EDUZONE: International Peer Reviewed/Refereed Multidisciplinary Journal (EIPRMJ), ISSN: 2319-5045
Volume 3, Issue 2, July-December, 2014, Available online at: www.eduzonejournal.com

A Review on Refrigerants for Commercial and Industrial Applications

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ABSTRACT

Basically Refrigeration and air-conditioning play a vital role in domestic and industrial applications. They have great impact on our day-to-day life. They have additionally added to the world's major natural issues like ozone layer consumption and an unnatural weather change. The advancement of the refrigeration frameworks and the refrigerants utilized in them, from the days when refrigeration was not known to the current day is extremely fascinating. The improvement of various refrigerants over the long haul occurred in view of wellbeing, strength and natural effect issues. In this paper, the various generations of refrigerants starting with those refrigerants utilized before the improvement of mechanical refrigeration framework to the conceivable cutting edge refrigerants which are ecological amicable and can supplant the customary refrigerants have been examined. The low GWP refrigerants like hydro-fluoro-olefins and normal refrigerants like alkali and carbon dioxide are considered as ecological agreeable cutting edge refrigerants.

They insightfully affect our day to day routines. They additionally add to the world's major natural issues, for example, consumption of the ozone layer and a dangerous atmospheric devation. The improvement of refrigerants is in different stages from the day of first experience with its new transformative phase is truly fascinating and it relies upon different variables like its innocuousness, capacity to endure and natural issues. In this review, we will see different generations of refrigerants from the main day of its utilization to this new generation of refrigerants which are climate agreeable and can be utilized at the spot of a few standard refrigerants which are unsafe for climate alongside their substance name, ordinary edge of boiling over, applications, ODP for example ozone consumption potential, GWP for example a dangerous atmospheric devation potential and their cost per kg.

Keywords: Air-conditioning, GWP, Hydro-fluoro-olefins, Natural Refrigerants, Refrigeration.

INTRODUCTION

Scientific data supports the hypothesis that chlorine from refrigerants has depleted the earth’s ozone layer and is linked to a rise in skin-related diseases. The cooling and refrigeration industry has upheld worldwide endeavors to safeguard the climate by presenting non-chlorine-containing refrigerants. The Montreal Protocol, laid out in 1987 and later modified, gives rules to individual nation regulation, setting plans for the stage out of chlorine containing refrigerants. Today, 196 countries host become get-together to the Montreal Protocol. The work began with an accentuation on cutting chlorofluorocarbon (CFC) refrigerants. Work in the last part of the 1980s and mid 1990s fixated on wiping out CFCs which were utilized in froth blowing, cleaning and refrigeration applications and radiating chillers for cooling. Toward the finish of 1995, created nations quit delivering CFCs, and they are not generally utilized in new gear today. These activities have altogether diminished environmental chlorine and are beginning to fix the ozone layer. 3 In 1997 the Kyoto Protocol, marked and sanctioned by numerous countries all over the planet, zeroed in consideration on the effect of human action on environmental change. Accordingly, there is currently more consideration on an unnatural weather change. Albeit the Kyoto Protocol doesn't have any significant bearing to the United States, our industry has attempted to bring down the effect of refrigerants on environmental change with higher-productivity refrigerants and framework plans. In 1997 the Air-Conditioning and Refrigeration Institute (ARI) completed a significant global testing program entitled the Alternative Refrigerants Evaluation Program (AREP). The AREP report indentified a few reasonable HFC substitutions for HCFC R-22. In the USA and Europe, these HFC substitutions are now being generally utilized. A portion of these substitution refrigerants have unexpected working qualities in comparison to HCFC R-22, however they all take out chlorine and potential ozone exhaustion, leaving environmental change as the concentration for future guidelines and control.

Coolers are an old innovation that began quite some time in the past. Refrigeration includes eliminating heat from a shut space or protest keep a lower temperature than the general climate. These days refrigeration has immense applications in different fields like homegrown and modern yet in conventional days there were various strategies like salting, drying, watering. It has been research out that expansion of synthetics, for example, sodium nitrate or potassium nitrate to water has brings about temperature decrease.

