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HFO– A replacement of ammonia in solar driven cooling systems

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ABSTRACT

As the energy is the most fundamental before technology, it's the basic element which affects the price as well as the overall economy of the industry. And we know that the conventional source of energy is continuously decreasing and in today's world non-conventional energy is gaining high importance, thus solar energy is of great interest to the scientists of the world. Another threat to the whole world is ozone layer depletion potential and the global warming potential. Use of a solar cooling system could be the best solution to this problem. And one must get motivated work on Hydrofluoro Olefin (HFO) as its almost unexplored and has tremendous potential in the future world and could be a replacement of ammonia (R-717). Unlike ammonia, HFO has a very low effect on global warming, this feature is common for its contribution to global warming and it is not greater than CO2, HFC's and other common refrigerants. It is mainly due to their short lifespan that is within a couple of weeks for most of the HFO's.

Keywords— *ODP(Ozone Depletion Potential), GWP (Global Warming Potential), CFC (Chlorofluoro Carbons), HFO (Hydrofluoro Olefin)*

1. INTRODUCTION

A review has been done from many international papers. Halogenated gases used as a refrigerant in conventional vapor compression cycle of the air conditioning system not have high ODP as well as GWP. Halogenated gases react with the ozone at high altitude and produce oxygen as a by-product, thus ozone disintegrates into oxygen and the protective layer of ozone is demolished. And the ultraviolet rays enter the earth surface and causes hazardous skin diseases. Therefore it becomes essential to cutoff CFC refrigerant from use in refrigeration and air-conditioning system.

Generally, R-717(ammonia) is used as a refrigerant to remedies the increasing GWP and ODP issues as its GWP and ODP is very low and it is eco-friendly buts its releases toxic which makes it out of the list of best refrigerant among. Similar to HFC's, HFO's are composed of hydrogen, fluorine, and carbon. The only difference is that they are unsaturated, that means they have at least one double bond. Such molecules are known as olefins. HFO's are relatively stable compounds but are mildly reactive than HCF due to the presence of carbon-carbon double bond. This also reduces global warming potential and therefore becomes the most favorable refrigerant in concern of climate change.R-1234yf, R-1234ze (E) are few examples of HFO's. They are used in a no. Of applications today, but have been barely studied.

CO and CO2 emitted from thermal plants in huge amount create a blanket like a layer over the earth environment, thus producing global warming from the reflected sunlight from CO and CO2 layers. To control the CO and CO2 production we have to cut down the dependency on thermal power. Solar energy-oriented appliances thus decreasing GWP to a large extent. Conventional energy sources will be completely exhausted within a few decades which leads to demand an alternative energy source.

Further, there is a theoretical discussion about the replacement of R-717 with the R-1234yf as R-717 is highly toxic in nature, and cannot be accommodated in copper pipes and secondly ammonia is very lightweight as compared to air such that it rises up and dissipate in the above atmosphere.

2. AMMONIA AS A REFRIGERANT (R-717)

In 1876, Carl Von Linde first used ammonia as a refrigeration system. Many countries in Europe have stopped the use of HCFC refrigerants, and new refrigerants, as well as well-tried and trusted refrigerants like Ammonia and Carbon Dioxide, are being considered for various new applications as well. R717 refrigerant grade ammonia will become the main refrigerant of industrial refrigeration equipment.

2.1 Advantages of R-717 liquid anhydrous ammonia

(i) Energy efficiency- Typically a flooded ammonia system would be 15-20 % more efficient than a DX R404A counterpart.
(ii) Environment- it has both GWP (Global Warming Potential) and ODP (Ozone Depletion Potential) equal to zero
(iii) Safety- At the same time, unlike most other refrigerants, it has a characteristic odor that can be detected by humans even at very low concentrations.
(iv) Smaller pipe sizes - In both vapor and liquid phase ammonia requires smaller pipe diameters than most chemical refrigerants.

(v) Better heat transfer - Ammonia has better heat transfer properties than most of the chemical refrigerants and therefore allow for the use of equipment with a smaller heat transfer area.

(vi) Refrigerant price - In many countries the cost of ammonia (per kg) is considerably lower than the cost of HFCs. This advantage is even multiplied by the fact that ammonia has a lower density in the liquid phase. Furthermore as any leakage of ammonia will be detected very quickly due to the odor, hence any potential loss of refrigerant will also be lower.

