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Development of Refrigerator Cum Chill Water Dispenser System Using R134a

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Abstract-

Refrigerator is not only utilized to store food, vegetables, medicine but also used preserve them below atmosphere temperature for long time. It is also used obtain cool water, for cool water users frequently opens the door of refrigerator so that heap on it increases and its directly affects the COP (coefficient of performance) or execution of (it).. But now days people buy separate chilled water container to obtain cool water. So they buy separate water dispenser and Refrigerator , so cost and size of devices increases. The aim of this work is to study various types of water dispenser available in market with different refrigerants used in it and the cost of this refrigerator cum water dispenser, recycling of old refrigerator and contribution of refrigerants in GWP & ODP of environment and it concludes that the water dispenser is costly which is not economically suitable for middle class family, the refrigerants used in this dispenser are very harmful for environment and the recycling is very costly. There is provision of chilled water inside the refrigerator with small opening tap beside the refrigerator door.
From literature survey it is conclude that this arrangement is very advantageous for the refrigeration COP of overall performance. Refrigerators manufactured since 1965 and there is more changes day by day in the refrigerator. There are various types of model available, but in 21st century because of higher technology these refrigerator becomes outdated and the recycling cost of this refrigerator also costly, hence it's better to modify this refrigerator by slightly do changes in it and use.

Key Words : preserve ,COP, dispenser, overall performance, ODP, GWP

1. Introduction

Today's, advanced technology implemented in the refrigeration industry, the main purpose this technology to reduce the energy consumption, increases the execution of the refrigerator and save the environment. so refrigeration industry develop and uses various cheap, less harmful to environment, low energy consumption, low GDP and ODP alternative refrigerants to CFC refrigerants. Many restaurants, Many dairy mill, hotels, textile industries, Hospitals require both refrigeration, freezing, cooling, heating. In dairy milk products are required to store at low temperature e.g butter or cooling of milks, curd.
In case of restaurants food need store and preserve at low temperature, in hospitals many medicines are required to store and preserve at low temperature, in case of textile industry it requires central air conditioning plant which requires chilled water and hot water for steam generation and heating purpose. so that they uses separate units for cooling,heating and refrigeration or cooling purpose so that this device consumes more purchased electricity from grid and increases the cost of the devices. The performance of this device is calculated in terms of the COP (coefficient of performance). so that it is convenient to design the device such that combine effect will be get from the single unit. Hence cost, execution of devices increases. also reduction in harmful gases to environments due to which Depletion of Ozon decreases and global warming decreases. Because of compact construction of water dispenser and refrigerator the saving in ODP, GWP. There is also electricity consumption is decreases so that the performance of this system (combination of refrigerator and water cooler dispenser) increases, running cost is decreases.[2] and this all modification we can do

in old refrigerators so that the recycling cost of this old refrigerator decreases and used with its high efficiency

2. Basic Refrigeration Principle

If you were to place a hot stainless steel glass of tea on a table and leave it for a while, the heat in the tea would be transferred to the materials in contact with the tea, i.e. to the stainless steel glass, to the atmospheric air. Tea inside the stailess steel glass becomes cold due to heat transfer to the atmosphere. Refrigerator use the same principle, it removes the heat from closed space container products and gives to the aatmosphere hence products or food inside the container becomes the cool.

The principle involves the transfer of heat. When you put ice cube on your hand , after some time ice cube starts melting because ice cube gets the latent heat from your hand. i.e heat is transformed from higher to lower temperature. This concept used in our day to day life.

In the winter, we use electric heater to increase the temperature of the house. In summer, we want to do the opposite, remove heat from our house to atmosphere and changing the temperature of our house.

