An Experimental study of the analyzing the COP of Refrigerants R-22/R-134a by Weight30/70 and R-22/R-410a by Weight30/70

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ABSTRACT

Nowadays due to increase in population, industrialization, pollution and global warming effects the temperature of earth surface is going higher and higher. Due to which it is becoming very difficult to survive in this kind of environment. The refrigerants used in these days has reduced their efficiency and creating pollution in the environment .It is becoming difficult for air conditioners and refrigerators to work properly in higher temperatures .The coefficient of performance of refrigerants used in these days is decreasing. So we need some alternatives of refrigerants by performing different experiments which will have a low impact on the environment pollution. So in this study we have tried to prepare and analysis the two combination of refrigerant having ratio Combination no 1:- R-22 and R-134a as 30/70 by weight and. Combination no 2:- R-22 and R-410a as 30/70 by weight. In this study we differentiate the COP of the two combinations. The refrigerants so chosen have very low effect on ozone layer depletion and global warming potential

Key Words: COP, Ozone layer depletion, Global warming potential

1. Introduction

Vapour compression refrigeration systems are the most commonly used among all refrigeration systems. As the name implies, these systems belong to the general class of vapour cycles, wherein the working fluid (refrigerant) undergoes phase change at least during one process. In a vapour compression refrigeration system, refrigeration is obtained as the refrigerant evaporates at low temperatures. The input to the system is in the form of mechanical energy required to run the compressor. Hence these systems are also called as mechanical refrigeration systems. vapour compression refrigeration systems are available to suit almost all applications with the refrigeration capacities ranging from 0.5TR to 20TR. A wide variety of refrigerants can be used in these systems to suit different applications, capacities etc. The actual vapour compression cycle is based on Evans-Perkins cycle, which is also called as reverse Rankine cycle.

1.1 Refrigeration System: Working Principle and Construction

Refrigeration system is based upon the Clausius statement of second law of thermodynamics. This statement shows, It are impossible to construct a device which, operating in a cycle, will produce no affect other than the transfer of heat from a cooler to a hotter body. The construction of vapour compression refrigeration system is illustrated in figure 1. A vapor compression cycle is used in most household refrigerators, refrigerator–freezers and freezers. In this cycle, a circulating refrigerant such as R134a enters a compressor as low-pressure vapor at or slightly above the temperature of the refrigerator interior. The vapor is compressed and exits the compressor as high-pressure superheated vapor. The superheated vapor travels under pressure through the condensers, which are passively cooled by exposure to air in the room. The condenser condenses the super-heated vapour into liquid form at constant pressure. As the refrigerant leaves the condenser, it is still under pressure but is now only slightly above room temperature. This liquid refrigerant is forced through a throttling device, also known as an expansion valve (essentially a pin-hole sized constriction in the tubing) to an area of much lower pressure. The sudden decrease in pressure results in decrease in pressure and temperature of the liquid refrigerant. This cold and partially vaporized refrigerant continues through the coils or tubes of the evaporator unit. A fan blows air from the refrigerator or freezer compartment ("box air") across these coils or tubes and the refrigerant completely vaporizes, drawing further latent heat from the box air. This cooled air is returned to the refrigerator or freezer compartment, and so keeps the box air cold. Note that the cool air in the refrigerator or freezer is still warmer than the refrigerant in the evaporator. Refrigerant leaves the evaporator, now fully vaporized and slightly heated, and returns to the compressor inlet to continue the cycle.

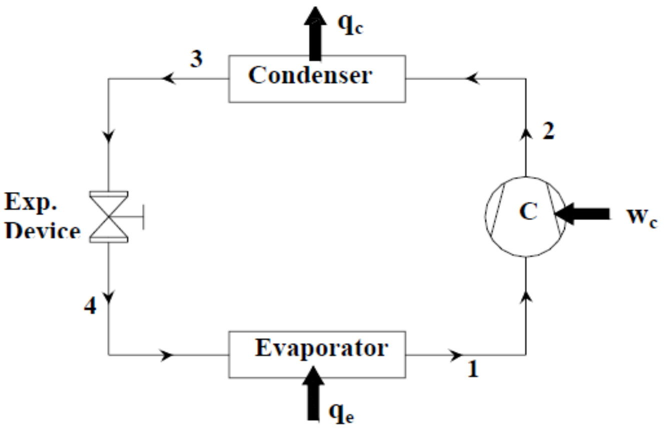

Figure 1 Construction of vapour compression refrigeration system[Google]