Coolers are substances that are utilized in refrigeration frameworks. They get dissipated by occupying heat from the room which is to be cooled, consequently creating a cooling outcome. There are many reasons, for example, innocuousness, capacity to endure and ecological issues, and so on behind the historical backdrop of advancement of the refrigerants. These are some significant trigger for this turn of events. Knowing the specific thing all through or having total information about specific thing makes oneself capable and effective to apply that information for the expected applications. In this paper we have momentarily depicted the various kinds of fridges and their significant particulars, for example, its R-number, compound equation, standard limit, application, GWP, ODP, and their kilogram esteem available.

Advancement phases of refrigerants to sum things up are given underneath:

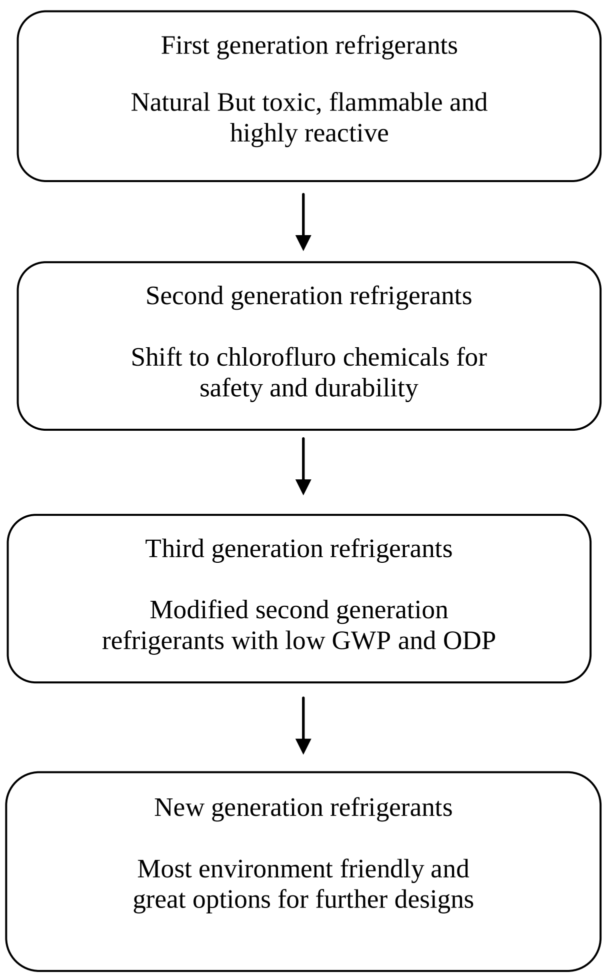

Fig-1: Development stages of refrigerants

REFRIGERANTS

Refrigerants are the functioning medium utilized in refrigerating frameworks which dissipates by taking the intensity from the space that will be cooled, in this manner creating the cooling outcome. Refrigerant advancement over the course, occurred because of various reasons, like security, dependability, sturdiness, financial or natural issues, subsequently bringing about new exploration and gear improvement regarding wellbeing and productivity. The refrigerants can be arranged into various generations which are talked about underneath.

FIRST GENERATION REFRIGERANTS

First Generation refrigerants were utilized in the nineteenth century which was only the start of the mechanical refrigeration process. The vast majority of the original refrigerants are regular like water, carbon dioxide, and so forth. Water was one of the most utilized refrigerants around then

Carbon dioxide was the successfully involved refrigerant for the significant time-frame yet it is the significant supporter of the ozone layer consumption. Refrigeration isn't just purpose for its commitment to the ozone exhaustion yet at the same time because of this it was completely superseded with Cfc's. Ethyle eather was additionally viewed as generally respectable refrigerant because of its less weight and its smoothness at ordinary temperature. However all original refrigerants were climate well disposed, refrigerants were combustible, harmful or both and some were additionally exceptionally responsive in this way, involving those outcomes in risky mishaps more often than not. Some original refrigerants and their attributes are examined underneath:

We can see from the table original refrigerant has exceptionally less number of ODP and GWP which implies they are not hurtful to the climate but rather with expanded advancement and necessity they neglected to meet wanted refrigeration impact and subsequently the second generation of refrigerants came into picture.

