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DOMESTIC REFRIGERATOR- A REVIEW

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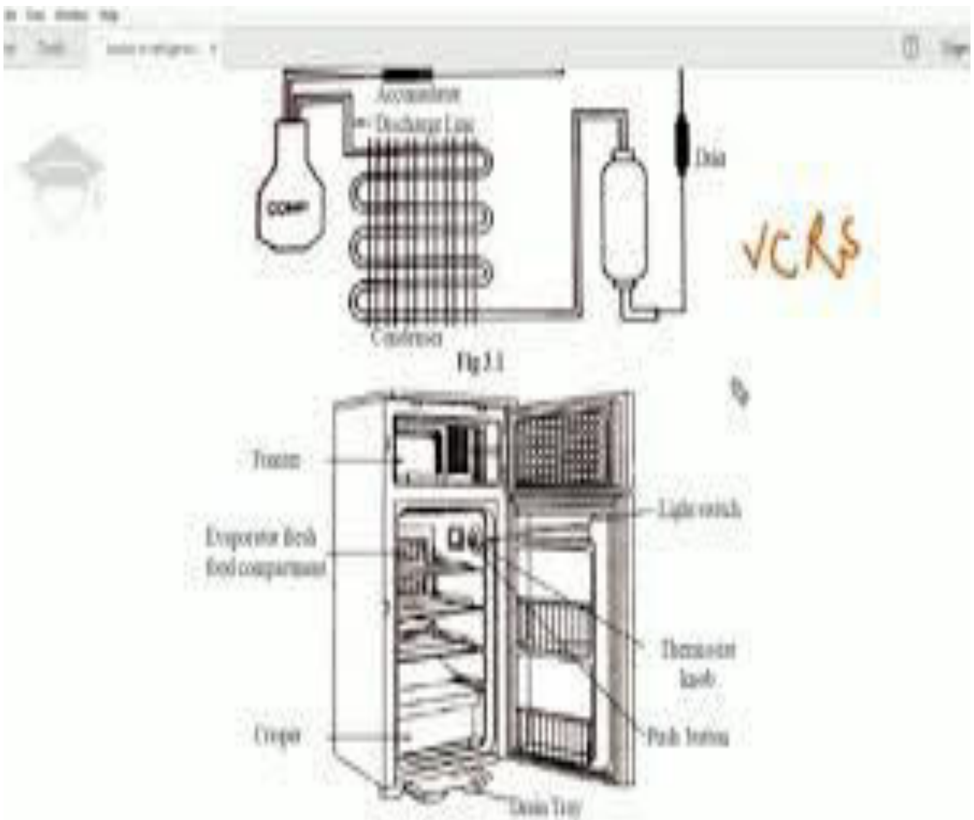
Abstract:

The energy performance of Refrigeration systems are usually evaluated based on the laws of thermodynamics. However, compared to energy analysis, exergy analysis shows better and accurate location of inefficiencies. Exergy analysis locates inefficient areas having greater potential for improvement. Exergy analysis helps to understand and quantify system irreversibility's, to measure to reduce these irreversibility's to minimum level, and to optimize Refrigeration systems. This paper describes the construction and testing of an integrated heat recovery system which has been designed both to enhance the performance of a domestic refrigerator and simultaneously to heat recovery from water heat exchanger. This condenser operates in parallel with the air-cooled condenser tubing of the refrigerator so that either one or the other is active when the refrigerator is running. The refrigerator was housed in a controlled environment chamber, and it was instrumented so that its performance could be monitored carefully. The system has been fabricated according to literature study which is different from the one which is not reported issues associated with commercial implementation of the concept; a review paper has been prepared.

Keywords: COP; refrigeration system; water cooled heat exchanger; heat recovery system

Introduction :

It is very much essential to put more efforts for improving the efficiency of thermal systems because of increasing energy prices and increasing concern of global warming. One of the methods of increasing efficiency is to recover and utilize waste heat from thermal systems for various applications like water heating. Hot water is required for various applications like bathing, processing, cooking, dish washing, sterilization, and utensils cleaning in dairy. In such applications, water is heated by electrical heating or burning the fossil fuels which is costly and also increases global warming. Use of waste heat recovery is an important technique of reducing total energy costs in energy system design. Attachments need to be developed to recover waste heat energy and coefficient of performance increment in refrigeration systems by sub cooling technique in domestic refrigerator. If the heat recovery system is designed optimally and implemented in residential and small-scale commercial systems, the cumulative benefits would be significant. At many places, heating and cooling systems are simultaneously used. Air conditioning and refrigeration systems are designed to remove the heat from interior spaces and reject it to the ambient air. Heat rejection may occur directly to the ambient, as in the case of most conventional air- cooled condenser, or to water, circulating from a cooling tower. The circulating water eventually rejects the heat to the ambient air, in the cooling tower. While this heat is of a "low grade variety," it still represents wasted energy. From an energy conservation standpoint, it would be desirable to reclaim this heat in a usable form. The best and most obvious form of heat recovery is for heating water. This waste energy can be recovered and utilized for various applications, which not only saves the energy but also enhances the performance of system. Heat recovery system will not change the basic refrigeration cycle. It will simply change the type of combination of condensers used to remove the heat from the refrigerant.



