Design and Development of Drinking Water Generator from Air

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Abstract— Water is the foundation of life. And even today, all around the world, far too many people spend their entire day searching for it. A person can survive without food for almost 50 days but only one week without water. 85% of the world population lives in the driest half of the planet. Clean, safe drinking water is scarce. Today, nearly 1 billion people in the developing world don't have access to it. The drinking water generator will comprise of the following parts. A double door refrigerator, a liquid pump, coolant, pipes, a filter, taps. The refrigerator will be used to cool the coolant which will flow through pipes and condense the water from air around it. This condensed water will then be filtered for to purify it and make it drinkable. The whole idea of creating this generator is to provide drinking water to households in remote areas where a pipeline system may not be feasible at the moment, besides the fact that electricity can be produced almost anywhere without the need of transmission from one place to another far away. The energy consumption will be as low as the normal running of a refrigerator. The aim of this project is to design and develop a water generator which can economically generate water which is potable especially in humid regions

Key words: Refrigeration, Condensation, Economical

I. INTRODUCTION

Water is the foundation of life. And even today, all around the world, far too many people spend their entire day searching for it. A person can survive without food for almost 50 days but only one week without water. 85% of the world population lives in the driest half of the planet. Clean, safe drinking water is scarce. Today, nearly 1 billion people in the developing world don't have access to it. The aim of this project is to design and develop a water generator which can economically generate water which is potable especially in humid regions. It condenses the atmospheric moisture and filters the condensed water to make it potable.

The mechanical design processed by definition defines a device that will carry out the specified task when appropriate inputs are given. In reality, however this definition provides a tunnel vision view into the world of design. Mechanical engineers who design consumer products have a twofold responsibility. In addition to designing functional machines, successful product designers must create devices that consumers will want to purchase and use while there are many possible factors that can make a product appealing to a buyer, perhaps the most important factor is an ability to make the user's life easier in some small way. In this way, product design is a service profession.

II. DIFFERENT TYPES

A. *Direct Cool Refrigerator*

Direct cool refrigerators are the most basic types where cooling within the fridge compartment is done without any fanning. The cooling is rather done by a natural convection where one part may become cooler than another area inside the compartment. However, these refrigerators are highly energy efficient for the same reason. This segment includes only few single-door refrigerators under it. Of late, some direct cool refrigerators have been featuring digital auto defrost technology to give you freedom from manual defrosting.

1) Advantages

- Cools with natural convection process inside the fridge
- Highly energy efficient
- Quite affordable from price point of view
- Efficient freezer chamber
- Latest models feature digital auto defrost technology

B. *Frost Free Refrigerator*

Almost all modern refrigerators except a very few basic ones are frost free refrigerators. These frost free models use electric fans to circulate cool air inside the chambers. This prevents formation of ice outside the freezer and enables even cooling of compartments. The end result also plays a part in ensuring long work life to refrigerator components. These models do not require you to manually defrost them from time to time. Moreover, frost free refrigerators are efficient at keeping a consistent temperature throughout the fridge cavity.

Frost free refrigerators can be further categorized as follows:

- Single Door Refrigerator
- Double Door Refrigerator
- Side-By-Side Refrigerator
- Bottom Mounted Refrigerator

III. REFRIGERATION AND REFRIGERATION CYCLES

Refrigeration is the process of removing heat from an enclosed space, or from a substance, and moving it to a place where it is unobjectionable. The primary purpose of refrigeration is lowering the temperature of the enclosed space or substance and then maintaining that lower temperature. The term cooling refers generally to any natural or artificial process by which heat is dissipated. The process of artificially producing extreme cold temperatures is referred to as cryogenics.

Cold is the absence of heat, hence in order to decrease a temperature, one "removes heat", rather than "adding cold." In order to satisfy the Second Law of Thermodynamics, some form of work must be performed to accomplish this. This work is traditionally done by mechanical work but can also be done by magnetism, laser or other means

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A. Methods of refrigeration

Methods of refrigeration can be classified as non-cyclic, cyclic and thermoelectric.

B. Non-cyclic refrigeration

In these methods, refrigeration can be accomplished by melting ice or by subliming dry ice. These methods are used for small-scale refrigeration such as in laboratories and workshops, or in portable coolers.