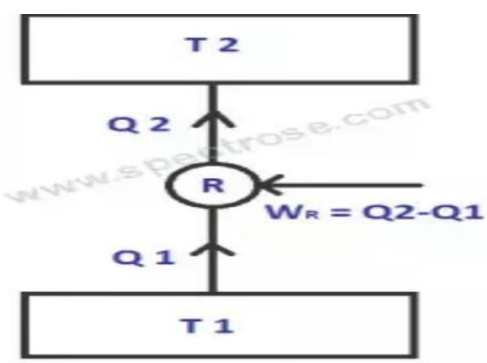


Fig.1 Working principle of refrigerator

From point (1) to point (2), the refrigerant vapor is compressed at constant entropy and exit compressor as a vapor which holding very high temperature.
From point (2) to point (4), the vapor moves through the condensing coil, condensing coil removes the heat from hot vapor and reject to the the atmosphere, so that there is phase change takes place and the hot vapor becomes cold and it gets converted into the liquid at constant pressure and temperature. In between points (4) and (5), the liquid refrigerant moves through capillary tube, where its pressure decreases suddenly, then this low pressure liquid refrigerant moves through the evaporative coil where it absorbed heat from the closed space and phase change occurs i.e. it changes from liquid to vapor, again this heated vapor moves towards the compressor, agin this thermodynamic cycle gets repeated.

2.1 Working cycle of Refrigerator

Consider a boundary enclosing a space in which a refrigerator is placed.
It is clear that some heat q_2 is given out at temperature higher than the surroundings.

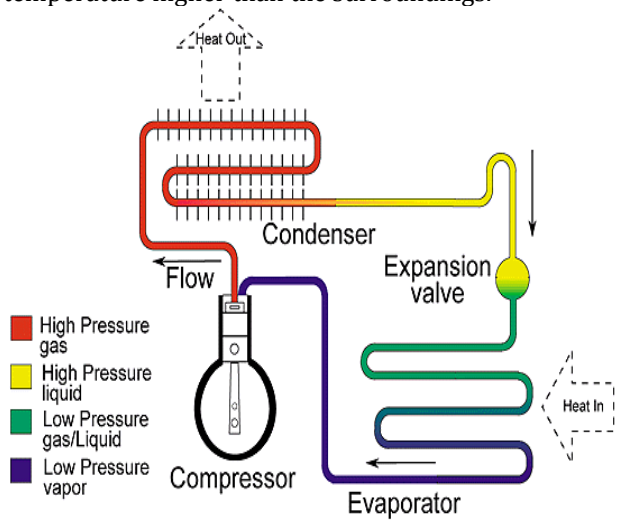


Fig.2 Simple Vapor Compression Refrigeration System

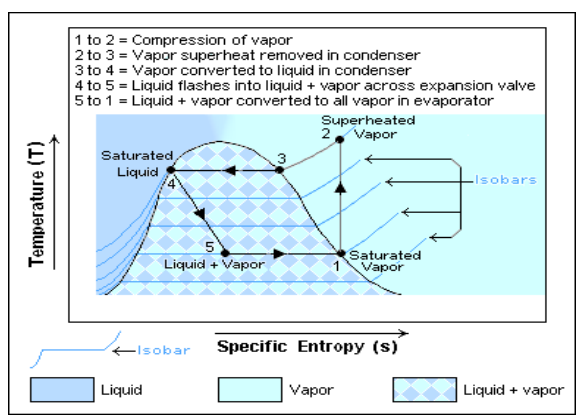


Fig.3 Thermodynamic Cycle of VCR

It will be likewise reasonable that those foodstuff set inside those cooler may be cooled Eventually Tom's perusing giving out their heat of the fridge

which in turn, thereabouts with say, absorbs heat q_1, obviously at bring down temperature over the surroundings.
Each refrigerator is supplied with vitality possibly in the structure from claiming high temperature or electricity, that is, a few worth of effort (w) is given to it. Those refrigerating device, In this way may be absorbing high temperature toward more level temperature What's more providing for out at higher temperature; this may be generally not could reasonably be expected for our normal life, since high temperature can't stream from easier on higher temperature, yet all the in the event that of a refrigerator this is attained during those cosset from claiming vitality supplied to it.
For those limit aggregate high temperature provided for crazy (q_2) is equivalent to those downright vitality enter in the structure for heat Consumed (q_1) and the worth of effort Consumed (w) adjusting them. For a refrigerator device, we need aid intrigued by the extent to which high temperature is concentrated starting with nourishment stuff what's more entryway minimal electrical vitality we spend, minimizing our force bill.
The proportion for high temperature Consumed of the worth of effort information in the type of electric vitality (w) will be called Coefficient of Performance (COP). Those proportion ought to make Concerning illustration secondary Similarly as could reasonably be expected.
C.O.P = refrigerating impact / Workdone
$= q_1/(q_2-q_1)$.
Theoretical COP is calculated from p-h chart for R-134a.
Actual COP is the proportion for real cooling impact of the real vitality supplied of the compressor known starting with watt-hour perusing. Relative COP is those proportion about actual COP of the theoretical COP. It is an dimensionless unit.