Literature Survey :

In 1994, R. N. Richardson and J. S. Butterworth, [1] Experiments have been conducted to investigate the performance of hydrocarbon refrigerants in a hermetic vapour-compression system. It is shown that propane and propane/isobutene mixtures may be used in an unmodified R12 system and give better COPs than R12 under the same operating conditions. In 1995, Alan Meier,[2] studied methods for energy tests of refrigerator. First method is “Department of Energy ANSI”, second method is “Japan Industrial Standard JIS” and third method is “International Standards Organization ISO/DIS”. He found “Department of Energy ANSI” is the efficient energy test method for refrigerator. The most reliable way to reduce refrigerator energy use is to replace old units with new ones. This action often cuts electricity use 60%. Programs to collect old refrigerators and encourage consumers to buy new, high-efficiency ones are likely to be highly effective for many years. In 1996, W. L. Martz, C. M. Burton and A. M. Jacobi, [3]studied The VLE predictive performance of six local composition mixture models was compared for seven refrigerant and oil mixtures. The mixtures exhibited positive, negative and mixed deviations from the Lewis-Randall rule. Interaction parameters for the mixture models were related to mixture behavior and he found The utility of any model depends on its simplicity, accuracy and generality. Models with many empirically determined parameters usually require more experimental data and are more complicated than models with fewer parameters. However, purely empirical models, like those of Grebner and Crawford and Thome , may be more attractive in some situations. In 1996, R. Radermacher and K. Kim, [4] he found the refrigerator/freezer is one of the most important and the biggest energy-consuming home appliances. There are several literature references that discuss the historical development of refrigeration. Recent environmental concerns led to a considerable boost in development efforts emphasizing two aspects: (1) environmentally safe fluids; and (2) reduced energy consumption. In 1998, C. Nikolaidis a & D. Probert b, studied The behavior of two-stage compound compression-cycle, with dash inter cooling, using refrigerant R22, has been investigated by the exergy method. The condenser's saturation- temperature was varied from 298 to 308 K and the evaporator's saturation-temperature from 238 to 228 K. The effects of temperature changes in the condenser and evaporator on the plant's irreversibility rate were determined. In 2001, Onrawee Laguerre, Evelyne Derens& Bernard Palagos, [6] A survey was carried out in France from April to June 1999. Temperatures were recorded at three levels (top, middle and bottom) of the refrigerator compartment and This study shows that the combination of the use conditions (temperature setting, frequency of door openings, heat sources and built-in) seems to have a major impact on the refrigerator temperature. In 2002, Cemil Inan, Turgay Gonul & M. Yalcin Tanes, [7] the transient behavior of a domestic refrigerator is investigated by the use of an X-ray system. The studies are made on a two-door upright freezer with a volume of 435 liters, and which has an automatic defrost feature. The refrigerant is R134a. X-ray system is very beneficial to understand some transient behaviors of the refrigerator. Tubes like steel and copper are not good for clear images. Aluminum tubes are recommended for clear observations. If the flow inside the steel tubes are a point of interest then the ‘‘Neutron Radiography Technique’’ is recommended. In 2003, R. Paul Singha & Ferruh Erdogdub, [8] In this, the time required for freezing and thawing different meat products was determined for five different models of household refrigerators. Two refrigerators had ‘‘quick thaw’’ compartments and three refrigerators had ‘‘quick freeze’’ capabilities. This research showed that some refrigerator models froze and thawed foods significantly faster than others. The refrigerators with quick freezing capabilities were successful in freezing the tested meat products in less time than the models without that capability Running the refrigeration system continuously in the ‘‘quick freeze’’ operation lowered the temperature in the freezer and caused faster freezing. In 2016, R.Hussain Vali , P.Yagnasri & S.Naresh Kumar Reddy, The design of condenser plays a very important role in the performance of a vapor compression refrigeration system. Effective new designs are possible through theoretical calculations, however may fail due to the reason that the uncertainties in the formulation of heat transfer from the refrigerant inside the condenser tubes to the ambient air. Hence experimental investigations are the best in terms of optimization of certain design parameters. The main objective in the present work is an attempt is made to verify the performance of existing condenser design to helical shaped condenser design and varying the length of the helical condenser coil to verifying the effect on the performance of a domestic refrigerator capacity 165lts, R134a as refrigerant, hermetic sealed compressor. It is expected that the helical shaped condenser installation may give optimum results. Finally it is observed that by changing the conventional design to Helical shaped condenser the performance of the refrigeration system is increased.