1.2 Refrigerant:

The working fluid used to transfer the heat from low temperature reservoir to high temperature reservoir is called refrigerant. The refrigerants may be classified into two groups

1. Primary refrigerants
2. Secondary refrigerants

1. **Primary refrigerants** are those fluids, which are used directly as working fluids, for example in vapour compression and vapour absorption refrigeration systems. When used in compression or absorption systems, these fluids provide refrigeration by undergoing a phase change process in the evaporator.
2. **Secondary refrigerants** are those liquids, which are used for transporting thermal energy from one location to other. Secondary refrigerants are also known under the name brines or antifreezes. Of course, if the operating temperatures are above $0^{o}C$, then pure water can also be used as secondary refrigerant, for example in large air conditioning systems. Antifreezes or brines are used when refrigeration is required at sub-zero temperatures.

   Unlike primary refrigerants, the secondary refrigerants do not undergo phase change as they transport energy from one location to other. An important property of a secondary refrigerant is its freezing point. Generally, the freezing point of a brine will be lower than the freezing point of its constituents. The temperature at which freezing of a brine takes place its depends on its concentration. The concentration at which a lowest temperature can be reached without solidification is called as eutectic point. The commonly used secondary refrigerants are the solutions of water and ethylene glycol, propylene glycol or calcium chloride. These solutions are known under the general name of brines.

1.3 Restrictions for use of refrigerants

Several refrigerants are expelled due to their environmental impact, are expected to be replaced. Replacing them is a difficult task considering that the only solutions currently available are the so-called "natural" refrigerants, such as ammonia, hydrocarbons and CO_2. The disadvantages of these products are mainly toxicity (NH_3), flammability (HC) and high pressures (CO_2). Some refrigerants are banned due to their high ozone depletion potential (ODP) and global warming potential (GWP). The first major concern is depletion of ozone layer. Ozone layer is a layer which protects the earth from ultraviolet rays. Ozone depletion potential is evaluated on a scale that uses CFC-11 as a benchmark. All the other components are based on how damaging to the ozone they are in relation to CFC-11.

The second major concern is global warming. Global warming is the increase in global earth surface temperature due to the absorption of infrared emission from earth surface. Global warming potential is evaluated on a scale that uses CO_2 as the bench mark i.e. CO_2 is assigned a value and other components are compared to CO_2.

2. Literature Review

Eric Granryd(2001) has enlisted the different hydrocarbons as working medium in refrigeration system. He studied the different safety standards related to these refrigerants. He showed the properties of hydrocarbons (i.e. no ODP and negligible GWP) that make them interesting refrigerating alternatives for energy efficient and environmentally friendly. But safety precautions due to flammability must be seriously taken into account.

Y. S. Lee and C. C. Su(2002) have studied the performance of VCRS with isobutene and compare the results with R12 and R22. They used R600a about 150 g and set the refrigeration temperature about 4 °C and -10 °C to maintain the situation of cold storage and freezing applications. They used 0.7 mm internal diameter and 4 to 4.5 m length of capillary tube for cold storage applications and 0.6 mm internal diameter and 4.5 to 5 m length of capillary tube for freezing applications. They observed that the COP lies between 1.2 and 4.5 in cold storage applications and between 0.8 and 3.5 in freezing applications. They also observed that the system with two capillary tubes in parallel performs better in the cold storage and air conditioning applications, whereas that with a single tube is suitable in the freezing applications.

James M. Calm(2002) has studied the emission and environmental impacts of R11, R123, and R134a due to leakage from centrifugal chiller system. He also investigated the total impact in form of TEWI and change in system efficiency or performance due to charge loss. He also summarized the methods to reduce the refrigerant losses by the system like design modifications, improvement in preventive maintenance techniques, use of purge system for refrigerant vapour recovery, servicing and lubricant changing in system.

R. Cabello et.al.(2004) have analyzed the performance of a vapour compression refrigeration system using three different working fluids (R134a, R407c and R22). The operating variables are the evaporating pressure, condensing pressure and degree of superheating at the compressor inlet. They analyzed that the power consumption decreases when compression ratio increases with R22 than using the other working fluids.

