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Vacuum Pressure Powered Cooling System

Implementation, Testing, Future Scope and Enhancements

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Abstract—**This paper presents the description and operation of a vacuum pump driven with a motor to cool a specified space by creating vacuum and with the help of zeolite .This idea is simple and also expected to be effective, since, the hybrid system of vacuum pump and refrigerator will be able to satisfy the cooling needs, thereby increasing the total efficiency of the system. Although this device is designed just for cooling a specified space, it can be applied to many energy saving fields such as air conditioning in car or house, and in the exhaust gas-driven air conditioning. Such a novel concept of energy utilization would also contribute to more efficient methods for sustainable development.**

Index Terms-- Zeolite, Vaccum gauge, Digital temperature sensor, Vaccum pump, Vaccum ball valves

INTRODUCTION

The refrigerator resides in the corner of your kitchen, quietly plugging away day in and day out. It keeps your ice cream at a freezing point and your carrots crisp and may possibly be the least understood mechanism in your home. The refrigeration cycle is an engineering feat of immense proportion. It is the cycle of a chemical whose boiling point is relatively low to constantly change from a liquid to a gas, alternately giving off heat and absorbing it depending on where it is in the system. The way the system is set up determines if the cycle will heat your home on a wintry day, cool your car in the heat of summer, or keep your favorite flavor of yogurt good all year round.

In today’s scenario there are so many refrigerants used in refrigerators for increasing their efficiency like ammonia, sulphur dioxide etc. These refrigerants are highly toxic to the environment as well as to human health also. This is a issue of growing concern for the present day environment is the impact of the various refrigerants on the ozone depletion and global warming of the environment. The main culprits in this case are the chlorine containing halogenated hydrocarbons, commonly known as CFC or chlorofluorocarbons which are being used as refrigerants.

For overcoming this disadvantage of these refrigerators we proposed an idea of cooling from the principle of relation between temperature and vapor pressure of water. Hence it is given the name of “Vacuum Pressure Power Cooling System”. It does not release toxic gases since in our project we have used water in place of refrigerant.

The ice box is connected to zeolite and vacuum pump through pipes. The vacuum pump is oil sealed rotary high vacuum pump which is derived from half horse power motor. A vacuum pressure gauge is attached to the pipe in between the ice box and the vacuum pump to note the vacuum pressure of the water container.

Also two stop valves are fixed out of which the stop valve near zeolite is closed when the stop valve near the vacuum pump is open. And the vice versa happens further in the process when the pump is closed.

PRINCIPLE

When we pump out gases from the water box in the refrigerator by a pump, we create low pressure area inside the box, due to this low pressure, water starts evaporating, and for that evaporation it needs heat from the surrounding which is our refrigerator. In that way it cools our refrigerator.Steam is generated in the process of evaporation which later been absorbed by Zeolite. Absorption of steam is a property of zeolite that's why we use it in this experiment.

WHAT ARE ZEOLITES ?

Zeolites are microporous, alumino-silicate minerals commonly used as commercial adsorbents.An example mineral formula is: $Na2Al2Si3O10·2H2O$, the formula for natrolite.The major producers in 2010 were China, South Korea, Japan , Jordan , Turkey ,Slovakia and United States. The ready availability of zeolite-rich rock at low cost and the shortage of competing minerals and rocks are probably the most important factors for its large-scale use.

Advantages of Zeolites:

1) It removes the hardness almost completely.
2) The equipment used is compact, occupying a small space.
3) The process automatically adjusts itself for variation in hardness of water.
4) It requires less time for softening.

Disadvantages of Zeolite process:

1) The outgoing water (treated water) contains more sodium salts.
2) The method only replaces Ca^{2+} and Mg^{2+} ions by Na^{+} ions.
3) High turbidity water cannot be softened efficiently by Zeolite process.

COMPONENT DETAILS

Vacuum Pump:

Vacuum pumps are used to reduce the gas pressure in a certain volume and thus the gas density. Consequently consider the gas particles need to be removed from the volume. Basically differentiation is made between two classes of vacuum pumps:

a) Vacuum pumps where – via one or several compression stages – the gas particles are removed from the volume which is to be pumped and ejected into the atmosphere (compression pumps). The gas particles are pumped by means of displacement or pulse transfer.

b) Vacuum pumps where the gas particles which are to be removed condense on or are bonded by other means (e.g. chemically) to a solid surface, which often is part of the boundary forming volume itself

Vacuum Oil:

The suitable pump fluids for oil diffusion pumps are mineral oils, siliconeoils, and oils based on the polyphenyl ethers. Severe demands are placed on such oils which are met only by special fluids. The properties of these, such as vapor pressure, thermal and chemical resistance, particularly against air, determine the choice of oil to be used in a given type of pump or to attain a given ultimate vacuum. The vapor pressure of the oils used in vapor pumps is lower than that of mercury. Organic pump fluids are more sensitive in operation than mercury, because the oils can be decomposed by long-term admission of air.