Global Warming

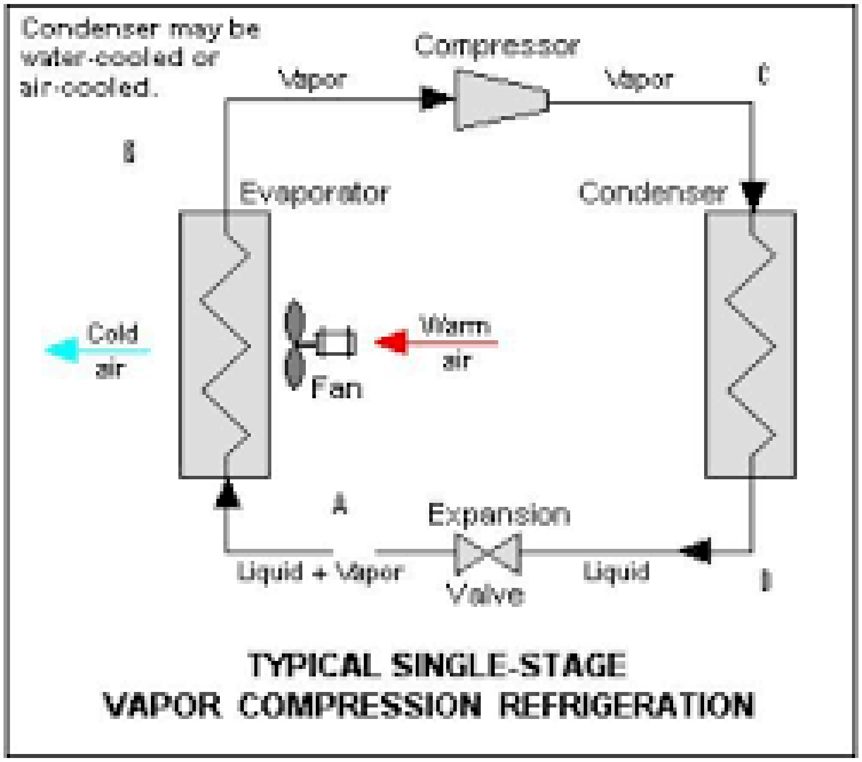
The global warming effect is the phenomenon of increase in earth's surface temperature because of the absorption of long wave radiation by certain vapors and greenhouse gases. The CFCs, HCFCs and HFCs are all greenhouse gases. Because of their molecular structure, they all have strong absorption featuares in the so-called window region of the infrared. The window region is the wavelength region from about 7 to 13µm, where absorption by the primary absorbers CO_2 and H_2O is weak (Wobbles 1994). Global Warming Potential (GWP) has been scaled with reference to carbon dioxide, which has GWP = 1.0.

Ozone Depletion Potential

Chlorofluorocarbons, which are a family of chemical compounds derived from simple hydrocarbons (methane, ethane, etc.) by substitution atoms with halons (chlorine and fluorine), have been known and characterized since the 1890s. In 1928 Thomas Midgley projected these simple hydrocarbon derivatives as working fluids in refrigeration equipment. The CFCs possess most of the desirable characteristics, such as chemical stability, high thermodynamic efficiency, non-toxicity, non-flammability, etc. However the ozone depleting Effect of CFCs is of great concern because of the harmful ultra violet radiation that might otherwise reach the surface of the earth (Rowland and Molina 1974). The CFCs and HCFCs which are stable chemicals persist for a long time in the atmosphere. They eventually break down in the stratosphere releasing chlorine or bromine, which in turn reacts with ozone (Earl 1990). The ability of a chemical to destroy ozone depends upon the halogen type (chlorine and bromine), the number of halogen atoms it releases and its residence time in atmosphere. Each chemical has been assigned a number according to its ozone depletion potential (ODP). The reference value is ODP = 1.0 for CFC11

Types of refrigerants used in household refrigerator:

Refrigerants are working fluids in refrigeration and air-conditioning systems. The refrigerant absorbs the heat from the space to be cooled through the evaporator and then reject it to the outside through the condenser. The refrigerants used and the alternative refrigerants must meet many requirements, the following features are considered as major standards in the selection of proper refrigerants such as environmental safety ,Chemical stability, Satisfactory thermal and physical properties, high latent heat of vaporization, Low cost, no corrosiveness, non-toxicity, Short atmospheric lifetimes, non-explosive, and Non-flammable .Unfortunately, there are no long-term refrigerants have all of these properties that fully meet these requirements, but at least both Eco-friendly and energy-efficient. There are different types of refrigerants which are described as following[2]. R-11trichloromonoflouromethane (CCL_3F) The R-11 is a synthetic chemical product which can be used as a refrigerant. It is stable, non-flammable and non-toxic. It is considered to be a low pressure refrigerant. It has a low side pressure of 0.202 bar at-15 C and high pressure of 1.2606 bars at 30 C. The latent heat at-15 C is 195 KJ/kg. The boiling point at atmospheric pressure is 23.77 C. due to its low operating pressures; this refrigerant is exclusive used in large centrifugal compressor of 200TR and above. The leaks may be detected by using a soap solution, a halide torch or by using an electronic detector. R-12 dichlorodifluoromethane (CCL2F2) The R-12 is a very popular refrigerant. It is a colorless, almost odorless liquid with boiling point of - 290C at atmospheric pressure. It is non-toxic, non-corrosive, non-irritating and non-flammable. It has a relatively low latent heat value which is an advantage in small refrigeration machines. R-12 has a pressure of 0.82 bars at -150C and a pressure of 6.4 bars at 300 c. The latent heat of R-12 at -150 c is 159KJ/kg. R-134a tetrafloroethane (C2H2F4) The preferred replacements of R-12 can be the HFC refrigerants R-134a. This has a boiling point of - 26.20C which bears reasonable comparison with the boiling point of R-12 (-29.80C). R-134 is a not a drop in replacement of R-12 because the refrigerating effect is slightly different. It does not seem to be compatible with conventional lubricants or more winding insulation. It gives higher benefits thenR-12 in using in conventional refrigerators where reasonable condensing temperature is specified. This would appear to be non-flammable and nontoxic substitute for R-12 at extreme pressure ratios. Propane + Isobutene (R290/R600a-LPG) It is an azeotropic mixture of propane (R290) &isobutene (R600a). It has Property very similar to R12 & R 134 which is commonly used refrigerant now days. This blend of hydrocarbons is used in most of the AC of European cars. It contains 60% propane+40%iso butane. It is named as mint gas because it has cooling property like mint. Moreover it has zero ozone depletion potential and a reliable global warming potential (the two property due to which we need to replace the CFC's). R410A-difluoromethane/pentafluromethane (CH2F2/CHF2CF3) R410A is azeotropic HFC blend of R125 and R32. In Australia R410A is a popular product for commercial and residential air conditioning systems as an alternative to R22. R410A exhibits higher pressures than R22 so is used in new equipment rather than as a retrofit gas. R22- chlorodifluromethane (HCFC-22) R22 is a single component HCFC refrigerant that has historically been used for air conditioning, medium temperature and low temperature refrigeration. R22 causes ozone depletion and as a result is subject to Legislation that is phasing down its use in Australia. Hydrocarbons (HC) Natural refrigerants refer to all non-synthetic natural materials. It can be drawn directly from the environment, including hydrocarbons (HC) propane (R290) and isobutene (R600a).Natural refrigerants are low global warming potential because they can easily be absorbed by nature. HCs have good thermodynamic properties and heat transfer performance, zero ODP and GWP near the unit, but are dangerous because of their flammability. Flammable gasses are common in many technical applications and do not cause many problems when observing simple precautions. Another area where propane could be a substitute for R-12 in the future refrigerators and freezers



Conclusion:

In developing country like India, most of the vapor compression based refrigeration, air conditioning and heat pump systems continue to run on halogenated refrigerants due to its excellent thermodynamic and thermo-physical properties apart from the low cost. However, the halogenated refrigerants have adverse environmental impacts such as ozone depletion potential (ODP) and global warming potential (GWP). Hence, it is necessary to look for alternative refrigerants to full fill the objectives of the international protocols (Montreal and Kyoto) and to satisfy the growing worldwide demand. This paper reviews the various experimental and theoretical studies carried out around the globe with environment friendly alternatives such as hydrocarbons (HC), hydroflurocarbon (HFC) and their mixtures, which are going to be the promising long-term alternatives. In addition, the technical difficulties of mixed refrigerants and future challenges of the alternatives are discussed. The problems pertaining to the usage of environment friendly refrigerants are also analyzed.

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