second generation refrigerants. CFC is non-harmful, nonflammable as well as less receptive. It is entirely steady that main UV beams can break it and it appropriate for assortment of use in view of its less creativenesses for example it doesn't respond with anything

Table-1: **First generation refrigerants and their applications**

First generation refrigerants and their applications								
Sr. no	**Name**	**R-number**	**Chemical formula**	**NBP (^oC)**	**Applications**	**ODP**	**GWP**	**Price/kg**
1	Carbon dioxide	R-744	CO_2	-78.46	• Food preservation	**0**	**1**	₹ 35
2	Ammonia	R-717	NH_3	-33.3	• Thermal storage system • HVAC chillers • Heat pump systems	**0**	**0**	₹ 65
3	Sulphur dioxide	R-764	SO_2	-10.0	• Cold storage plants	0	0	₹ 150
4	Ethyl ether	R-610	$(C_2H_5)_2O$	35	• Generally used in refrigerants blends	**0**	**0**	₹ 1000
5	Dimethyl ether	R-170	C_2H_6O	-25	• Generally used in refrigerants blends	**0**	**0**	₹ 180
6	Methyl chloride	R-40	CH_3CL	-24.2	• Refrigerant of choice in some type of refrigerator and air conditioners	0.02	16	₹ 1200

SECOND GENERATION REFRIGERANTS

Key feature of second generation refrigerant is changing to chlorofluoro synthetic compounds for security and strength as we have seen the shortage of wellbeing and solidness in original refrigerants. Chlorofluoro carbons and its variety in hydrocarbon enormously affect combustibility and harmfulness of refrigerant. Along these lines CFC's are second generation refrigerants. CFC is non-harmful, nonflammable as well as less responsive. It is truly steady that main UV beams can break it and it appropriate for assortment of use due to its less sensitivity for example it doesn't respond with anything

A portion of the second generation refrigerants are R-11, R-12, and so on. R-11 is actually an incredible refrigerant which is for the most part utilized for refrigeration and cooling applications. It is additionally not harmful, combustible and unstable. The main issue related with second generation refrigerants is that, they are significant supporters of the ozone consumption and a worldwide temperature alteration (We can see from the Table-2) thus, this issue made the need of third generation refrigerants, which are changed second generation refrigerants.

Table-2: Second generation refrigerants

Second generation refrigerants and their applications								
Sr. no	**Name**	**R-number**	**Chemical formula**	**NBP (^{0}C)**	**Applications**	**ODP**	**GWP**	**Price/kg**
1	Trichloro fluoro methane	R-11	CCL_3F	23.71	• Considered as safe refrigerant • Used in air conditioning of small buildings, factories, stores, etc.	1	4000	₹ 550
2	Dichloro difluoro methane	R-12	CCL_2F_2	-29.75	• Domestic refrigerators and freezers • Water coolers • Ice makers • Liquid chillers • Transport refrigeration	1	8500	₹ 550
3	Chloro trifluoro mthane	R-13	$C_{48}H_{48}O_{20}$	-81.3	• Low temperature refrigeration • Flash freezing and cryogenic processes	1	11700	₹ 460
4	Chloro difluoro methane	R-22	$CHCLF_2$	-40.8	• Air conditioners • Heat pumps • AC system • Mini splits	0.055	1700	₹ 650
5	R-22	R-502	$C_3HCL_2F_7$	-45.3	• Low temperature and transport refrigeration	0.33	5600	₹ 275
6	R-115	R-502	-	-45.3	• Low temperature and transport refrigeration	0.33	5600	₹ 310

THIRD GENERATION REFRIGERANTS

Third generation refrigerants are the refrigerants fully intent on diminishing the a dangerous atmospheric devation and ozone consumption potential. This is the new gathering of refrigerants in view of hydrochlorofluoro (HFO) and hydrofluoro carbon (HFC) compound. These re changed second generation refrigerants which safeguard Another new class of fluorocarbon coolers called hydrofluoro olefin (HFO) with decreased GWP limit has been gotten to the next level. Their fundamental benefit, aside from their low GWP, is that they can be utilized with existing refrigeration framework plans. This is really great for the business and their clients, yet it is as yet a fluorine gas.

