ISSN 2278-7763

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Research Project Report:

Green Refrigeration

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ISSN 2278-7763

Abstract:

It works on two principles, First, on acoustics and second on thermodynamics i.e. It transfers heat by using oscillations of the sound waves produced.

Today's refrigerators works on the vapor compression cycle which uses a compressor, condenser, an expansion valve and an evaporator. It uses CFC's or ammonia as its refrigerants. To avoid the pollution created by this refrigerator's residue, a new innovation is needed with the better efficiency. Thermo acoustic refrigerator is an effective example of the same.

It produces sound waves of nearly 190 decibels using any mechanical vibrator or any piezoelectric material. An acoustic shield is provided to prevent such high decibel sound affecting the human ear. With the use of a stack (that is some closely spaced metal plates, as they have a higher capacity to store heat compared to air) ,a temperature gradient is created that helps in heat exchanger with the refrigerated space using heat , that ultimately provides cooling effect in the refrigerated space.

It is effective in reducing the pollution created by normal refrigerators since this refrigerator consists of some gas such as helium or xenon that is eco-friendly gas. It is better also because it has no moving parts in it that undergoes any wear or tear. Such refrigerator is highly efficient in micro chips manufacturing and working as they show better efficiency at low temperature.

Due to these advantages thermo acoustic refrigerator can prove to a better alternative for the normal refrigerators in near future.

ISSN 2278-7763

Principle:

The principle of thermo acoustic refrigeration is based on two major aspects, one is thermodynamics and the other one is acoustics.

Reason of Paper Work:

. The main reasons are:

1. It uses Helium Gas which is inert in nature and easily dissipated in atmosphere without creating pollution.
2. It doesn't contain any moving parts thus it doesn't undergoes any wear and tear thus having better long term efficiency.

Details of my Paper:

Principle:

The principle of thermo acoustic refrigeration is based on two major aspects, one is thermodynamics and the other one is acoustics.

Construction:

The parts of thermo acoustic refrigerator are:

1. Mechanical vibrator
2. Resonator tube
3. Stack
4. Heat Exchangers
5. Working gas (Helium)
6. Acoustic shield

Mechanical Vibrator:

It uses a piezoelectric transducer or a speaker that converts electrical energy into mechanical vibrations that produces ultrasonic waves. It produces nearly 190 decibels sound energy which will be helpful in obtaining the operating pressure of thermo acoustic refrigerator i.e. nearly 150psi.

Resonator tube:

Ultrasonic waves generated by the mechanical vibrator passes through the resonator tube. One end of the resonator tube is closed while the other end is attached to the mechanical vibrator. It contains a working gas mainly helium.

Three main aspects are to be taken into consideration while constructing a Resonator tube:

- Mechanics
- Acoustics and
- Heat transfer.

As high pressure is created inside the resonator tube the prime requirement is to use a material that can resist high pressure and so it should have a high impedance. Higher density refers to high impedance. Metals have high density

ISSN 2278-7763

but as they have higher thermal conductivity (0.19 W/m-K) they cannot be used as a resonator tube. The material to be used must be light in weight and also it must be cost effective. Taking into consideration all the above aspects, PVC is found to be a good alternative as it can be machined easily. The main drawback is that it is not acoustically resonant. Also we use an acoustic shield to prevent such high decibel noise get into human ear as it is unbearable. Length of the resonator tube should be of quarter wavelength taking into account the formation of standing wave pattern and interference.

Stack:

Stack is an array of closely spaced flat plates. Design of stacks involves square pores formed by an array of square parallel channels, having low thermal conductivity as it has to produce high temperature gradient. Also it should have a higher heat capacity than the working gas.

In order to fulfill these requirements ceramics and plastics are used but as the machinability of ceramics is poor due to their brittle nature plastics are significantly used. Also, it is cost effective. The pore size should be such that the stack and working gas can easily transfer heat. Pore size should be as small as possible to allow maximum possible thermal penetration. Since small pores have greater surface area, thermal as well as viscous losses increases which can be neglected.

At both ends of the stack heat exchangers are attached. One on the cold side is called cold heat exchanger and one on the other side is called hot heat exchanger.

Heat Exchangers:

Heat exchangers are mainly used to exchange heat between two fluids without any direct contact between them.

Two heat exchangers are used in thermo acoustic refrigerator which are attached to the two ends of the stack. The main purpose of thermo acoustic refrigerator is obtained with the help of heat exchanger.

- **Cold heat exchanger**:
  It is attached to the cold end of the stack. It contains a working fluid that absorbs heat from the refrigerated space and transfers it to the cold side of the stack.
- **Hot heat exchanger:**

It is attached to the hot end of the stack. It contains a working fluid that absorbs heat from the hot end of the stack and transfers it to the outside atmosphere. The axial length of the hot heat exchanger should be twice of the acoustic displacement amplitude so that the gas parcels having maximum energy come in contact with the stack can transfer its energy to the heat exchanger. Heat exchanger are kept in serpentine pattern in order to exchange more heat due to increased surface area. Heat exchangers are mainly made

ISSN 2278-7763

up of copper tubes because of its higher thermal conductivity.

Working gas:

Working gas used in thermo acoustic refrigerator should be inert in nature, as it should react with the material of the stack, heat exchanger or resonator tube. Also inert nature of the working gas makes the Thermo acoustic Refrigerator pollution free and better than that of the present Refrigerators which uses CFC and ammonia gas, when released in atmosphere causes pollution and adds to the 'Green House Effect . Also as Helium gas have higher heat conductivity it is used as a working gas as the main purpose of working gas is the transfer of Heat from hot region to cold region and from cold region to hot.

Acoustic Shield:

Acoustic Shield is an important parameter in Thermo Acoustic Refrigerator because the sound produced by this refrigerator is of the order of 190 decibels which is harmful for human ear. Thus Acoustic Shield insulates the refrigerator from the surrounding atmosphere.

Material mainly used as an acoustic shield is sintered boron with silicon fluid filled in the pores.

Working:

Working of Thermo acoustic refrigerator begins with the generation of sound waves by mechanical vibrator it produces vibrations in the helium gas thus molecules of helium gas starts vibrating. As sound waves propagates it causes pressure differences in the Resonator tube thus results in temperature differences which is the prime requirement for refrigeration. Length of the Resonator tube is equal to the quarter wavelength thus at the point near the mechanical vibrator there is velocity node and pressure anti-node at the same time at the closed end of the resonator tube there is pressure node and velocity anti-node thus at the end near the mechanical vibrator the temperature is higher and the closed end is at low temperature. Thus two sides of the Stack one is hot and other is cold. Stack has the property to store heat due to higher heat capacity of the material this helps in creating temperature gradient between two ends of the stack. Heat exchanger are attached to the two ends of the stack heat hot heat exchanger on the hot side of the stack and cold heat exchanger on the cold side of the stack. Cold heat exchanger is kept in the refrigerated space, thus it absorbs heat from refrigerated space and hot heat exchanger releases heat in the atmosphere.

ISSN 2278-7763

Conclusion:

After doing this Research project I realized that there is better green way of refrigeration which gives Carnot efficiency similar or more than current refrigerators. So now it is time to adopt new, eco-friendly and better way of refrigeration.

