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Multistage Vapour compression Refrigeration system Eco-friendly with R290

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Abstract - ***The possibility of using R290 refrigerants in a multistage vapour compression refrigeration system were studied and compared theoretically and experimentally with other refrigerant. Refrigerant 22 is a Hydro Chlorofluorocarbon (HCFCs) group Refrigerant, having Ozone Depletion Potential of 0.05 and Global Warming potential 1700 which causes more environmental impact, world community has decided to replace these. The environmental friendly refrigerant like Hydrocarbon refrigerants (HCs) and Hydro fluorocarbon (HFCs) have emerged as Zero Ozone Depletion Potential and low Global warming Potential . To phase-out HCFCs the overall evaluation in terms of Energy Efficiency , safety, Economic aspects is studied for favourable performance for lower capacity i .e.1´TR air conditioning systems. The operating temperatures for Evaporator at -15°C and condensing temperatures at 30°C and 40°C were considered for theoretical performance comparison. With compare to R22, The Coefficient of performance for R290 and R32 is closely matches for higher condensing temperature. At higher ambient (condensing) temperature, R290 gives better COP than that HCFC-22 per TR. Pressure ratio indicates the size of compressor and condenser, R32 pressure ratio is 25%high, R290 pressure ratio is 14 % more with compare to R22.Per TR refrigeration R32 requires very high Power (hp) because the pressure ratio is very high. As compare to the environmental impact, R32 has zero ODP and 220 GWP, R290 have zero ODP and 3 GWP.R32 requires robust condenser and R290 (Propane) as a refrigerant has two disadvantages, One is fire risky and second is size of the compressor should be bigger than while using of R22 of the assigned Refrigeration machine.***

Key Words: *compressor, Refrigerant, Evaporator*

1 Multi stage Vapour Compression System

We have discussed the simple vapour compression refrigeration system in which the low pressure vapour refrigerant from the evaporator is compressed in a single stage (or a single compressor) and then delivered to a condenser at a high pressure. But sometimes, the vapour refrigerant is required to be delivered at a very high pressure as in the case of low temperature refrigerating systems. In such cases either we should compress the vapour refrigerant by employing a single stage compressor with a very high pressure ratio between the condenser and evaporator or compress it in two or more compressors placed is series. The compression carried out in two or more compressors is called compound or multistage compression.

Whereas conventional single-stage system will usually give satisfactory results with evaporator temperatures down to -40^{0}F, provided that condensing temperatures are reasonably low, for evaporator temperature below -40^{0}F, some form multistage compression must be employed in order to avoid excessive discharge temperature and maintain reasonable operating efficiencies. In larger installations, multistage compression should be considered for any evaporator temperature below 0^0 F. In such cases multi-stage systems are used in practice. Generally, for fluorocarbon and ammonia based refrigeration systems a single stage system us used up to an evaporator temperature of – 30^{o}C. A two stage system is used up to – 60^{o}C and three-stage system is used for temperatures below – 60^{o}C Apart from high temperature lift applications, multi-stage systems are also used in applications requiring refrigeration at different temperatures For example, in a dairy plant refrigeration may be required at – 30^{o}C for making ice cream and at 2^{o}C for chilling milk.

1.1 Multi -Staging For Efficiency

Efficient compressor operation requires that the compression ratio be kept low, to reduce discharge pressure and temperature. For low temperature applications involving high compression ratios, and for wide temperature range requirements, it is preferable (due to equipment design limitations) and often economical to employ multi-stage reciprocating machines or centrifugal / screw compressors. There are two types of multi-staging systems, which are applicable to all types of compressors: compound and cascade. With reciprocating

