

Effects of Low Quality Refrigerants in Refrigerators—A Review

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ABSTRACT

Technology of refrigeration and air-conditioning helps human in various ways like preservation of food, in controlling temperature of indoor air and also in various process control in industries. These technologies used about 20% of electric energy all over the world. The technologies plays important role in today's society. Refrigeration is great achievement in field of engineering. In these technologies, refrigerants perform very important function. Refrigerants are those type of agents which absorbs and release heat from that place which is to be cooled. These work as mediator between source and sink to transfer heat. Today there is great concern for refrigerants which used in various heat cycles due to strict laws of environment and policies of government. There are various types of refrigerants present, these are selected on the basis of which type of heating and cooling is required. Due to different refrigeration systems, there are suitable refrigerants present for each refrigeration system. There are different properties of refrigerants on the basis of which quality of refrigerants can be evaluated. Refrigerants of poor quality have adverse effect on functioning of refrigeration system. In this paper, various effects are discussed which can arise due to low quality refrigerants in refrigerators.

Keywords: Technology, Refrigeration, Refrigerants, Quality, Effects

INTRODUCTION

Refrigeration systems have great importance in industry as well as in home where they maintain temperature according to desired value. Refrigeration is great achievement in engineering field **Constable G and Somerville B.(2003)**. Generally 20% of electric energy used worldwide in refrigeration and air-conditioning **Kitanovski A et al.,(2015)**. Refrigeration is generally a removing heat form space or substance for decreasing the value of temperature. The most important application of refrigeration is preserving food at very low temperature. Thermal comfort is also provided to human beings by refrigeration system through application of air-conditioning.

Vapour Compression cycles(VCC) mainly used in Refrigeration systems. VCC is main centre in these systems. VCC play a important role in technology of refrigeration because efficiency of refrigeration systems depend on VCC. Improving in VCC result increase in efficiency of refrigeration system **Devesh Kumar et al.,(2023)**. This can be improved by using large surface area heat exchangers, efficient compressors and good quality refrigerants.

Refrigeration is important pillar in today's society which perform various functions which range from preserving food to maintain favourable climate in unfavourable climatic regions. All refrigeration systems requires medium for working. This medium is provided by refrigerants. In refrigerating system, refrigerants take heat from that region which is to be cooled during evaporation and produce cooling.

There are various types of evolution of refrigerants occur from ancient time of mechanical refrigeration to present days. Development of refrigerants occur due to various purposes like for stability, safety of equipment, environment issues and for smooth function of refrigeration system. During development of refrigerants, generation of refrigerants explained by **Calm J.M(2008)**.

Refrigerants can be natural and synthetic. Natural refrigerants have no environmental issues while other refrigerants can impact the environment adversely **LorentzenG(1995)**. Water is very good refrigerant i.e its refrigeration effect so well but it requires large capacity compressors **Riffat S.B et al (1997)**.

Palm B (2008) used hydrocarbon as refrigerants and he also compares the properties and performance of hydrocarbon in various refrigeration system as refrigerant. In view of pungent smell of ammonia or sulphur dioxide refrigerant, odourless safety refrigerant produced **Car Lighting and Power Co..(1922)**.

Liquefiable vapours is used by mostly refrigerator for transferring heat. This liquefiable vapours are refrigerants. In 1927, General Electric introduce “Monitor Top” refrigerator which is first affordable refrigerator **Gantz C (2005)**.

Classification of Refrigerants

Primary Refrigerants: Refrigerants absorb heat from system directly E.g. Freon

Secondary Refrigerants: These refrigerants cooled with the help of primary refrigerants after that they circulated. Eg.: Chilled Water, Chilled Brine

Properties of Good Refrigerants

Refrigerant possess various types of properties i.e physical, chemical and thermodynamic. These properties decide the quality of refrigerants or which refrigerant is more efficient for which refrigeration system. Any fluid may have the capability of refrigerants but for effective refrigerants it should possess following properties **Benhadid-Dib S and Benzaoui A (2012)**

- Low boiling point and Low freezing point shows good refrigerant.
- High Latent heat of vaporisation is favourable properties of refrigerants
- Refrigerant should be non-toxic, non-corrosive and it also should be non-flammable and non-explosive.
- Refrigerant pressure should be optimal for use in refrigeration system with normal pipe and compressor size.
- Refrigerant should be properly mix with lubricating oil.
- It should be able to provide high COP in working range of temperature.
- Zero Ozone Depletion Potential(ODP) and low Global Warming Potential(GWP) are most favourable properties of refrigerants.