Table-3: Third generation refrigerants and their applications

Third generation refrigerants and their applications								
Sr. no	**Name**	**R-number**	**Chemical formula**	**NBP (^{0}C)**	**Applications**	**ODP**	**GWP**	**Price/kg**
1	Difluoromet hane	R-32	CH_2F_2	51.65	- • Low temp. refrigeration • Replacement of 410a	0	580	₹ 45
2	tetrafluoroet hane	R-134a	CF_3CH_2f	-26.07	• Automotive air conditioning • Medium temperature refrigeration • Replacement of R12	0	1300	₹ 420
3	Pseudo azeotropic mixed Refrigerant	R-404a	R125+R14 3A+R134A	-46.6	• Low and medium temperature replacement	0	3800	₹ 400
4	Nonazeotopic mixed refrigerant	R-407c	R32+R125 +R134a	-43.8	• Commercial air conditioning • Replacement of R-22	0	1600	₹ 350
5	Near azeotropic refgrigerant	R-410a	R32+R125	-51.6	• Air conditioning	0	1900	₹ 365

DESIRABLE PROPERTIES OF REFRIGERANTS

Every refrigerant should have a few properties enemy its legitimate suitable working of plan arrangement of specific application.

These beneficial properties are as per the following:

- Low limit
- Low edge of freezing over
- Positive evaporative and condenser pressure
- Basic temperature should be higher than the condenser temperature
- High inert intensity of refrigeration
- Less harmfulness, combustibility and destructiveness
- Compound dependability
- High warm conductivity
- Low thickness
- Low smell and release propensity

REGULAR REFRIGERANTS

Regular refrigerants are effectively accessible, and long experience exists with their application dating far into the start of mechanical refrigeration. Numerous new refrigerants have come into picture to defeat the detriments of utilizing normal refrigerants yet the "circle" is presently some way or another shut as we previously got back to regular refrigerants, yet presently with new innovations and with a ton of involvement behind us. Normal refrigerants partition advantageously into hydrocarbons, smelling salts and CO2 and have been talked about here.
The prevailing attribute of the hydrocarbon refrigerants is their high combustibility. If safeguards are taken to alleviate the results of their combustibility, hydrocarbons make brilliant refrigerants practically speaking. They are miscible with mineral oils and have generally high basic temperatures.

NEXT GENERATION REFRIGERANTS

The elective refrigerants have been classified as momentary refrigerant or HCFC/HFC incompletely chlorinated refrigerants and into medium and long haul refrigerants (Fig.3). HCFC/HFC (halfway chlorinated refrigerants, for example, R22 and R134a are en route to deliberately get rid of because of natural concern. Under medium and long haul refrigerants like HFC chlorine free and their mix, low GWP refrigerant (R1234yf,1234ze) and halogen free refrigerant (regular refrigerant) are at present looking as the suitable choices for future refrigerant.