Ice owes its effectiveness as a cooling agent to its constant melting point of 0 °C (32 °F). In order to melt, ice must absorb 333.55 kJ/kg (approx. 144 Btu/lb) of heat. Foodstuffs maintained at this temperature or slightly above have an increased storage life. Solid carbon dioxide, known as dry ice, is used also as a refrigerant. Having no liquid phase at normal atmospheric pressure, it sublimes directly from the solid to vapor phase at a temperature of -78.5 °C (-109.3 °F). Dry ice is effective for maintaining products at low temperatures during the period of sublimation.

C. Cyclic refrigeration

This consists of a refrigeration cycle, where heat is removed from a low-temperature space or source and rejected to a high-temperature sink with the help of external work, and its inverse, the thermodynamic power cycle. In the power cycle, heat is supplied from a high-temperature source to the engine, part of the heat being used to produce work and the rest being rejected to a low-temperature sink. This satisfies the second law of thermodynamics.

A refrigeration cycle describes the changes that take place in the refrigerant as it alternately absorbs and rejects heat as it circulates through a refrigerator. It is also applied to HVACR work, when describing the "process" of refrigerant flow through an HVACR unit, whether it is a packaged or split system.

Heat naturally flows from hot to cold. Work is applied to cool a living space or storage volume by pumping heat from a lower temperature heat source into a higher temperature heat sink. Insulation is used to reduce the work and energy required to achieve and maintain a lower temperature in the cooled space. The operating principle of the refrigeration cycle was described mathematically by Sadi Carnot in 1824 as a heat engine.

The most common types of refrigeration systems use the reverse-Rankine vapor-compression refrigeration cycle although absorption heat pumps are used in a minority of applications.

1) Cyclic refrigeration can be classified as:

(1) Vapor cycle, and
(2) Gas cycle

2) Vapor cycle refrigeration can further be classified as:

(1) Vapor compression refrigeration
(2) Vapor absorption refrigeration

D. Vapor-compression cycle

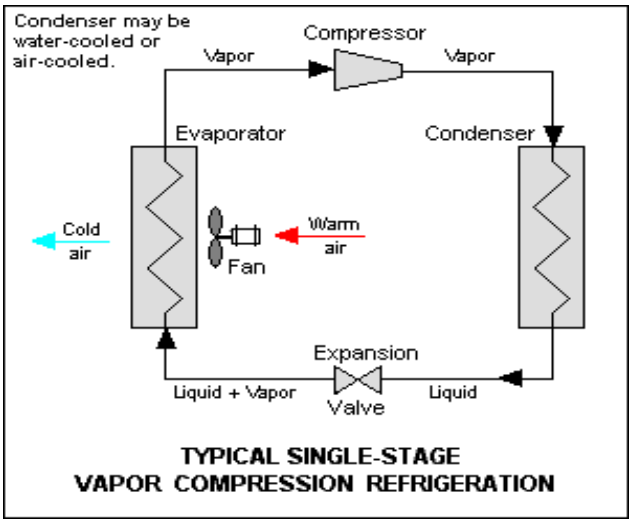

Fig.1

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There are six main components in a refrigeration system:

- The Condenser
- The Metering Device or expansion valve
- The Evaporator
- Piping material
- Refrigerant

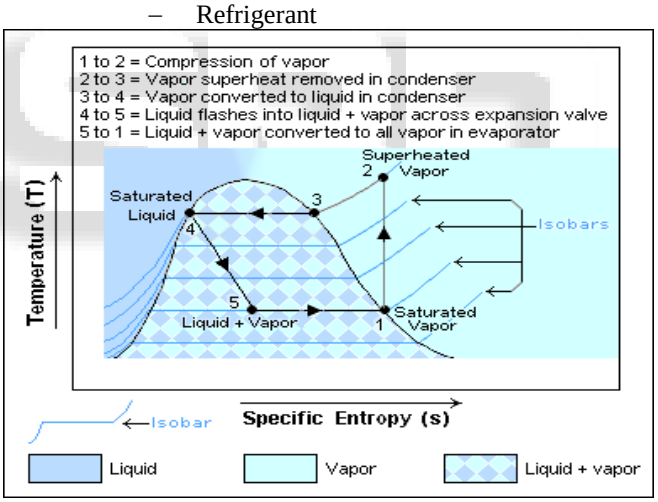

Fig. 2

E. Compressor

It is heart of the refrigeration system as it circulates the refrigerant in the system like the heart of a human being circulating the blood in the body.