Kim et al.,(2015) explain that absorption level can increase 3.21 times through nanoparticles in refrigerant while **Nair et al.**, review preparation of nano-refrigerants, its thermophysical properties and its performance in home use refrigerator.

In US most safety standard for refrigerants is **ANSI/ASHRAE Standard(2019)**.

Today there is major concern for refrigerants in regards of safety, durability and also various issues related to performance. In ancient times, from beginning of mechanical refrigeration, natural refrigerants are used. Water and Air are first refrigerants which are used in this system. The natural refrigerants which still the most popular refrigerant is ammonia in various industries.

Lychnos G and Tamainot-Telto Z (2014) review the performance of hybrid refrigeration system which operated by dual source(heat and electricity) with combined absorption and conventional VC refrigeration machine.

The review in this paper focus on effects which arise in refrigerator due to usage of Low Quality Refrigerants. The quality of refrigerants is depend on combination of various properties like latent heat of vaporisation, thermal conductivity, oil miscibility, toxicity, density, viscosity etc. Low quality refrigerant made adverse effect on these properties which arise various problems in refrigeration system.

AHRI Standard 700 explain the specification regarding purity and also provide information of composition of refrigerants. In AHRI Standard 700, refrigerants purity is described by assigning value to various parameters which involve composition, moisture, volatile impurities, high boiling residue, contaminants, non-condensables **Air Conditioning, Heating and Refrigeration Institute(2017)**.

Effects of Low Quality Refrigerants in Refrigerator

There are various effects which can arise due to low quality refrigerants.

- If temperature is too low, paths of expansion valves and capillary tubes clogged due to bad solubility of moisture in refrigerants.
- If any impurities present in refrigerants, then it results various adverse effects like increase the energy usage, it decreases the capacity of cooling and it also results failure of equipment in refrigerator.
- If any type of solid residue present in refrigerant then it can cover transfer area of heat which ultimately decreases cooling in refrigerators and sometimes it can damage the components of compressors.
- In presence of moisture, some low quality synthetic refrigerants break and form acid. This acid can attack the compressor and reduce the lubricating capacity of components by mixing with lubricants and form sludge.
- If refrigerants have high viscosity then for circulation through system it requires more energy which results high energy consumption.
- Low Quality refrigerants can compressed in case of high temperature rise which can damage the compressor by heating up the cylindrical walls.

These properties give rise to low quality refrigerants which involves moisture insoluble refrigerants, impure refrigerants, solid residues, instability of synthetic refrigerants, high viscosity, easily compressible. Finally these low quality refrigerants affect the system adversely and also causes big economical loss in heavy industries.

Pure refrigerants mixture in refrigeration system gives good results **Pearson A (2005)**.

Dalkilic A S and Wongwises S (2010) describe vapour compression refrigeration system through application of various refrigerants mixture based on R134a, R112a, R32, R290, R1270, R600, R600a in various proportion and result compared with R12, R22 and R134a as an alternative.

McLinden, M.O and Didion D.A. define R134a is good alternative for R12 refrigerant in automotive AC.

Domanski P.A and Didion, D.A(1987) and Hodberg M. and Vamling L.,(1996) explain how property of individual refrigerants affect the performance of system with different extents or sensitivities. Hydrocarbons refrigerants is best options for using in refrigeration system because of low liquid viscosity which result high Heat Transfer Coefficient in evaporator and condenser **Chang Y.S.,(2000)**.

There are some approaches in regard of which refrigerant has high HTC or low pressure drop. **Lee H et al.,(2006)** done evaluation on the basis of similar mass fluxes while **Choi T.Y et al.,(2000)** on the basis of same specified heat fluxes.

Problem Formulation

This paper reviews the effects of low quality refrigerants in refrigerators. Low quality refrigerants arises many problems in refrigerators like clogging of valves and tubes, failure of equipment and high energy consumption. Low quality refrigerants put adverse effects in refrigerators. This also causes high economical loss in case of heavy refrigeration system. To overcome this problem, we should use pure or good quality refrigerants which meet AHRI Standards of refrigerants.

Objectives

The objectives of this study is to avoid the usage of low quality refrigerants in refrigerators because these refrigerants affect the refrigerator or refrigeration system in various ways. Some are discussed below:

- These low quality refrigerants affect the smooth functioning of refrigerators.
- These refrigerants decreases the COP of refrigerators
- These refrigerants leads to failure of equipment like compressors

This paper deals with various effects which arise due to low quality refrigerants. The main objectives of this study is to protect the refrigerator from harmful effects of low quality refrigerants.