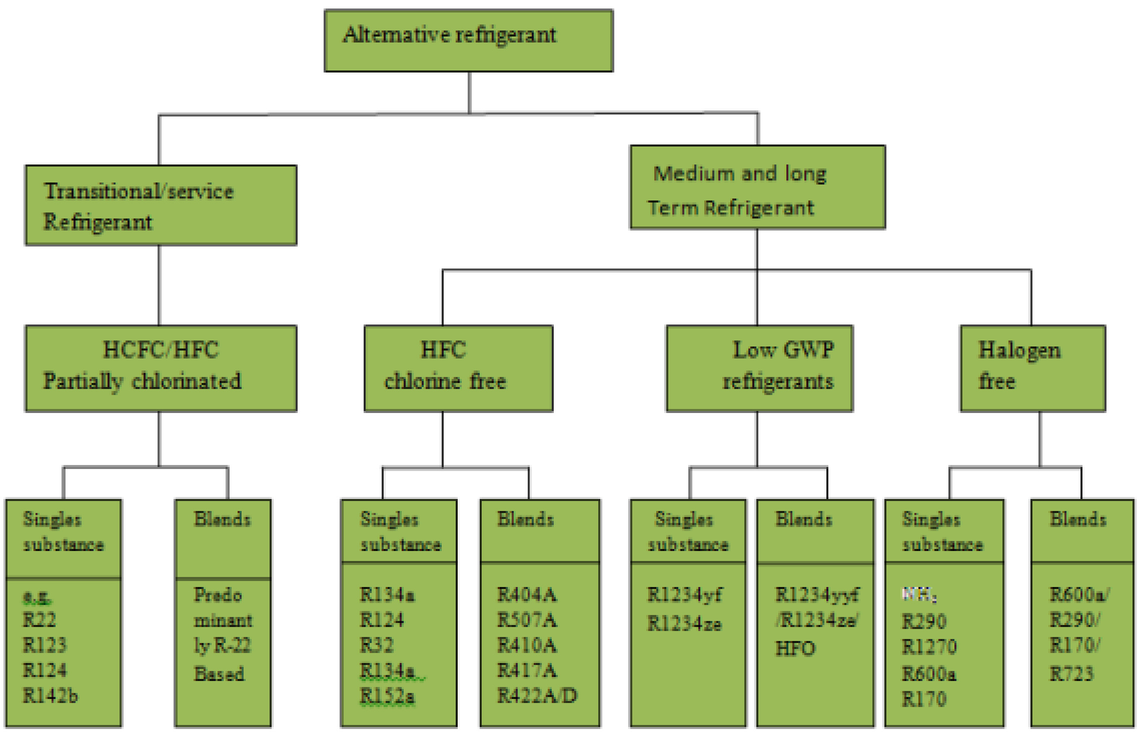

Figure 3: Classification of Alternative Refrigerant

LOW GLOBAL WARMING REFRIGERANT

Recently, R1234yf (2, 3, 3, 3-Tetrafluoropropene) having chemical formula CH2=CFCF3 has been proposed as a potential elective refrigerant for HFC134a. R1234yf has zero ODP and brilliant life cycle environment execution (LCCP) when contrasted with HFC134a. HFO-1234yf has the least exchanging cost for automakers among the as of now proposed other options, albeit the underlying expense of the item is a lot higher than that of R-134a. Another HFO based refrigerant HFO 1234ze (trans-1,3,3,3-Tetrafluoroprop-1-ene, CF3CH=CHF) is an energy-productive option in contrast to conventional refrigerants in air-cooled and water-cooled chillers for stores and business structures, as well as in other medium temperature applications, for example, heat siphons, fridges and CO2 overflow frameworks in business refrigeration. Refrigerant HFO-1234ze is the best medium tension, zero ODP and low GWP refrigerant available while thinking about the equilibrium, all things considered. An interesting trait of this refrigerant is the shortfall of combustible blend with air under 30°C of vibe. The exhibition of fume pressure refrigeration framework with two cutting edge climate well disposed refrigerants was examined and contrasted and the presentation of the framework with R134a, a third generation refrigerant [Calm and Hourahan, 2001]. Examination has been made between R1234ze, R1234yf and R134a and it was found that those two ecological well disposed refrigerants gave marginally lower execution than that of the R134a. Contrast in cooling limit was determined between R-134a and both R1234ze and R1234yf. It was viewed as 3% - 12% less for R1234yf inside the tested temperature range, while this distinction was determined to be less by 4% - 6% for R1234ze. Likewise, COP of the framework was additionally observed to be marginally lower for the new refrigerants contrasted with R134a. However the exhibition of the framework debased marginally with these two new refrigerants, they have undeniably less ecological effect contrasted with R134a. In this way, those two can supplant the current refrigerant R134a in not so distant future. The varieties of cooling limit and COP with evaporator temperature for the above said three refrigerants have been different condenser temperatures.

CONCLUSION

The accompanying ends can be drawn from this survey on cutting edge refrigerants:

[1]. The cutting edge refrigerants ought to be created in view of zero ODP and low GWP

[2]. R1234ze and R1234yf are appropriate substitutions for R134a

[3]. HFC/HCFC Blends are Non-ODP trade for R-22 and R-409A substitution for R12

[4]. The re-visitation of normal refrigerants at a new, high innovation level ought not be neglected.

Carbon dioxide as a refrigerant was investigated from its verifiable foundation to explicit properties which influence its presentation in the refrigeration business. Because of its unrivaled properties, particularly concerning refrigeration, we accept R744 will be a prevailing refrigerant in numerous uses of the refrigeration innovation later on.

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