APPLICATION OF THERMOACOUSTIC EFFECT TO COOLING OF AIR USING ACOUSTIC WAVES

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ABSTRACT

The present world is facing greater difficulties in solving the problems that is created due the advancement in science and technology which is not at all good for our environment and our atmosphere. The basic objective of this project is to provide the alternative method with regard to the present working methods which are harmful to all in one way or the other. The process behind this project is the compression of the working fluid (atmospheric air) by the application of high frequency sine waves that results in the generation of thermal energy. Generation of the sine waves involves the use of an acoustic driver coupled to a resonator with a heat exchanger embedded into it. Using sine wave generator, a standing sine wave is generated. This project makes use of the thermoacoustic effect to produce thermal radiation. Thus at the end simultaneous cold and hot air are obtained by transfer of the heat from the cold region to hotter region. The entire aspiration of this project is to promote an environmental friendly and a cost effective method for cooling of air.

Keywords: *Thermoacoustic Effect, Refrigeration, Acoustic Waves*

1.INTRODUCTION

The Thermo-Acoustic effect is one of the most effective and feasible concepts, relating to the use of a mechanical system for achieving cooling effect. The recent developments in the field of Thermo-Acoustics promise to revolutionize the way that many machines currently operate. By manipulating the temperature changes along the acoustic longitudinal waves, a machine can be created that can replace current refrigeration and air conditioning devices. These machines can be integrated into refrigerators, home generators, hot water heaters and coolers. The Thermo-Acoustics devices contain no adverse chemicals or environmentally unsafe elements that are characteristics of the current refrigeration systems.

1.1 THERMO-ACOUSTIC REFRIGERATION

The process of refrigeration means the cooling of desired space and maintaining the temperature below the ambient temperature. Acoustics deals with study of sound production, transmission, and effects. Thermoacoustic deals with thermal effects of the sound waves and the inter conversion of sound energy and heat. Sound waves travel in a longitudinal fashion. They travel with successive compression and rarefaction of the medium in which they travel. This compression and expansion respectively lead to the heating and cooling of the gas. This principle is employed to bring about the refrigeration effect in a thermoacoustic refrigerator.

2. OBJECTIVE

Generally the proposed thermoacoustic refrigerators by previous encounters resulted in the use of helium which is an inert gas for accelerated cooling process. Though it may be harmless the original purpose of eliminating the use of a working medium is not achieved. Therefore, this project aims to provide cooling effect without the use of any external applicants; mainly gases, thereby achieving refrigeration with the use of atmospheric air alone. Moreover, the use of cost effective materials and comprising of non moving parts proving the economic viability of the refrigerator. This project makes use of efficient parts that are easily available, also specialized modifications of a heat exchanger to provide enhanced cooling which was not used elsewhere.

3. EXPERIMENTAL SETUP

Thermo acoustic refrigerator is a special kind of device that uses energy of sound waves or acoustic energy to pump heat from low temperature reservoir to a high temperature reservoir.

The source of acoustic energy is called the "driver" which can be a loudspeaker. The driver emits sound waves in a long hollow tube filled with gas at high pressure.

This long hollow tube is called as resonance tube or simply resonator. The frequency of the driver and the length of the resonator are chosen so as to get a standing sound wave in the resonator.

A solid porous material like a stack of parallel plates is kept in the path of sound waves in the resonator. Due to thermo acoustic effect (which will be explained in detail in the animation), heat starts to flow from one end of stack to the other.

One end starts to heat up while other starts to cool down. By controlling temperature of hot side of stack (by removing heat by means of a heat exchanger), the cold end of stack can be made to cool down to lower and lower temperatures.

A refrigeration load can then be applied at the cold end by means of a heat exchanger. Thermo acoustics combines the branches of acoustics and thermodynamics together to move heat by using sound.

While acoustics is primarily concerned with the macroscopic effects of sound transfer like coupled pressure and motion oscillations, thermo acoustics focuses on the microscopic temperature oscillations that accompany these pressure changes.

Thermo acoustics takes advantage of these pressure oscillations to move heat on a macroscopic level. This results in a large temperature difference between the hot and cold sides of the device and causes refrigeration.