Vacuum gauge:

BOURDON Vacuum Gauge:

The inside of a tube which is bent into a circular arc (the so-called Bourdon tube) is connected to the vacuum system. Due to the effect of the external atmospheric pressure, the end of the tube bends more or less during the evacuation process. This actuates the pointer arrangement which is attached to this point. The corresponding pressure can be read off on a linear scale. With Bourdon gauges it is possible to roughly determine pressures between 10 mbar (7.5 Torr) and atmospheric pressure.

Vaccum Hose Clamps:

Re-usable Stainless Steel Clamps with Worm Drive Mechanism.

Features:

- Lightweight compact design
- Stainless Steel construction
- Reusable! Allows for attach/re-attach
- Installation requires a screwdriver or hex head wrench
- High sealing pressure with only 10-15 in/lb of torque.

Vacuum Hose Barb Fittings:

Construction:

- All fitting threads meet Dry Seal Standards
- Made from CA 360 and CA 345 brass
- Top quality Electro-Less Nickel Plated Finish
- Meet functional requirements of SAE J512, ASME and ASA
- NPT or metric sizes available
- Precision Machined

Applications:

Vacuum hose barb plated fittings have been designed for vacuum or medium pressure line connections and are used in conjunction with wire reinforced vacuum hose and worm gear drive hose clamps.

Specifications:

- Max. Pressure: 1000 psi
- Vacuum: 30 in. Hg
- Temperature: -65° to 250° F

Vented Ball Valves with Locking Handles:

Features:

- Ball Valves are Vented for easy manual vacuum release
- Forged body design, extends the life of the ball valve
- Optimum flow design. Blow-out proof stem
- Now supplied with a Locking Handle for added safety
- Nickel Plated with a Chrome Plated appearance
- More economical and compact than 3-way valves

Specifications:

- Max. Pressure: 250 psi
- Max. Vacuum: 29 in. Hg
- Temperature: 0° to 250° F (-18° to 121° C

Sealed Tape:

Poly tetra fluoro ethylene (PTFE) Thread Seal Tape is made of virgin white PTFE. Economy-grade, low density tape. Provides a clean, positive seal on threaded connections. PTFE Thread Seal Tape is an all purpose thread sealing tape and can be used with plastic, brass, copper, aluminum, galvanized steel or black iron piping. Nonflammable.

Digital Temperature Sensor:

This is the latest DS18B20 1-Wire digital temperature sensor from Maxim IC. Reports degrees C with 9 to 12-bit precision, -55C to 125C (+/-0.5C). Each sensor has a unique 64-Bit Serial number etched into it - allows for a huge number of sensors to be used on one data bus. This is a wonderful part that is the corner stone of many data-logging and temperature control projects.

WORKING

The refrigerator works by creating a vacuum in a system of 2 chambers to drive a thermodynamic reaction (boiling of water) at room temperature. The lowering in vapor pressure of the water drives the water to boil. In order to do this, the

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water must capture heat from a system (the inside space of refrigerator. The continued pumping of air by the pump (which drives the vacuum pump down to 10^-2 atm) will ensure that the water freezes as it continues to boil. After only 10 minute of pumping, the valve to the vacuum pump can be shut off, and the zeolite container line opened.

Zeolite are common absorbers based on aluminium silicates and will swell up to 30% its mass with water. The zeolite then absorbs the vapor produced by the boiling of the water, and in order for the liquid water to remain in equilibrium with the vapor phase, it must continue to boil (for up to a day).

In general, one can achieve constant temperatures of 0-6 celsius for one day with only 10 minute of pumping. Now this is a real way to cool for cheap. Even ice cubes can be made, and one cool advantage of this system is that the hotter it is outside, the more cold you can generate inside.

CALCULATIONS

Once it was decided that the conventional refrigerator would be built, the group then had to find a number of calculations to determine how large the refrigerator could be built. The first of these was the Co-Efficient of Performance. The equation used to find the Co-Efficient of Performance is:

$$\frac{\textbf{Refrigeration Effect}}{\textbf{Work Input}}$$

This equation was necessary so that we could find how much work input was needed to get the area within the refrigerator from room temperature to thirty degrees Fahrenheit. To do this it was decided that a modified equation for the Co-Efficient of Performance would be used.

The equation was the following:

$$\frac{1}{\frac{\text{room temp}}{\text{desired temp}} - 1}$$

It was found that if a refrigerator was to have a forty degree difference from a room temperature at seventy degrees Fahrenheit to an inside temperature of thirty degrees Fahrenheit, a Co-Efficient of Performance of 3.8 would be achieved. Once the Co-Efficient of Performance was found, it was then possible to apply the information to Fourier's Law of Heat Conduction. This would give us the size of our refrigerator.