2.2 DOMESTIC REFRIGERATOR

There are mainly two types—either a single door refrigerator and a double door refrigerator-freezer combination, with the freezer compartment on the top portion of the refrigerator, or a vertically split cabinet (side-by-side), with the freezer compartment on the left side of the cabinet.
They are completely self-contained units and are easy to install. Most refrigerators use R-22 refrigerant, normally maintaining temperatures of -15^{0}C in the freezer compartment and about 1.7^{0}C to 8^{0}C in the refrigerator compartment. The technician must be able to perform various duties in the maintenance and repair of domestic refrigerators, water coolers, and ice machines.

This section provides information to aid you in handling some of the more common types of troubles.But let us remind you that the information given here is intended as a general guide and should, therefore, be used with the manufacturer's detailed instructions.

2.3 Technical Data of a Household Refrigerator

1. Compressor H.P.-1/8 to 1/6.
2. Capillary-0.82 mm in diameter.
3. Normal refrigerant charge-160 to 190 grams for 165 liters capacity but varies as per capacity.
4. Power consumption - 3 to 4 kW-hr for 286 liters capacity refrigerator per day and 2 to 3 kWh for 165 liters capacity unit.
5. Maximum running time- 40 to 60% of day time for small refrigerator and 60 to 80% for bigger refrigerator. 6. Lower evaporator temperature-(-17±2)^0 C.
7. Temperature in chill tray-0^0 C or below.
8. Suction pressure -0.7 to 1.6 bars.
9. Discharge pressure-12 to 15 bars.

3. WATER COOLERS

The reason for water coolers will be with make water accessible at a consistent temperature regardless of encompassing temperature. They would intended to transform chilly water during around 8^{0}C should 13^{0}C to quenching the thirst of the people attempting on heated earth. The warm or typical water might serve those physical prerequisite of our framework for the best possible working of the constitution organs Be that it doesn't quench those thirst particularly Previously, hot summers.

3.1Water Coolers

The water coolers are two types i.e. the storage type and the instantaneous type. In the storage type water coolers, the evaporative coil wound around container in which water is stored.
The tank may be of galvanized steel or stainless steel sheets or aluminium tank. The water level in the tank is maintained by a float valve. In this type of water cooler, the machine will have to run for long time to bring down the temperature of the mass of water in the storage tank. Once the temperature touches the set point of the thermostat, the machine cycle is stopped.

When the water is drawn from the cooler and an equal amount of fresh water is allowed in the tank, the temperature will rise up slowly and the machine starts again. As such there is always a reservoir of cold water all the time .In instantaneous type water coolers, the evaporator consists of two separate cylindrically wound coils made of copper or stainless tube.

The evaporating refrigerant is in one of the coils and the water to be cooled is in the other coil. The water is cooled by the refrigerant in evaporator by conduction. These water coolers are further classified as (a) bottle type, (b) pressure type, and (c) self contained remote type, these are discussed, in detail, as follows : (a) Bottle type-As the name suggests, this type of instantaneous water cooler employs a bottle or reservoir for storing water to be cooled.

