Cooling Technology: Why and How utilized in Food Processing and allied Industries

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Module No 09

Lecture 42

Compressor

Good afternoon my dear boys and girls and my dear friends. Today we shall start the individual components, right. We are in the 9th week ok. So, today we shall do individual components. For example, one of the most important, which normally is called, heart of the refrigeration system, that is, compressor, right. So, we will do on compressor and as I told obviously, we will cover most of the part, which is required, but it could be that, some, we can skip and allow you to read.

And, hopefully, not only this, I have no idea of course, I cannot commit that, the slides could be available to you. I have no idea about that, but definitely, the lectures you can access, right, those, who are registering for the course, right. I again repeat, some day back, I told that this course is designed, I have designed, is designed means, I have designed in such a way that, this is very very helpful for agricultural and food engineering only, food engineering or food technology etc. Then, chemical engineering, then, mechanical engineering and also civil engineering, because, if even civil people, they do not know refrigeration. So, how can they go on building the system, typically the storage facilities, right.

So, this will be very helpful course for multidiscipline, ok. Now let us come to the compressor. So, what is a compressor? It is a device that is used for pumping compressible fluids that is air, gas, steam, whatever it be, right. So, it is a device pumping compressible fluids, that is a compressor. Then, what is the basic difference between a compressor and a blower? We have seen, blower blowing lot of air and many others.

So, what is the difference between a blower and a compressor right. According to API, pressure rise above 0.35 bar is compressor, and below is blower. So, it is basically a pressure, right. So, anything beyond 0.35 bar is undergoing to the head of compressor and less than that is the blower. Now basic some techniques, or some terminologies are required, that is flow rate, is in meter cube per hour, or it could be CFM, that is cubic feet per minute, right. One CFM is roughly point not, roughly exactly 0.586meter cube per hour. Pressure ratio, that is ratio of absolute discharge pressure, and absolute inlet

pressure.

Now, again, I will, let me tell, one more, once more, rather, that inlet pressure is normally suction pressure, and exit pressure is normally, discharge pressure. Here, we have directly said that absolute pressure is that gauge pressure plus atmospheric pressure, is the absolute pressure. Have you seen any gauge? If you have seen, let me tell that, this gauge looks like this, and it is graduated and there is indicator, like this, which is at 0, if it is not in use right. So, 0 gauge pressure, like here, if it is 0, then absolute pressure is the atmospheric pressure, but if you have some pressure in the, if you have some, sorry, if you have some pressure in the gauge, then your absolute pressure is that, plus the atmospheric pressure. Obviously, atmospheric pressure is the pressure exerted by the atmosphere.

At the sea level, atmospheric pressure is 1.033 kg per centimeter square, and area A is one, say, rather at 1.033 kg / centimeter square and is equal to 1.013 bar, and is equal to 14.696 psi absolute, all are in absolute, right.

This is also in absolute, this is also in absolute, this is also in absolute, and this is also in absolute, right. So, that, we have to keep in mind, that the relation between pressures, and also equal to 760 millimeter of mercury, or it could be, 1 atmosphere. Now, 1 kg per centimeter square, that is equal to 14.22 psi, and 1 mega Pascal is 10.1 bar. Obviously, we have said earlier also that 0 degree centigrade is roughly taken as 273 Kelvin, right. So, a compressor is the most important and often the costliest component, typically around 30 to 40 percent of the total cost of the refrigeration system, if it is under vapour compression refrigeration system. The function of the compressor, in a vapour compression refrigeration system, is to continuously draw the refrigerant vapour from the evaporator, so that a low pressure and low temperature can be maintained in the evaporator at which the refrigerant can boil extracting heat from the refrigerated space. The compressor, then, has to raise the pressure of the refrigerant to a level at which it can condense by rejecting heat to the cooling medium in the condenser, right.