- Two different pressures exist in the refrigeration cycle. The evaporator or low pressure, and the condenser, or high pressure.
- The inlet to the compressor is called the “Suction Line”. It brings the low pressure vapor into the compressor.
- After the compressor compresses the refrigerant into a high pressure Vapor, and the outlet of the compressor is called the “Discharge Line”.

There are three types of compressors namely reciprocating, rotary and centrifugal. The type of compressor depends on the pressure difference between the high pressure side (condenser) and low pressure side

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(evaporator) of the refrigeration system. This further depends on the refrigerant selected for the application under consideration.

F. Condenser

The "Discharge Line" leaves the compressor and runs to the inlet of the condenser. Because the refrigerant was compressed, it is a hot high pressure vapor. The hot vapor enters the condenser and starts to flow through the tubes. Cool air is blown across the out side of the finned tubes of the condenser (usually air by a fan or water with a pump). Since the air is cooler than the refrigerant, heat jumps from the tubing to the cooler air (energy goes from hot to cold – "latent heat"). As the heat is removed from the refrigerant, it reaches its "saturated temperature" and starts to change state, into a high pressure liquid. The high pressure liquid leaves the condenser through the "liquid line" and travels to the "metering device" through a filter dryer to remove any dirt or foreign particles.

G. Expansion Device

- Metering devices regulate how much liquid refrigerant enters the evaporator as per heat load on evaporator.
- Common used metering devices are, small thin copper tubes referred to as "capillary tubes", thermally controller diaphragm valves" (thermostatic expansion valves, called "TXV's. This valve has the capability of controlling the refrigerant flow. If the load on the evaporator changes, the valve can respond to the change and increase or decrease the flow accordingly.

IV. METHODS USED

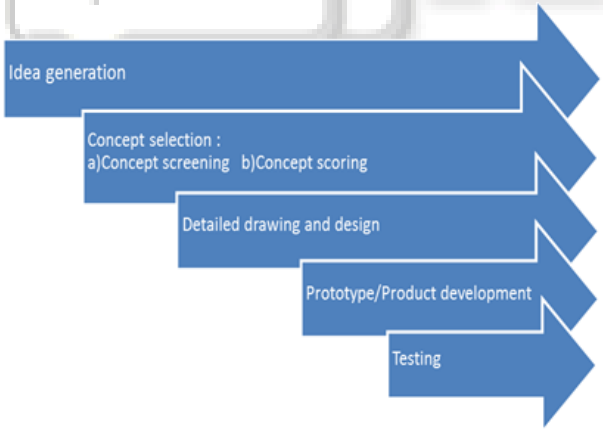

Fig. 3

V. WORKING

This concept involves the use of cold alcohol mixture flowing through the copper helical pipes.

The components used in this concept are:

- Refrigerator
- Container which is made to hold the coolant
- Copper helical pipe
- Pump
- Collection tray
- Filter
- 2 plastic tubes.
- Alcohol mixture