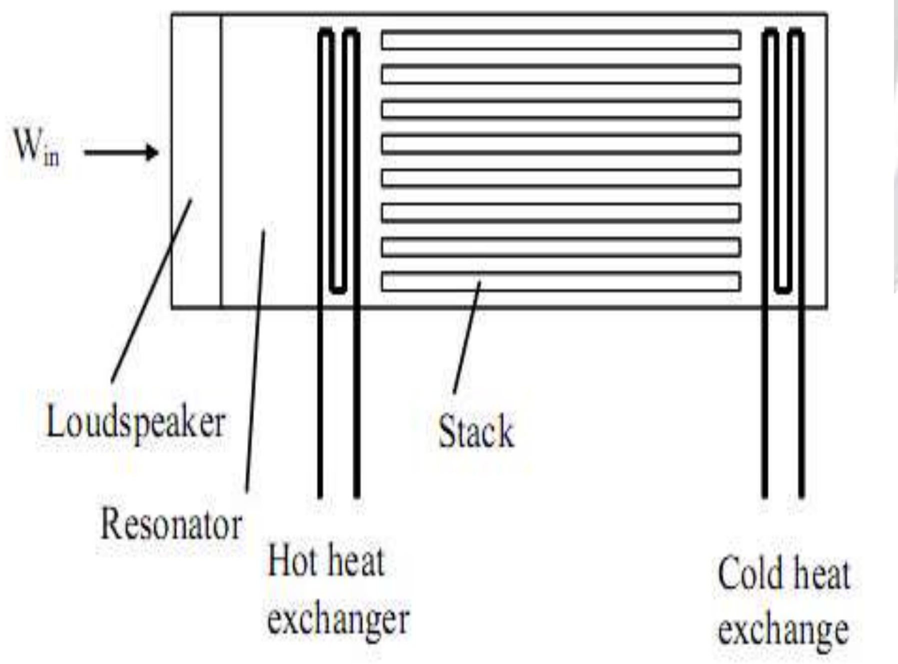

Fig.1. The basic construction of Thermo -Acoustic refrigeration system

4. RESULT AND DISCUSSIONS

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The most important piece of a thermo acoustic device is the stack. The stack consists of a large number of closely spaced surfaces that are aligned parallel to the to the resonator tube.

The purpose of the stack is to provide a medium for heat transfer as the sound wave oscillates through the resonator tube. A functional cross section of the stack we used. In typical standing wave devices, the temperature differences occur over too small of an area to be noticeable.

The stack consists of a large number of closely spaced surfaces that are aligned parallel to the to the resonator tube.

If the holes are too narrow, the stack will be difficult to fabricate, and the viscous properties of the air will make it difficult to transmit sound through the stack. If the walls are far apart then less air will be able to transfer.

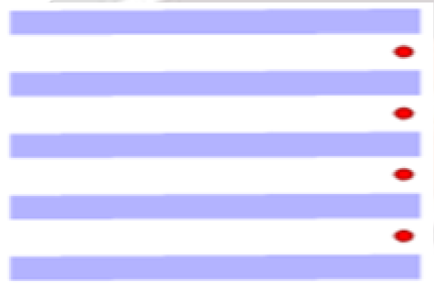

Fig.2: Hot compressed gas at the right end of stack

Fig.3: Gas expands while moving to left and cools

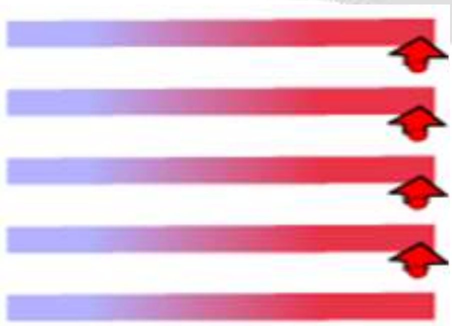

Fig.4: Heat loss to stack. Stack temperature rises.