So, classification of compressors can be made in this way, that compressors used in refrigeration system can be classified in several ways. Number 1, based on the working principle, that is, whether it is positive displacement type, or rotodynamic type. If it is positive displacement type compressor, then, compression is achieved by trapping a refrigerant vapour into an enclosed space and then reducing its volume. Since a fixed amount of refrigerant is trapped each time, its pressure rises as its volume is reduced. When the pressure rise to a level, that a slightly higher than the condensing pressure, then it is expelled from the enclosed space and a fresh charge of low pressure refrigerant is drawn in and the cycle continues, right.

So, we can say, depending upon the construction, positive displacement type compressors used in refrigeration and air conditioning, can also be classified into as we said reciprocating type, or rotary type with sliding vanes, that is, rolling piston type or multiple vanes type, or it can be rotary screw type, that is, single screw or twin screw type, or it can be an orbital compressor and lastly it could be acoustic compressors, right. Then, unlike positive displacement type, the rotary dynamic type compressors are steady flow devices. Therefore, these are subjected to less wear and tear. Depending upon the construction, rotary dynamic type compressors can be also classified into either radial flow type or axial flow type right. I hope, axial flow you know at your house, you have the fan on your head, right it is rotating and this is called axial fan, ok. Axial compressors also known as turbo compressors, are radial flow type rotary dynamic compressors.

These compressors are widely used in large capacity refrigeration and air conditioning systems. Axial flow compressors are normally used in gas liquefaction applications, right. Then, it can be based on that division, or the type can also be based on arrangements of compressor motor, or external drive. So, it can be open type, it can be hermetic or type, it can be semi hermetic or semi type. The other day, when I was talking about household refrigerator, there also, I said that the compressor is hermetically .

Hermetically means, you will look you will see complete this kind of enclosed thing, where, there are two, one is inlet and another is outlet there, and normally they are capped, normally, right, before it is used. So, that is hermetically type, but open type one, which we come across is the one, which normally used in the higher level of refrigeration requirement, right. So, there, it is open type because, hermetically types are with the small capacities, or small refrigeration or tonnage requirement. There is, and another thing, this hermetically sealed compressors are hermetically, they are so absolutely. So, its maintenance is a very very problem.

Normally, it does not go wrong. Have you ever seen that your household refrigerator, the compressor has gone wrong? It may be some other, may be a little condenser, or mostly the evaporator coil or insulation, may be, but, compressor, you have never seen, it has gone wrong, right. So, they are well made for which, it can be trusted, and it can be said that, the hermetically sealed compressors work more or less lifelong. There is another one, which is called semi hermetically sealed type compressor. This hermetically sealed are not possible to open, or repair easily. Semi hermetically is made in such a way that, a part can be opened and can be repaired, if required.

It is definitely a better one, than the hermetically sealed, but obviously, the cost will go

up. So, for a given refrigeration unit, if hermetically sealed are doable, then, why you will go for the semi hermetically ones, right. In open type compressors, the rotating shaft of the compressor extends through a seal in the crank case for an external drive. The external drive may be an electrical motor or an engine, for example, diesel engine or similar. The compressor may be belt driven or gear driven.

Open type compressors are normally used in medium to large capacity refrigeration system, for all refrigerants and for ammonia in particular, right. Compressors, due to its ammonia, means, due to its incompatibility with hermetic motor materials, they are normally not used. Ammonia is normally not used in hermetically sealed compressors. Open type compressors are characterized by high efficiency, flexibility, better compressor cooling and serviceability, which is a very very fundamental. It is open type, but it is not serviceable, and the compressor is not working and the people are, they are, they are not able to work.

So, serviceability is one of the primary consideration . However, since the shaft has to extend through the seal, leakage of refrigerant, rather refrigerant leakage from the system cannot be eliminated completely. That is why, in most of the engine room, that is, where the compressors are there, they call it to be an engine room. If you go there, you will find some or other obviously, ammonia, I do not say flavor, here, some odor. So, that is making it to understand that leakage is happening. Whereas, if it is CFC, it does not have any such odor.