LITERATURE REVIEW

Mohanraj M et al.,(2009) review various halogenated refrigerants and its various alternatives.

MadhuSruthiEmani et al.,(2017) explain refrigerants development, its properties and also explain next generation refrigerants.

Giroto S et al.,(2004) used CO₂ refrigerant in commercial refrigeration system.

Sekiya A. and Misaki S.(2000) review how hydrofluoroethers are alternatives to CFC, HCFCs and PFCs.

Tillner Roth R(1998) discuss pure and blended HFCs refrigerants's thermodynamic properties.

Huber ML et al.,(1992) predicts refrigerants and refrigerants mixture's thermal conductivity.

Klein S.A et al.,(1997) estimate viscosity of pure refrigerants and mixtures.

Granryd E.(2001) reviews how hydrocarbon act as refrigerants.

Sale B and WendlandM(2006) analyses pure fluids which can be used as refrigerants as alternative source.

RajapakshaL(2003) uses refrigerant mixtures for evaluation of performance of reversible heat pumps.

Kumar KS and Rajagopal K.(2007) investigate low GWP and low ODP and CFC-12 alternatives are HCFC-123 and HC-290 refrigerant mixture.

Youchi Idrissi et al.,(2003) review effects of solubility of refrigerants in oil for evaluating the performance of evaporator.

Hwang Y and Rodermacher R.,(2002) find various opportunities for alternative refrigerants.

Chaudhary CS and Sapali S.N.,(2017) investigate performance of natural refrigerants R290 as an alternative to R22.

Uddin K and Saha B.B.,(2022) review refrigerants which are eco-friendly for using in air-conditioning.

Aized T et al.,(2022) use low GWP refrigerants and analyse vapour compression refrigeration systems.

Yu C.C and Teng T.P.(2014) use hydrocarbon refrigerants for retrofit assessment of refrigerators.

Shaik S.V. and Babu T.A.,(2017) analyse eco-friendly refrigerants for replacing R22 in air conditioning applications.

Souayeh B et al.,(2022) select best eco-friendly refrigerants for HVAC sector and for various renewable energy devices.

Park K.J et al.,(2007) analyse alternative refrigerants for application of residential air-conditioning.

Jwo C.S et al.,(2009) analysis efficiency of domestic refrigerator by replacing hydrocarbon refrigerants.

Savitha D.C et al.,(2022) discuss suitable refrigerants for environment sustainable environment.

Tegus et al.,(2002) discuss metal based magnetic refrigeration for applications of room temperature.

Fedele L et al.,(2023) review various properties of low GWP refrigerants.

Lyubina J. et al.,(2008) explain metamagnetic transition of magnetic refrigerants.

Karthick L et al.,(2022) use environment friendly refrigerants and analyse compression refrigeration cycle.

Vamshi J. et al.,(2022) used nano particles in refrigeration system as nano-refrigerants.

Lin S. et al.,(2001) explain flow boiling in small tubes of refrigerant R141B.

Jung D et al.,(2003) explain flow condensation HTC of pure refrigerants.

Kilicarslan A and Muller N(2005) compare water refrigerant with other refrigerants.

Liang N. et al.,(2010) explain refrigeration system's instability.

Lachnar Jr et al.,(2007) use water vapour as refrigerants.

Messinco A and Panno.D (2012) use different refrigerants for analysing the performance of cascade refrigeration system.

Kasaeian A et al.,(2018) review the uses of eco-friendly refrigerants and nano refrigerants.

Katoch A et al.,(2022) review performance of nanoparticles in refrigeration system.

Suerdem K et al.,(2023) analyse refrigerants performance which used in rooftop air-conditioner.

Pinni KS et al.,(2021) review nanoparticles heat transfer characteristics suspended with refrigerants in refrigeration systems.

Kumar D.S. and Elansezhian R.,(2012) studied refrigerant AL₂O₃-R134a experimentally in refrigeration system.

Abas N et al.,(2018) review on various synthetic and natural refrigerants.

Mota-Babiloni et al.,(2015) reviews current status of commercial refrigeration.

CONCLUSION

This paper shows the effects of various low quality refrigerants in refrigerator and how refrigerants are important key in refrigeration system. These low quality refrigerants affect refrigeration system in following ways:

- Clogging of valves and tubes
- Decreasing the cooling capacity
- Failure of equipment
- More energy consumption
- Decreasing of lubricating capacity of lubricants

The above are some effects due to usage of low quality or poor refrigerants in refrigeration system. In this paper, there are various properties of refrigerants are discussed on the basis of which evaluation of refrigerants can be done i.e which are good or bad quality refrigerants.

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