Fig.5: Cold gas takes heat from stack. Stack is colder

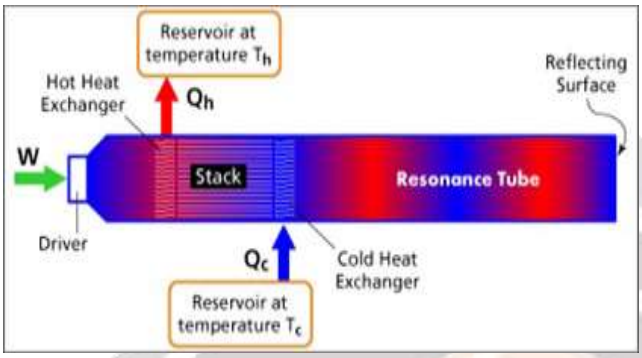

Fig.6: Temperature variation in device

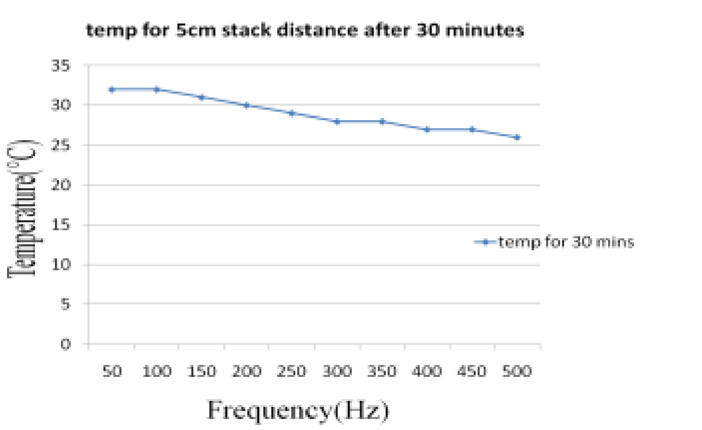

Fig.7: Temperature variation for 5cm stack distance

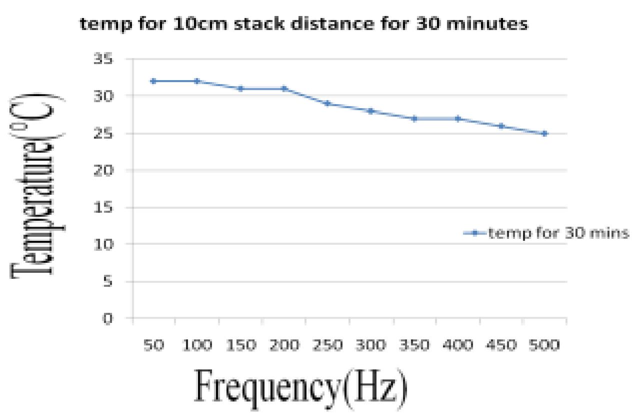

Fig.8: Temperature variation for 10cm stack distance

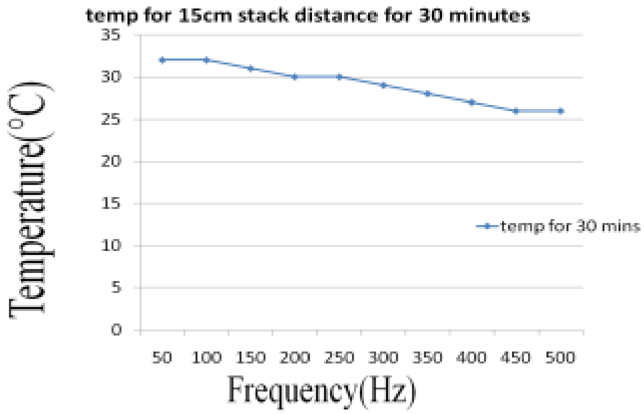

Fig.9: Temperature variation for 15cm stack distance

Here the stack was placed at different lengths and various frequencies were set to find the temperature changes that take place for every change in the parameters. First the frequencies are set and due to the thermoacoustic property the temperature difference takes place where the heat is transferred from the colder area to the hotter area and thus the cold and hot air are obtained at each ends of the heat exchangers.

TABLE.1: List Of Materials

SL. NO.	**NAME OF THE PARTS**	**MATERIAL**	**QUANTITY**
1	Sine wave generator	NCH Tone generator	1
2	Laptop	Hardware	1
3	Resonator tube	PVC	1
4	Heat exchanger	Copper	1
5	Acoustic driver	Philips speaker	1
6	Amplifier	360 Hz Amplifier	1
7	Thermometer	Mercury thermometer	1

Fig.10: Assembled parts

4.1 ADVANTAGES

- The working fluid is air which is environmental friendly unlike common refrigerators.
- The simplicity of the design makes it robust, small and light weight.
- It has almost no moving parts which translate into longer working life with fewer repairs
- In turn, this makes the system less expensive.
- It has ability to attain a higher level of the limiting carnot efficiency than current refrigeration method.
- The loud speaker is the only moving part which is more durable than the compressor.

5. CONCLUSION

The Thermo acoustic Refrigeration System consists of no moving parts. Hence the maintenance cost is also low. The system is not bulky. It doesn't use any refrigerant and hence has no polluting effects. From the case study, it is observed that cooling power is dependent on working frequency, cooling load and pressure. It is also observed that for best performance of the system, it is necessary to choose operating parameters wisely. This project can be used as a reference for design, understanding and improvement in the Thermoacoustic Refrigeration System. Thermoacoustic cooling have been achieved quite simply without any refrigerants or use of a compressor under atmospheric conditions. Although the temperature drop below ambient was small, the clean technology poses as a potentially attractive alternative to the conventional system in view of the increasing concern over the degradation of the environment caused by refrigerants from the cooling industries. Moreover no inert gases are used and the working medium is the atmospheric air.

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