So, if there is a leak, you cannot identify, other than going through the pressure. But, if it is ammonia, as refrigerant, you can easily find out, or recognize that, some leakage is happening, right. So, it cannot be again from compressor, say from compressor, then, condenser, then evaporator, either expansion device, then evaporator, back to compressor. It is a huge part, right, and many lines and joints are there. So, it is likely that, there could be some or other kind of leakage and which is detectable by its odor. Most refrigeration systems, using open type compressors, require a refrigerant reservoir, to take care of the refrigerant leakage for some time, and then regular maintenance, for charging the system with refrigerant, charging of sealed gasket, etc. are also taken care of in hermetically sealed compressors. So, the motor and the compressor are enclosed in the same housing to prevent refrigeration leakage.

The housing has welded connections for refrigerant inlet and outlet and for power input socket. As a result of this, there is virtually no possibility, there is virtually no possibility of refrigerant leakage, from the compressor. All motors reject a part of the power supplied to it due to eddy currents. I hope eddy currents, you know, I am not, because, we have time very limited. So, I am not going into that also. So, eddy currents and friction

that is inefficiencies. Similarly, the compressor also gets heated up due to friction, and also due to temperature rise of the vapour during compression.

So, in open type, both the compressor, and the motor, normally, reject heat to the surrounding air for efficient operation. So, in hermetically sealed compressors, heat cannot be rejected to the surrounding air, since, both are enclosed in a shell. Hence, the cold suction gas is made to flow over the motor and the compressor, before entering the compressor, this is cold one is supplied, this keeps the motor cool. The motor winding is in direct contact with the refrigerant. Hence only those refrigerants which have high dielectric strength can be used in hermetic compressors.

Otherwise, it will be electrocuted. So, high dielectric constant, that are used. So, can be used as hermetic compressor, or with hermetic compressors. The cooling rate depends upon the flow rate of the refrigerant, its temperature, and the thermal properties of the refrigerant. If flow rate is not sufficient and or if the temperature is not low enough the insulation on the winding of the motor can burn out and in that case short circuiting may occur. So, short circuiting is obviously, not desirable because if there is short circuit there may be fire.

Hence, hermetically sealed compressors give satisfactory and safe performance over a very narrow range of design temperature and should not be used for off design condition. The COP of the hermetic compressor, based on the lower, I mean the COP of the hermetic compressor base system, is lower than the that of the open compressor base system. Hence, a part of the refrigerant or refrigeration effect is lost in cooling the motor and the compressor. In hermetically sealed one, you are using for cooling the motor, a part of the refrigerant.

So, COP is reduced there itself. However, hermetic compressors are almost universally used in small systems such as domestic refrigerator, water coolers, air conditioners etc. where, efficiency may not be that important, as customer convenience, right. So, you are, you are buying the convenience, with a compromise with the efficiency, right. So, due to the absence of continuous maintenance, your convenience goes up, because, once you buy, you normally forget about the compressor, if it is hermetically sealed. But the other one, that is, open type obviously, every now and then, you have to keep constant eye or constant supervision, such that, the compressor runs effectively, right. In addition to this, the use of hermetic compressors, in ideal systems, which use capillary tubes as expansion devices.

I said also one day, that household refrigerators, you will see that, capillaries are used as expansion device, and are critically charged systems. Hermetic compressors are normally

not serviceable. They are not very flexible, as it is difficult to vary their speed to control the cooling capacity. In some, normally larger hermetic units, the cylinder head is usually removable, so that the valves and the piston can be serviced and this type of unit is called semi hermetically sealed compressor, or semi sealed compressor, right. So, with these preamble of compressors, particularly those, who use mostly, one is hermetically and another is that open type, that is, your open type one. So, these two we have already talked about. We will see a little design of the hermetic type, may not be thoroughly, all over and then, we will also look into the other types, like, your way, as we said that, centrifugal or the screw type.

So, perhaps, this ninth week, we will be using mostly, the compressors, ok. Our time is up. So, thank you for listening. We will meet again in the next class.