Mao-Gang He et.al.(2005) have analyzed that the R152a/R125 mixture in the composition of 0.85 mass fraction of R152a has a similar refrigeration performance with the existing refrigerant R12.Experimental research on the main refrigeration performances of domestic refrigerators was conducted, under the different proportions and charge amounts, when R152a/R125 is used to substitute R12 as a ‗drop-in‘‘refrigerant. The experimental results indicate that R152a/R125 can be used to replace R12 as a new generation refrigerant of domestic refrigerators, because of its well environmentally acceptable properties and its favorable refrigeration performances.

K. Mani and V. Selladurai(2008) have analyzed a vapour compression refrigeration system with the new R290/R600a refrigerant mixture as drop-in replacement was conducted and compared with R12 and R134a. The VCRS was initially designed to operate with R12.The results showed that the refrigerant R134a showed slightly lower COP than R12. The discharge temperature and discharge pressure of the R290/R600a mixture was very close to R12. The R290/R600a (68/32 by wt %) mixture can be considered as a drop-in replacement refrigerant for R12 and R134a.

A.S. Dalkilic and S. Wongwises(2010) have studied the performance on a VCRS with refrigerant mixtures based on R134a, R152a, R32, R290, R1270, R600 and R600a was done for various ratios and their results are compared with R12, R22 and R134a as possible alternative replacements. The results showed that all of the alternative refrigerants investigated in the analysis have a slightly lower COP than R12, R22, and R134a for the condensation temperature of 50 °C and evaporating temperatures ranging between −30 °C and 10 °C. Refrigerant blends of R290/R600a (40/60 by wt. %) instead of R12 and R290/R1270 (20/80 by wt. %) instead of R22 are found to be replacement refrigerants among other alternatives.

3. Experimental Design

The following procedure is adopted for the testing and analyzing purpose

a. Preparation of the combination of refrigerants.
b. Analysing the properties of refrigerants after mixing
c. Preparation of test rig for experimental work having capacity 1.5TR
d. Filling up the combination no 1 having refrigerants R-22/R-134a by weight 30/70
e. Note down the reading of temperature & pressure by keeping constant outside temp.
f. Filling up the combination no 1 having refrigerants R-22/R-410 by weight 30/70
g. Again note down the reading of temperature & pressure by keeping constant outside temp.
h. Analysing the reading and find out the C.O.P. of combination no.1 & combination no 2

4 Results and Discussion

Figure 1 shows the comparison between C.O.P. of combination no 1 and combination no 2 .As the C.O.P. of combination no 1 is higher as compared to combination no 2 when the outer temperature is constant i.e. 34°C to 36°C, the main reason behind is latent heat, the latent heat of R-134a is 315.9kj/kg and R-410a is 256.7kj/kg. Due to lower latent heat of combination no 2 the C.O.P of combination no 1 is lower than combination no 2.

