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CHAPTER 1

1.1. HISTORY OF REFRIGERATOR

A refrigerator is a popular household appliance that consists of a thermally insulated compartment and a heat pump (mechanical, electronic or chemical) that transfer heat from the inside of the fridge to its environment, so that the inside of the fridge is cooled to a temperature below the ambient temperature of the room.

Refrigeration is an essential food storage technique in developed countries, of which the lower temperature lowers the reproduction rate of bacteria. So therefore, the refrigerator reduces the rate of spoilage.

Refrigerator maintains a temperature of few degrees above the freezing point of water, and also the optimum temperature range for perishable food storage is 3 to 5ºC (37 to 47ºF). Another common device that maintains a temperature below the freezing point of water is known as the FREEZER.

The refrigerator replaces the ICEBOX which had been a common household appliance for century and half, for these reasons the refrigerator in American usage is sometimes referred to as the ICEBOX.

The first artificial refrigeration system began in the mid-1750s and developed in the early 1800s. In 1834, the first working vapor-compression refrigeration system was built. And also, the first commercial ice-making machine was invented in 1854 and in 1913 refrigerator for home use was invented. In 1923, Frigidaire introduced the first self-contained unit, and the introduction of Freon in 1920s expanded the refrigerator market.

Newer refrigerators may include automatic defrosting chilled water and ice from a dispenser in the door. Domestic refrigerators and freezers for food storage are made in a range of sizes, among the sizes; the smallest is a 4l Peltier refrigerator which can hold about 6 cans of beer while the largest size is as tall as a person and about 1m wide with a capacity of 600l.

1.2. HISTORY OF REFRIGERATION TECHNOLOGY

The history of artificial refrigeration began when a Scottish professor William Cullen design a small refrigerating machine in 1755. Cullen used a pump to create a partial vacuum over a container of diethyl ether, which then boiled absorbing heat from the surrounding air. This experiment by Cullen created even a small amount of ice but had no practical application at that time.

In 1805, American inventor Oliver Evans described a closed vapor-compression refrigerator cycle for production of ice by ether under vacuum. In 1820, the British scientist Michael faraday liquefied ammonia and other gases by using high pressures and low temperatures.

Also, in 1834 an American expatriate to Great Britain Jacob Perkins built the first working vapor-compression refrigeration system and it was a closed-cycle device that could operates continuously. In 1842, a similar attempt was made by American physicist john Gorrie who built a working prototype but it was a commercial disaster.

The first practical vapor-compression refrigeration system was built by James Harrison, a British journal who had immigrated to Australia. His 1856 patent was for a vapor-compression system using ether, alcohol or ammonia. He built a mechanical ice-making machine in 1851 on the banks of the Barwon River at rocky point in Geelong, Victoria and his first commercial ice-making machine followed in 1854.

Harrison also introduced commercial refrigeration system using vapor-compression to breweries and

meat packing houses and by 1861 a dozen of his system were in operation.

The first gas absorption refrigeration system using gaseous ammonia dissolved in water (referred as “aqua ammonia”) was developed by Ferdinand carr of France in 1859 and patented in 1860. Carl von Linde, an engineering professor at the technology university Munich in Germany, patented an improve method of liquefying gases in 1876. His new process made possible the use of gases such as ammonia sulfur dioxide (SO2) and methyl chloride (CH3Cl) as refrigerants and they were used for that purpose until the late 1920s.

1.2.1. DOMESTIC REFRIGERATION SYSTEM

In 1913, refrigerators for home and domestic use were invented by Fred w. wolf of Fort Wayne, Indiana with models consisting of a unit that was mounted on top of an icebox.

In 1914, engineer Nathaniel B. wales of Detroit, Michigan, introduced an ideal for a practical electrical refrigeration unit which later became the basis for the kelvinator.

A self-contained refrigerator with a compressor on the bottom of the cabinet was invented by Alfred Mellowes in 1916. Mellowes produced this refrigerator commercially but was brought out by William C, Durrant in 1918, Durrant started the Frigidaire Company to mass-produce refrigerator. Also in that same year, 1918 Kelvinator Company introduced the first refrigerator with any type of automatic control.

The absorption refrigerator was invented by Baltzar Von Platen and Carl Munters from Sweden in 1922, while they were still student at Royal institute of technology in Stockholm. It became a worldwide success and was commercialized by Electrolux. Other pioneers include Charles Teller, David Boyle, and Raoul Picket.

Carl Von Linde was the first to patent and make a practical and compact refrigerator in the whole world

1.2.2. HISTORY OF REFRIGERANT

Commercial refrigerator and domestic refrigerators uses gases such as ammonia (R-717) or sulfur dioxide (R-764), which occasionally leaked, making them unsafe for home use.

In 1930s, a non-flammable refrigerant such as Freon-12(R-12) were introduced but however the R-12 causes damages to the ozone layer which makes the USA government to issue a ban on its use in new refrigerators and air conditioning system in 1994.