No city main inlet connection is required as it is normally used to cool water supplied in 20 to 25 litre glass bottles, which are placed on top of the unit, as shown in

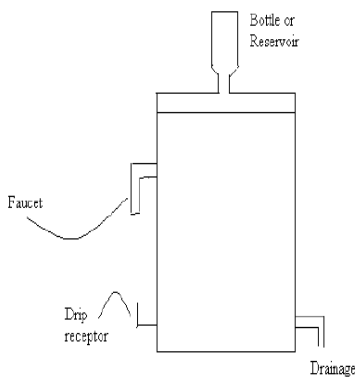


Fig.4 Bottle type

(b) Pressure type-

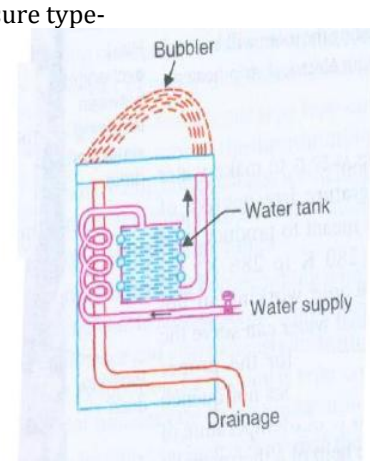


Fig.5 Pressure gauge

In this type water is supplied under pressure. The city main water enters the cooler through the inlet connection at the rear of the cooler. It then passes through a pre-cooler. The pre-cooler is cooled by the waste water of the cooler. As the waste water temperature is low, it is made use of cooling the supply water by passing through a pipe coil In this kind from claiming immediate water cooler, as indicated Previously, fig. 5 water is supplied under weight. The city primary water enters those cooler through those bay association during the back of the cooler.

It At that point passes through a pre-cooler. Those pre-cooler will be cooled by those waste water of the cooler. Concerning illustration the waste water temperature will be low, it is made utilization of cooling those supply water Eventually Tom's perusing death through An channel loop wrapped around those waste transport. This course of action aides in diminishing those cooling load for those cooler.

The measure about cooling relies upon the amount for waste water and the length of the channel loop including of pre-cooler.

(c) Self contained remote type cooler-

This type of cooler employs a mechanical refrigeration system. The water cooled from the remote cooler is supplied to desired drinking place, away from the system.

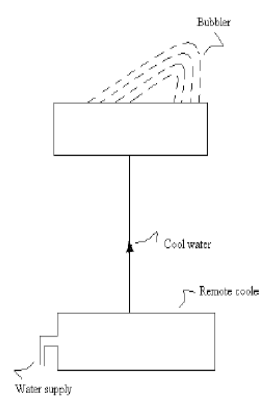


Fig.6 Self contained remote type cooler

This type of arrangement does not require extra space near the place of work and is quite useful.

3.2 Capacity of Water Coolers

The cooling load for the water cooler (Q) may be obtained from the following relation:

$Q=m_w c_p (T_i-T_o)$

Where

m_w= Rate of water consumption

c_p= Specific heat of water
T_i= Inlet temperature of water, and
T_o= Outlet temperature of water.

The amount of cold water requirements under various conditions is given. These figures are based on extensive statistical survey. The refrigerants such as ammonia, sulphur dioxide etc. are now-a-days not used because of safety reasons. Generally R-12, R22, R134a is the most common refrigerant and R-22 used as a refrigerants.
The amount of wastage of cold water should be included while estimating the amount of water consumption. Usually heavy insulation around 40mm to 60mm thick glass wool or thermocole is As per Government scenario 80 MT e-waste produced in INDIA due to Refrigerators, LED, LCD, Computers, Calculators etc. they mainly contain plastic, lead, cadmium, mercury, Green house gases e.g. CO2, Freon, R-22 gases.
They badly impact on environment and human health. So that it necessary to recycle this e-waste, dispose very carefully or modified old appliances and use it.