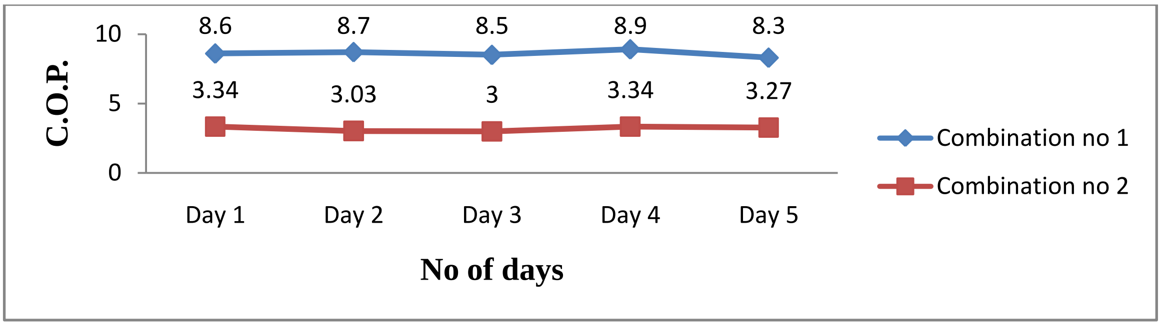

Figure 1 Comparison between the C.O.P. of combination no 1 & combination no 2

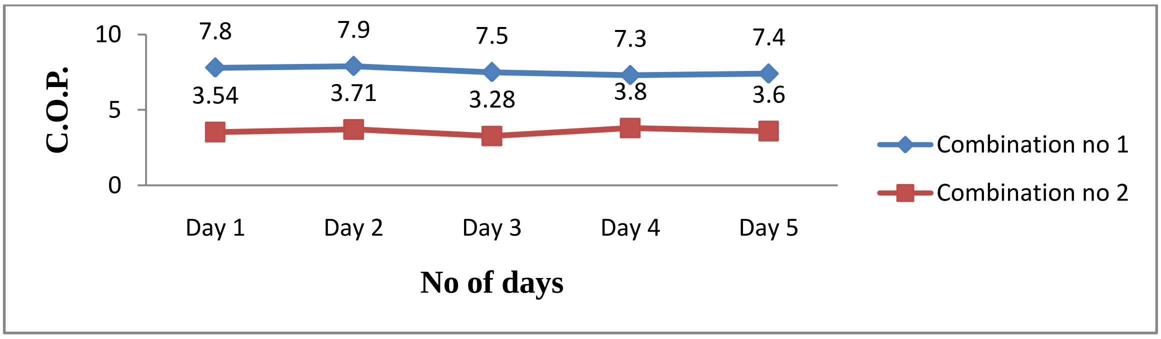

Figure 2 Comparison between the C.O.P. of combination no 1 & combination no 2

Figure.2 shows the comparison between C.O.P. of combination no 1 and combination no 2, when the outside temperature is 37°C to 39°C. In this setup also the C.O.P. of combination no 2 is lower than combination no 1, due to the low contents of latent heat of combination no 1. But the C.O.P. of combination no 1 is decreased as compared to the previous condition of ambient temperature of 34°C to 36°C and C.O.P. of combination no 2 is increased as compared to the previous condition of ambient temperature 34°C to 36°C was used.

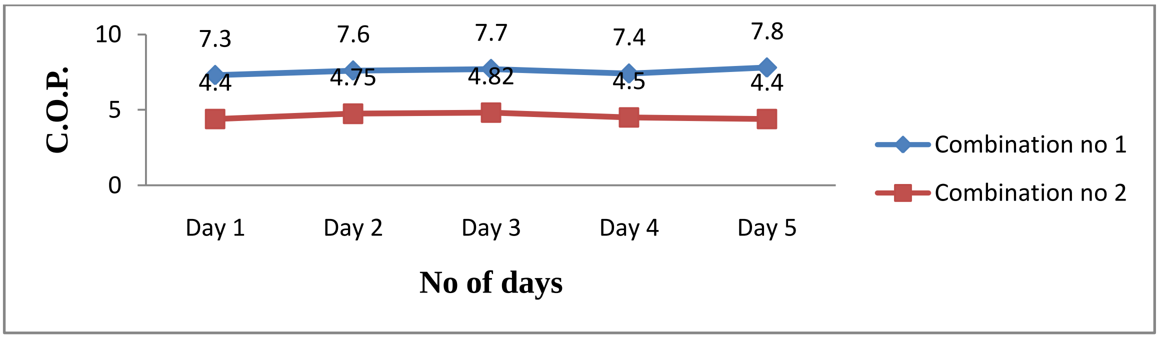

Figure 3 Comparison between the C.O.P. of combination no 1 & combination no 2

Figure3 also shows the comparison of C.O.P. of combination no 1 and combination no 2 when outside temperature is 40°c to 42°C. The C.O.P. of combination no 2 is lowerthan C.O.P. of combination no 1. But the huge rise in C.O.P. of combination no 2 is observed as compared to previous ambient temperature 37°c to 39°C. But the C.O.P. of combination no 1 is almost constant when compare with the previous ambient temperature of 37°c to 39°C.

5. Conclusions

1. The average C.O.P. of combination no 1 is 8.6 and combination no 2 is 3.20 at outside temperature 34°c to 36°c .
2. The average C.O.P. of combination no 1 is 7.58 and combination no 2 is 3.58 at outside temperature 37°c to 39°c .
3. The average C.O.P. of combination no 1 is 7.56 and combination no 2 is 4.57 at outside temperature 40°c to 42°c .
4. The C.O.P. of combination no 1 is higher that the combination no2.But the C.O.P. of combination no 2 is increased as the outside temperature increases while the C.O.P. of combination no 1 decreases

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