or rotary compressors, two-stage compressors are preferable for load temperatures from –20°C to –58°C, and with centrifugal machines for temperatures around –43°C. In a multi-stage operation, a first-stage compressor that sized to meet the cooling load feeds into the suction of a second-stage compressor after inter-cooling of the gas. A part of the high-pressure liquid from the condenser is flashed and used for liquid sub-cooling. The second compressor, therefore, has to meet the load of the evaporator and the flash gas. A single refrigerant is used in the system, and the two compressors share the compression task equally. Therefore, a combination of two compressors with low compression ratios can provide a high compression ratio. For temperatures in the range of –46°C to –101°C, cascaded systems are preferable. In this system, two separate systems using different refrigerants are connected so that one rejects heat to the other. The main advantage of this system is that a low temperature refrigerant, which has a high suction temperature and low specific volume, can be selected for the low stage to meet very low temperature requirements.

1.2. Ozone Friendly Refrigerant: - R290 (Green Refrigerants)

Propane (R-290) is a common refrigerant known as hydrocarbons. It is commonly found in large chemical processing or refinery facilities. While propane is suitable as refrigerants they are also flammable gases. This restricts their use to facilities where the requirements of specific area classifications such as explosion proof electrical devices are common place. The refrigerant selected for an industrial refrigeration system should be based on the actual requirements of the cooling process. Some refrigerants offer significant benefits over other refrigerants for specific reasons.

Additional criteria may include; safety considerations, operating temperatures, familiarity with the refrigerant and its specific requirements, or ease of integration into existing infrastructure. R290 (propane), propane has excellent thermal performance, low price, and R290 can be compatibility with general machinery lubricants and structural material, ODP = 0, GWP is small, does not require synthesis, not to change the content of the nature of the hydrocarbon , has no direct impact on the greenhouse effect. Propane unit volume greater cooling capacity, it is suitable for small rotary compressor. The main physical property of propane is extremely similar with R22, could be used R22 systems, don't change the original machine and transform production lines, directly filling propane, is a direct substitute. Khalid A and E. Halimic research the R290 as the performance of alternative refrigerants, Ming-Wei Tong do the experiment find that a variety of metal and R290 have a good compatibility. Taking into account the CFC alternatives cost, R290 is particularly suitable for developing countries. At present, in Germany R290 has been used in home water heaters and air-conditioning systems.

2. Ozone Depletion Potential and global warming

Ozone depletion and global worming require replacement of chlorofluorocarbon refrigerant like R-12, R-22, the hydrofluorocarbon R134a is nonflammable, difficult to synthesize, has zero ozone depletion and high global warming potential. TheR-290(Hydrocarbon) Refrigerant are highly flammable, occurs naturally, has zero ozone depletion and of negligible global warming. In Germany most new Refrigerator and Air conditioners uses hydrocarbon Refrigerants. The R-290 with measured energy consumption 10 to20% lowers than R-12, R-22 & R-R134 a. Due to global warming, ozone depletion and consumption of energy. The natural occurring Refrigerant R-290 is selected for the multistage compression. Considerable work has been done on the field of optimization of multistage vapour compression system but this thesis environmental friendly Refrigerant are consider.

3. CONCLUSIONS

The Coefficient of performance of R290 is nearly matches with R22 with low power consumption, R32have lower molecular weights, The relative performance of a refrigerant is directly related to molecular weights as well , the lower molecular weight would have low mass flow rate, higher latent heat. R32 pressure ratio is 25% high, R290 pressure ratio is 14 % more with compare to R22. R32 Consumes very high power per TR. The advantage of R32 is very low flammability with compare to (HCs) R290. Hydrocarbons refrigerants have zero ODP and very small GWP. As they have Potential of better performance, they are being used in many countries now days. The only limitation with Hydrocarbon refrigerants is they are flammable; hence the safety issues must be addressed in terms of Manufacturing, handling, storage and servicing. The HFCs are transitional compounds substitutes with low ODP, but, these will also have to be replaces. The hydrogen atom causes hydrolysis and also having GWP, hence these are also uncertain candidates in near future .To prevent the environmental damage and to reduce the harmful effects the refrigeration industry must shift to natural refrigerant.

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