3.3. Problem Statement

Currently a day's cooler will be not a extravagance it need turn into and only prerequisites for each center Also bring down white collar class families. Those cooler will be used to store sustenance items, medicines, refreshments Furthermore such different materials. Those handy life for nourishments Furthermore different things could make protracted because of storing toward low temperatures. Those household's fridge will be likewise utilized to cool water and ice cubes. They are generally specified by the interior terrible volume and the profound freezers volume. An stockpiling temperature about 0^0C with 4^0C is acceptable for those protection about mossycup oak of the crisp nourishments. The reason for water cooler may be should make water accessible during An steady temperature regardless for encompassing temperature. They are intended to transform frosty water toward around 8^0C should 13^0C for quenching those thirst of the kin working for hot surroundings. The warm or typical water might serve the physical prerequisite of our framework to those fitting working of the form organs Yet it doesn't quench those thirst particularly to hot summers. Over available times large portions groups use cooler for both nourishment protection and water cooling. An example overview led uncovers that in A large number houses, those cooler entryway is every now and again opened barely will get those cool water bottles.
Because of this incessant opening of the fridge door, those encompassing hot air continues entering under the fridge lodge. It brings about those expansion of lodge temperature. To decrease the lodge temperature the compressor runs The majority of the occasion when. It prompts a greater amount force utilization. By seven or eight liters for water may be kept inside the fridge lodge to drinking end goal.
In we camwood keep the water outside those cooler cabin, those space spared might be used for keeping other results. Refrigerators made since 1965 What's more there is a considerable measure of transforms in the fridge early. There are different sorts from claiming model available, Yet On 21st century due to higher engineering these fridge gets to be old fashioned and the reusing expense of this fridge Additionally costly, Consequently it will be preferred on change this cooler Eventually Tom's perusing marginally do progressions in the fridge Also utilize. This Look into arrangements with the result of that of age cooler.
There need aid huge numbers refrigerators need aid accessible Previously, advertise for high tea. e.g. Water allocator for refrigerator, freezer, twofold entryway cooler ice maker, chilly water or boiling hot water gadget figure The following indicates the this high tea refrigerators with their cosset.

Fig. 7 Double door refrigerator

Fig.8 Double door refrigerator with water dispenser

From above figures we conclude that the cost of such appliance are very high , because of this middle class people cant buy this products. So its better to modify existing refrigerator. This research paper deal with the modification of the existing old refrigerator so that cost of that refrigerator decreases.

4. Experimental Setup

In the present work a domestic refrigerator is modified to serve both the purposes of refrigerator as well as water dispenser. Suitable design and operation conditions were made to save space, initial cost and maintenance cost. Those household fridge Also water allocator meets expectations on the vapor layering refrigeration framework.

Those provincial fridge is used to preserve the sustenance things also how. The water gadget will be used to cool water. This project concentrates should change those provincial cooler will serve both the purposes, Similarly as fridge Also likewise water gadget. In this changed cooler the water will be cooled will be put away in the tank altered outside the cabin, In those highest priority on the fridge.

Those water streams starting with the tank of the gatherer found The following the evaporator, through 10mm copper channel transport which wound around the evaporating loop. Henceforth the water inside the copper tube may be cooled Toward those refrigerant streaming through those evaporator channel accordance. Those cool water starting with the gatherer may be made out starting with the outside of the fridge entryway by utilizing a adaptable channel between those gatherer outlet and tap, which will be orchestrated outside the cooler entryway. In this plan those fridge is served as cooler and also water gadget.

In place with know the execution aspects of the vapor layering refrigerating framework the temperature and weight gauges would introduced at every passage What's more retreat of the part. Different sorts about instruments are likewise utilized in tube cutter - to slice the tubes, tube binge - on twist the copper tube of the obliged angle, bolt situated - on riveting procedure and welding gears - to joining procedure. At last the household fridge will be created Likewise for every the prerequisite of the one task.

4.1 Experimental Set up of Domestic Refrigerator

Domestic refrigerator selected for the project has the following specifications
Refrigerant used: R-134a
Capacity of The Refrigerator: 160 liters
Compressor capacity: 0.16 H.P.
Compressor
Length - 8.5 m
Diameter- 6.4 cms
Evaporator
Length - 7.62 m
Diameter- 6.4 cms
Capillary
Length - 2.428 m
Diameter- 0.8 mm

- By using drilling machine hole is create at the middle of the top of the refrigerator.
- To give support as well as to store the water at the top of refrigerator, the plastic or steel bowl or aluminium bowl size is selected : Diameter: 85mm Height: 105mm
- At the bottom of the the plastic or steel bowl or aluminium bowl 10 mm dia hole is produced by drilled machine to give connection to the water pipe which is wound around the refrigerator.
- Water from this bowl is move through the copper tube.
- To give support to the bowl at the top of the refrigerator four L plates welded at the bottom of the bowl.
- The water pipe is wound around the evaporating coil.
- A hole is made in the refrigerator door at convenient location to tap water.
- A tap is fitted to the door.
- A flexible pipe is connected between the accumulator and the tap.