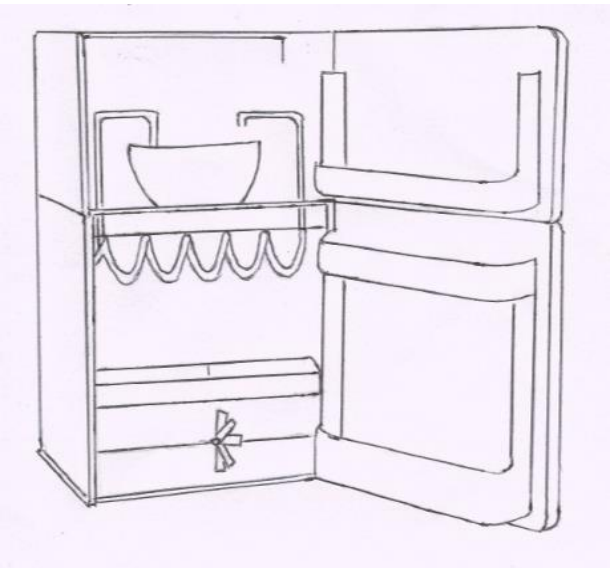

Fig. 4: Prototype Design

VI. CONSTRUCTION:

The container containing the alcohol mixture is kept in the freezer of the refrigerator. The pump is also present in the container. Two holes are made at each extreme end of the refrigerator freezer compartment bottom. The plastic tubes are passed through these holes. One end of 1 of the plastic pipe is connected to the pump and the other to the horizontally placed copper helical pipe. The other plastic pipe is connected to the other end of the copper helical tube and its other end is left free in the container of the water kept in the freezer. The helical copper pipe is placed horizontally in the bottom compartment of the refrigerator. The collection tray is placed below it along with the filter.

VII. WORKING:

The freezer cools the alcohol mixture which is present in the container. The pump is made to run once the alcohol mixture is cool enough before the alcohol mixture freezes though the plastic pipes and then though the vertically placed helical copper pipes. The alcohol mixture finally enters back into the container though the other plastic pipe. The cooling of the copper pipes causes atmospheric moisture to condense on the copper pipes as the pipe is below the dew drop temperature of the atmospheric humidity. The water that is condensed around the copper pipes finally accumulates and hence causes it to form drops. These drops ultimately fall into the collection tray which is placed below and then filtered.

A. Advantages:

- Water generated
- Easy construction
- Easy to collect water droplets
- Alcohol mixture has lower freezing point and hence does not freeze in the pipes
- Alcohol mixture cools faster

B. Disadvantages:

- Alcohol tends to evaporate
- Less efficient fridge

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– Climatic condition

Fig. 5

VIII. DEW POINT

The dew point is the temperature at which the water vapor in a sample of air at constant barometric pressure condenses into liquid water at the same rate at which it condensed water is called dew when it forms on a solid surface.

A. Formulae's:-

B=(ln(RH/100)+((17.27*T)/(237.3+T)))/17.27
D=(237.3*B)/(1-B)
T=Air temperature (dry bulb) in ^{0} C
RH=Relative Humidity in %
B=Intermediate value
D=Dew point in ^{0} C

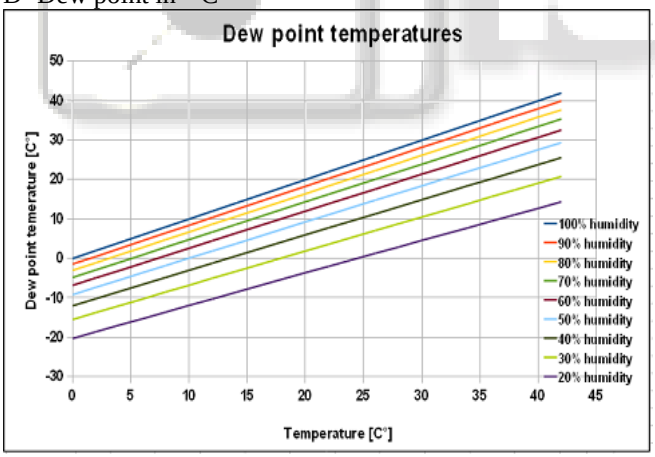

Fig. 6

Graph showing relationship between Dew point temperatures, Humidity & Temperature

B. Result

Sl No.	Humidity	Temperature	Dew Point Temperature	Amount of water generated in 12 hours(Litres)
		(ºC)	**(ºC)**	
1	100%	30-36	29.9-35.9	0.7
2	100%	25-29	24.99-28.7	0.8
3	100%	26-31	25.7-30.8	1.4
4	100%	30-35	29.9-34.9	0.85
5	100%	23-28	22.8-27.8	1.2

IX. FUTURE SCOPE

– Condensing loops and the fridge are both less efficient than expected, future design will include spending significant time for testing of various coolants and coil design for improvement of the product.
– The use of this product is limited to generating water and filtering it to make it potable. However, the operating cost can be reduced in the future by using solar energy.

REFERENCE

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