In 1990, a less harmful refrigerant R-134a (tetrafluoroethane) was use for perfect replacement to R-12 in 1990, but still found in many old systems.

Figure: 1.1: p-h diagram of refrigeration cycle for R-134a

1.2.3. HISTORY OF STYLES OF REFRIGERATORS

In the 1950s most refrigerators were white, but from mid-1950s through present day designers and manufacturers put colours into refrigerators. In late 1950s/early 1960s, pastel colours like turquoise and pink became popular, brushed chrome-plating (similar to stainless finish) was available in some model from different brands. In late 1960s and throughout 1970s, earth tone colours were popular including Harvest Gold, Avocado Gold and Almond. In 1980s, black became fashionable. In 1990s, stainless steel came into vogue, and in 2009, one manufacturer introduced a multi-colour design.

1.3. GENERAL TECHNICAL EXPLANATION OF REFRIGERATING SYSTEM

A vapor-compression cycle is used in most household refrigerators, refrigerator-freezers and freezers. In this cycle, a circulating refrigerant such as R-134a enters a compressor as low-pressure vapor at or slightly below the temperature of the refrigerator interior. The vapor is compressed and exit the compressor at a very high-pressure superheated vapor, the superheated vapor travels under pressure

through coils or tubes that makes up the condenser, the coil or tube are passively cooled by exposure to air in the room. The condenser cools the vapor which liquefies.

As the refrigerant leaves the condenser, it is still under pressure but it is slightly above the room temperature of the system. The liquid refrigerant is forced through a metering or throttling device, also known as the expansion valve (essentially a pin-hole sized construction in the tubing) to an area of much lower pressure. The sudden decrease in pressure result in explosive-liked flash evaporation of a portion (typically about half) of the liquid. The latent heat absorbed by the flash evaporation is drawn mostly from adjacent still-fluid refrigerant, a phenomenon known as auto-refrigeration. This cold and partially vaporized refrigerant continues through the coil 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 heat from the box air.

The cooled air is returned to the refrigerator or freezer compartment, and so keeps the box air cold. But the cooled air in the refrigerator or freezer compartment is still warmer than the refrigerant in the evaporator. The refrigerant leaves the evaporator, now fully vaporized and slightly heated, and returns to the compressor inlet to continue the cycle.

1.4. PURPOSE OF CONSTRUCTION

The aim and purpose of which this project is designed is to achieve the followings:

To construct a portable lightweight cooling and freezing equipment.

To construct a movable cooling or freezing equipment, this can easily be transferred from one corner of the apartment to the other.

To construct a mobile refrigerator with good performance and high percentage of local technology.

To construct a cooling and freezing equipment that will be mobile, economical and cost effective.

To construct a cooling or freezing equipment that is efficient and with little or no complication in maintenance.

1.5. IMPORTANCE AND SPECIFICATION OF THE PROJECT

The importance attached to this design accomplishment of a fast cooling and freezing system without adverse effect on the food tissue, flavours, fleshiness, and natural nutrients of the food materials. The design intentions are based on reduced cost, longer life spans, fast freezing and cooling techniques, compactness, probability, easy of mobility and more of improving on the existing design taking into consideration the Nigeria factor and possibility of expending and marketability.

The specifications were obtained considering the items, which are to be cooled or preserved. Also the dimensions of the framework and the covering sheets were also considered immensely.

The component part for the design of the middle cooling system includes:

The Compressors or the Engine

The Condenser

The Capillary tube

The Evaporator

Refrigerant

Relay

Drier Strainer or Drier

Thermostat

Lubricating Oil
Rubber seal
Fibre of lagging material
Mild steel-square pipe
Metal sheets of mild steel / galvanized – sheet
Rollers
Filler
Metal
Coal Materials
Plastic guilders
Metal screw nails

1.6. SCOPE AND LIMITATION

Refrigeration consist of three main categories which include –

Domestic refrigeration
Industrial refrigeration
Commercial refrigeration

The design scope of the cooling and freezing systems or mobile refrigerator is mainly for commercial domestic reasons due to the movable nature and freezing capacity.

The limitations, is the specification in terms of the size, area and capacity that determines the limitation of the design of the machine. In an industrial situation or uses or purpose where bigger refrigeration units are needed or required, the specification of this equipment may not be ideal (i.e. it might not be suitable).

1.6.1 LIMITATIONS ENCOUNTERED

Inaccessibility of a 12 volts DC compressor.
Inaccessibility of a poly-foam for insulation.
Lack of sophisticated workshop tools for machining.

1.7. STATEMENT OF THE PROBLEM

The most common uses of this mechanized refrigeration are the preservation of perishable goods more especially food stuffs, cooling of drinks etc. In serving both functions and considering the area and situations of need such as resort centers, student hostels, single room apartment etc. Hence the need arises more than ever to design mobile cooling and freezing system of acceptable standard that will meet certain essential requirements such as cost effectiveness and portability.

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