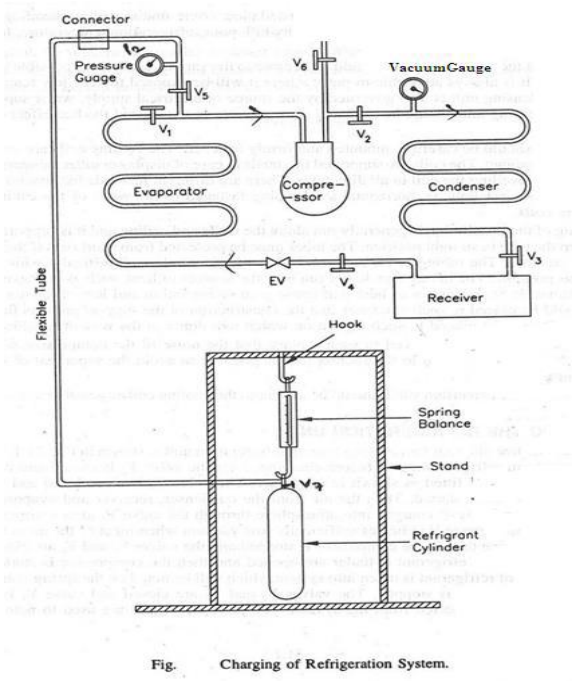


Fig 9 .Systematic line diagram for charging

The following procedure is adopted for experimental setup of the vapor compression refrigeration system

1. The domestic refrigerator is selected, working on vapor compression refrigeration system.
2. At the entry and exit of compressor pressure and temperature gauge are installed.
3. cleaning of the internal parts of the refrigerator is done by pressurized N_2 gas.
4. Refrigerant R134a is charged inside the refrigerator by using below process
5. It is ensure that all air inside the VCR system removed before charging of R134a refrigerant. First of all to installed vacuum pressure gauage, valve V_2 is closed and vacum pressure gauge installed as shown in above fig and at the same time the valve V_5 is closed and valves V_1, V_4, V_6 and V_3 are opened and now start the vacuum pump so that it removes the air from condenser receiver, evaporator the motor is started thus the air from the condenser receiver and evaporator is sucked through the valve V_1 and it is rejected to the atmosphere through the valve V_6 after compressing it in the compressor the vacuum gauge V indicates sufficiently low vacuum when all air inside the system is rejected to the atmoshere , pressure indicates vacuum pressure 72 to 76 cm of Hg.. If the vacuum is retained per above an hour it may be concluded that the system is free from the air. After vacuum cleaning the stop the compressor and valves V1 and V6 are closed, the valves V_5, V_2 and V_7 of the refrigerant cylinder are opened and then the compressor is started whenever the sufficient quantity of refrigerant is taken in to the system which will be noted in the pressure gauges. The compressor is stopped. The valves V_7 and V_5 are closed and valve V_1 is opened the refrigerant cylinder is disconnected from the system the pressure gauge is used to note the pressure during the charging the system.
6. by using soap solution leak detection test perform.
7. Now start the refrigerator and take reading after one hour at each pressure gauge and temperature gauge and record it.
8. the execution of the refrigerator calculated from pressure and temperature gauge which are held in the system then by using .p-h chart relation

5. Calculations

The various thermodynamic properties at state point of Domestic Refrigerator are as follows:

Temperature

Compression Suction Temperature in ^oc

T_1= 11^oc

Compression Discharge Temperature in ^oc

T_2= 52^oc

Condensing Temperature in ^oc

T_3= 43^oc

Evaporating Temperature in ^oc

T_4= -2^oc

Pressure

Compression Suction Pressure in bar

P_1=0.65 bar

Compression Discharge Pressure in bar

P_2=12.2bar

Condenser Pressure in bar

P_3=11.9 bar

Evaporator Pressure in bar P_4=0.78bar

Enthalpies

From Pressure-Enthalpy (p-h) chart for R-134a enthalpy values at state point 1,2,3,4 respectively. The state point are fixed by using Temperature and Pressure at each point:

h_1 = 250.2kj/kg

h_2 = 272.5 kj/kg

h_3 = 114 kj/kg

h_4 =114 kj/kg

6.1 Calculation Performance Parameters

1) Refrigerating Effect (R.E) =h_1-h_4 kj/kg

=250.2-114 kj/kg

= 136.2kj/kg

2) Mass flow rate to obtain One TR (kg/min) m_r

m_r= 210/ Refrigerant Effect kg/min

m_r= 210/ 136.2 kg/min

m_r= 1.54185 kg/min

3) Work of Compressionkj/kg =h_2-h_1

=272.5 –250.2 kj/kg

= 22.3kj/kg

4) Heat equivalent of work of compression per TR

=m_r * (h_2-h_1) kj/min

= 1.54185 * 22.3 kj/min

=34.383255 kj/min

5) Power consumed by the compressor (theoretically)

= m_r * (h_2-h_1) /60 kj/sec or kw

= 34.383255 / 60 kw

=0.573025 kW

6) Coefficient of Performance (COP)

=(h_1-h_4) / (h_2-h_1)

= (250.2-114)/(272.5-250.2)

=136.2 / 22.3

= 6.1076

7) Heat to be rejected in condenser

=h_2-h_3 kj/kg

=272.5 - 114

= 158.5kj/kg

8) Heat rejection per TR

= (210/ Refrigerant Effect) * (h_2-h_3) kj/min

=1.54185 * 158.5

= 244.3832 kj/min

RefrigeratorCum Water Dispenser

Temperature

Compression Suction Temperature in ^oc

T_1= 14^oc

Compression Discharge Temperature in ^oc

T_2= 57 ^oc

Condensing Temperature in ^oc

T_3= 46 ^oc

Evaporating Temperature in ^oc

T_4= 2 ^oc

Pressure

Compression Suction Pressure in bar

P_1=0.74 bar

Compression Discharge Pressure in bar

P_2=13.8 bar

Condenser Pressure in bar

P_3=13.3 bar

Evaporator Pressure in bar

P_4=0.88 bar

Enthalpies

From Pressure-Enthalpy (p-h) chart for R-134a enthalpy values at state point 1,2,3,4 respectively. The state point are fixed by using Temperature and Pressure at each point:

h_1 = 249.3 kj/kg

h_2 = 273 kj/kg

h_3 = 114.3 kj/kg

h_4 = 114.3 kj/kg

6.2 Calculation Performance Parameters

1) Refrigerating Effect (R.E) $=h_1-h_4$ kj/kg

=249.3 -114.3 kj/kg

= 135 kj/kg

2) Mass flow rate to obtain One TR (kg/min) m_r

m_r= 210/ Refrigerant Effect kg/min

m_r= 210/ 135 kg/min

m_r= 1.5555 kg/min

3) Work of Compressionkj/kg $=h_2-h_1$

= 273 – 249.3 kj/kg

= 23.7 kj/kg

4) Heat equivalent of work of compression per TR

$=m_r * (h_2-h_1)$ kj/kg

= 1.5555 * 23.7 kj/kg

= 36.86535 kj/kg

5) Power consumed by the compressor (theoretically)

$= m_r * (h_2-h_1) /60$ kj/sec or kw

= 36.86535 /60 kw

= 0.614422 kw

6) Coefficient of Performance (COP)

$=(h_1-h_4) / (h_2-h_1)$

= (249.3-114.3) / (273-249.3)