Fourier's Law of Heat Conduction is:

$$\frac{\textbf{Heat Flow (BTU's/hr.)}}{\textbf{Unit Area (Sq. Ft.)}} \qquad \frac{\textbf{K (DT)}}{\textbf{B}}$$

The Heat Flow for this particular equation is the amount of energy created by a human exercising lightly for one hour. With the aid of the biomedical engineering department, it was discovered that a person exercising lightly creates between 1,000-2,000 BTU's/hr (British Thermal Units). The group decided on 1500 BTU's/hr, as a n approximation. K stands for the thermal conductivity of the chosen material desired for the construction of the refrigerator, which was a two inch Styrofoam with a R-value of ten. DT is the change in temperature between room temperature and the desired temperature within the refrigerator. For this refrigerator there was a 3-3 desired forty degree change. Finally, B is the thickness of the insulation on the refrigerator, and Unit Area is the variable that is needed, or in other words, the largest space that could be cooled to forty degrees in an hour going at a constant rate of 1500 BTU's per hour in a perfect refrigeration cycle. When all these factors are plugged in, the equation looks like this:

$$\frac{1500\ \text{(BTU's/hr.)}}{\text{Unit Area (Sq. Ft.)}} = \frac{0.0.2\ (40)}{1/6}$$

The end result was that we could build a refrigerator with 31.25 Sq. Ft. of space. It was then decided that we would build a refrigerator with one cubic foot of space inside, or six Sq. Ft. of space.

TESTING

When construction of the refrigerator was complete, testing commenced. The refrigerator lowered five degrees in approximately 20 minutes. The refrigerator started at thirty five degree Celsius and it was lowered to thirty degrees Celsius. After the temperature was lowered to thirty degrees, however, the refrigerator temperature quit cooling. Because the temperature leveled off, the pressure was checked. When that was done, it was found that the whole system had been de-pressurized; a leak was somewhere in the system. So, once again testing was delayed while we attempted to find the leak and seal it.

Although the refrigerator has only been tested once, and there was only a small amount of cooling involved before the refrigerator system de-pressurized. Testing was continued to the best of our abilities until the end to see what improvements can be made to our system to make it more efficient.

RESULT AND CONCLUSION

Three weeks ago, this group set off to build a human-powered refrigerator. Without knowing how a refrigerator works, or how we would get one to work, we struggled over one obstacle after another to come to the end, where a fully functional human-powered refrigerator lay at our feet. As a result of all our hard work, we made certain discoveries. We found that our finished product, though fully functional, was not efficient. We did lower the temperature inside our refrigerator, but it was only several degrees below room temperature. This was evidence of the difference between the ideal scenario found in Fourier's Law and reality, with complications including leaks and friction. Regardless, we view our project as a success. Though it is not efficient, our refrigerator still works and can lower the temperature of the air within it. In addition, the project proved to be very educational, both in conceptual and practical knowledge.

All members of the group were ignorant as to the processes of the refrigeration cycle prior to this project and all leave well versed in what goes on inside a refrigerator. It is for this reason that this project can be classified as a success.

FUTURE SCOPE AND APPLICATION

As there is nothing which can be said to be perfect, with the advancement in technology, more and more can be expected from it. There are some advancements which can be done in this project in near future.

Future Scope

Using the proposed technology, we can enhance the use of conventional refrigerators by removing use of refrigerants from it and hence making it environment friendly. Connections of the project are not very complex as the unit is designed to perform operations just by a single pump and only two valves being used. In the near future, the proposed technology has its scope in various fields like Air conditioning, Refrigeration and cooling places etc.

Applications

Conventional Refrigeration technology is gaining popularity in almost every area that utilizes smart machines. This project has a wide variety of applications like:
Ideal for short-term storage of

- Fruit,
- Vegetable,
- Medicines V
- Vaccines, Beverage bottles, etc.

Also, the proposed technology can be made human powered. It can be used in automobile and houses as air conditioner also to cool it.

FUTURE ENHANCEMENTS

Although the project does the required work it should do, it is still left with so many things to do. The ideas which are left to be implemented are as follows:

- The pump could have been driven by pedaling a bicycle i.e it can be made human powered by using a simple bicycle.
- Dunlop pipes could have been used in place of gas pipes used to avoid leakage occurring, due to which the temperature achieving rate is slow.
- Could work with solar energy driven motor, if needed.
- Could have been operated without electric or motor power.

REFERENCES

Book References:

S. No	Book	Author	Publication
1	A Textbook Of Refrigeration And Air & Conditioning	R. S. Khurmi J. K. Gupta	S. Chand
2	Textbook of Refrigeration and Air-Conditioning	R.K Rajput	S.K Kataria & Sons
3	Steam Table	M.L. Mathur	Jain Brothers

Website References:

- www.google.com
- www.youtube.com
- www.iprojecthome.blogspot.in
- http://makezine.com