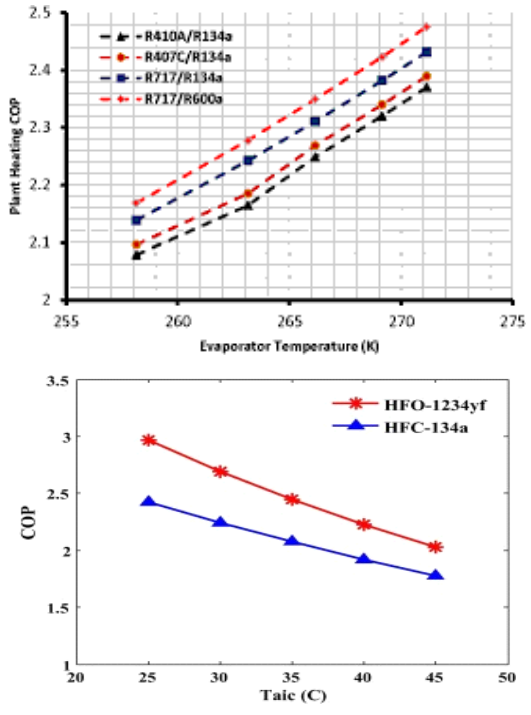
3. TOXICITY AND FLAMMABILITY

Ammonia has a strong toxicity and flammability. In the volume meter, if the content of ammonia in the air reaches 0.5% ~ 0.6%, and in which if people stay for half an hour then it can be poisoning, 11% ~ 13% can ignite, reaching 16% flame would explode. The upper and lower explosive limit of pure ammonia is 27% to 16% by volume. The exposure to high concentration of 1500ppm will result in damage to body tissues and death may result at 2500ppm, therefore the ammonia refrigeration machine room must pay attention to ventilation and exhaust, and the air and other non-condensable gases in the system must be eliminated frequently.

4. THERMODYNAMIC PROPERTIES OF HFO-1234YF

There was a very fewer theoretical work done in this area and most of the work done on HFO-1234yf is experimental. The purpose of this study is to investigate experimentally the appropriate replacement of other harmful refrigerants (like R717) tested by the huge organizations which are more eco-friendly and productive.

European F gas regulation state that any replacement automotive refrigerant should have a GWP lower than 150 in comparison to other refrigerants its lifespan when released in the air is just about 11 days, which ultimately reduced the damage to the environment. The performance of HFO-1234yf is very much similar to the R-134a.



In the above figure, we can see the comparison in the cop of different refrigerants.

5. EXPERIMENTAL TESTINGS

*When HFO-1234 is leaked on the hottest metal surface in an automobile it just forms white smoke and similarly when HFC-134a is leaked on the hot metal surface even then a white smoke is formed, which simply proves that it is not that flammable as compared to other highly flammable compounds these tests are stated by honey well.

Properties	R-1234yf or HFO-1234yf	R-717
Boiling point (°c)	-29	-33.34
Critical point(°c)	95	132
Liquid density at 25°c (kg/m^3)	1.094	0.73
Freezing point at 101kpa (°c)	-150	-248

- "HFO-1234yf can be safely accommodated through established industry standard and practices for vehicle design, engineering manufacturing and service" SAE cooperative research program.
- Daimler is against the use of HFO-1234yf as a refrigerant as they declare it as a flammable compound.
- ISO 13043 and SAE J-639 recommend using engineering best practices to manage the risks associated with any refrigerants including HFO-1234yf.

6. MATERIAL SAFETY MEASURES

- Devices that generate spark may need to be isolated, purged with an inert gas (for ex. nitrogen).
- Avoid contacting HFO-1234yf with white hot or red hot surfaces.
- Fire or explosion can take place if vapor in air concentration is within the flammable range and an ignition source of adequate energy level is available.
- Do not locate the apparatus that produce effective ignition sources in proximity to air conditioning systems, equipment or storage vessels that contain HFO-234yf.

Implementation of a solar driven refrigeration system using HFO-1234yf: solar cooling system strongly depends on local conditions example solar radiation, ambient temperature, or cooling load systems should, therefore, be specifically designed for each location, therefore obtaining the best performance for thermally driven systems, a solar cooling system requires less solar collector area pre-cooling (kWh) in tropical areas than in areas above tropic of cancer or tropic of Capricorn that means that countries under these areas will be most benefited. As the energy consumption for a domestic refrigeration system is less and is not flammable even at high temperature hence these solar driven refrigeration systems are feasible for domestic purpose and mobile air conditioners by using HFO-1234yf. It is going to be favorable for the sustainable development and this area of study needs to put in concentration to accomplish such solar driven refrigeration system with high efficiency and not life or property hazardous from safety.

7. CONCLUSION

Solar-driven refrigeration system could be an alternative in the refrigeration on considering the ODP and GWP. The next decade is going to be technology based on solar energy. The only demerit of using solar driven cooling systems is is its low efficiency and weather dependency. And one of the other significant demerits is its setup cost is higher as compared to the conventional energy system.

The manufacturers have favored HFO-1234yf because current automotive design uses low-pressure air conditioning systems.

HFO-1234yf is compatible with these low-pressure systems and can be used as a replacement for R-717 with the minimal re-engineering of automotive systems. In a theoretical study, it is proven that cop of HFO-1234yf is up to mark and be a good replacement for other harmful refrigerants. All the tests and statements by the huge organization prove that HFO-1234yf is safe and can be used in automobile and in industries also

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