=135/23.7

=5.8960

7) Heat to be rejected in condenser

$=h_2-h_3$ kj/kg

= 273-114.3kj/kg

=158.7 kj/kg

8) Heat rejection per TR

= (210/ Refrigerant Effect) * (h_2-h_3) kj/min

=1.5555 * 158.7 = 246.8578 kj/min

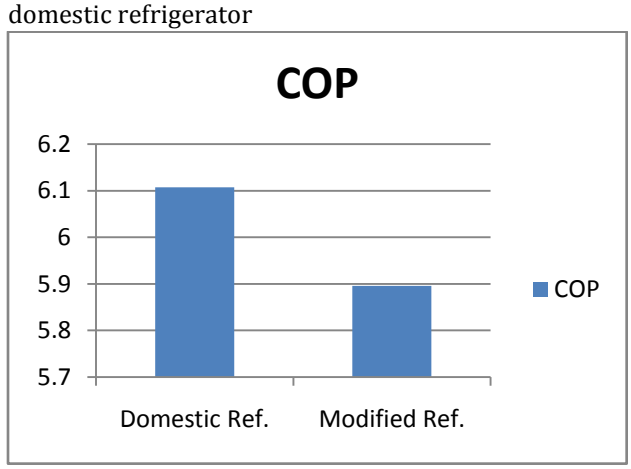
6. RESULTS

Experimental investigations are carried out on Refrigerator cum Water cooler and the results are compared with a domestic refrigerator and the following are the outcome for above investigation.

Table 1Comparison of Performance Parameters

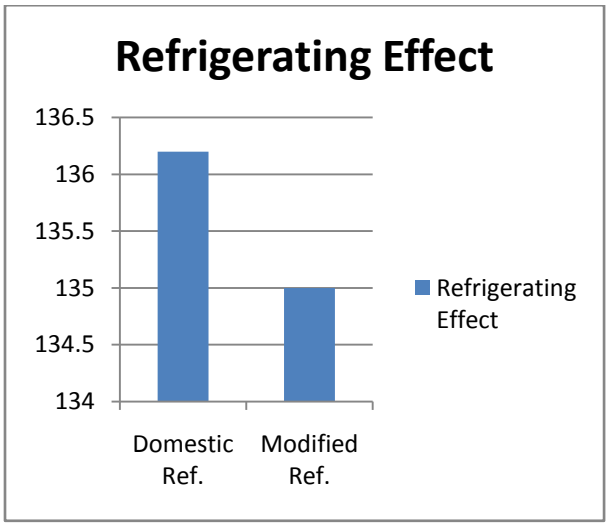
Sr no.	Performance Parameter	Domestic Ref.	Modified Ref.
1	COP	6.1076	5.8960
2	Refrigerating Effect	136.2 kJ/kg	135 kJ/kg
3	Compressor Power	0.5730 Kw	0.61442kW

1. The cop of the system is almost equivalent to domestic refrigerator



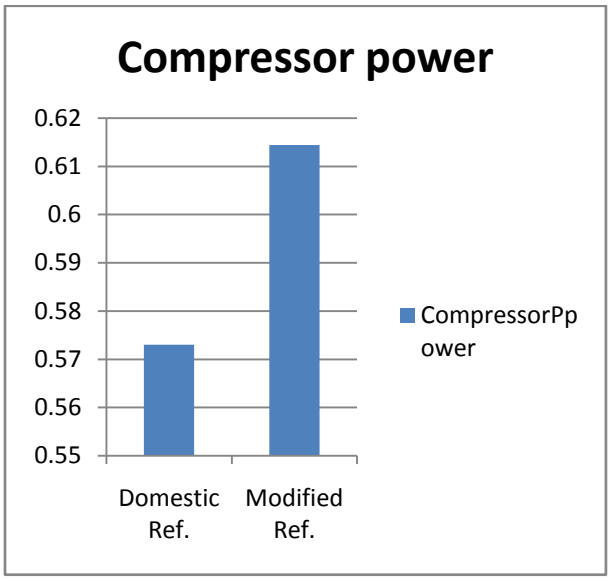
Graph 1. COP comparison

2. The net refrigeration effect of combined system is 24% less than the domestic refrigerator.



Graph 2. Refrigerating Effect comparison

3. The Power required to drive the compressor remains same.



Graph 3. Compressor power comparison

8. Conclusions

Refrigerator is generally used for storing foods , vegetables, milk etc. Refrigerator also used to store cold water , for that frequently open the door.

In the present work a refrigerator is modified such that we get cold water as well as storage of vegetables , foods etc.

It is found that a small modification saved power..

It is also found that the temperature inside the cabinet are not much changed and C.O.P of the system did not changed. It shows that chilled water is dispensed and even then COP is not changed means that system gives superior performance with this modification

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