hot air is strikes the lower half of the body sometimes it is not possible because you have only one air conditioner and it works it works as a pump in winters and cooling device in the summers it is not possible.

But if it is possible then such arrangements should be made now they are number of application of air conditioning system not only for comfort application it as got means industrial application also.

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For comfort applications the AC are used in the residences as all of us know retail facilities if yoj go to market find right in the number of the shops they are using air conditioners commercials and public building hotel and restaurants now most of the restaurants are air conditioned hotels are so rooms in the hotels are also air conditioned education facilities now schools and the

colleges part of the schools and colleges they are also put in the control environment or air conditioners health care felicities hospitals now a day's hospitals are also air.

So it as got wide application so it is not confined to the residential cooling the air conditioning system even the automobile stream, aircrafts ships in addition to this comfort applications where industrial application also for air conditioning there is a huge industrial application like I'm coating some of the facilities.

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Like engine test facility laboratories most of the laboratories are air conditioned data processing and telecommunication textile industries printing plants museum and libraries there are special kind of air conditioning is required in the industries f=or example museums and libraries the air flow ratio not be very high right fresh air as to be maintained inside the museums and where been control for any one in plants power plants nuclear facilities even in the mine air conditioning in the and they are more 100 and 1000's of applications.

So that mean tool environment as become way of life now a days and definitely when we work in control environment or air condition environment our efficiency and the increase and it as been also notice that where a class room is air conditioned the students are more alert and attentive and there grasping power also increasing and controlled they in conduction of air conditioned where in the next class we will start with property of most air thank you.

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