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THERMOACOUSTIC REFRIGERATION

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Abstract
Thermoacoustic have been known for over years but the use of this phenomenon to develop engines and pumps is fairly recent. Thermo acoustic refrigeration is one such phenomenon that uses high intensity sound waves in a pressurized gas tube to pump heat from one place to other to produce refrigeration effect. In this type of refrigeration all sorts of conventional refrigerants are eliminated and sound waves take their place. All we need is a loud speaker and an acoustically insulated tube. Also this system completely eliminates the need for lubricants and results in 40% less energy consumption. Thermo acoustic heat engines have the advantage of operating with inert gases and with little or no moving parts, making them highly efficient ideal candidate for environmentally-safe refrigeration with almost zero maintenance cost. Now we will look into a thermo acoustic refrigerator, its principle and function

Index Terms: *speaker replace compressor and air replace refrigerant fluid***.**

1.INTRODUCTION

The process of refrigeration means the cooling the desired space and maintaining the temperature below the ambient temperature. In 19th century, modern refrigeration technologies were introduced to world. In the last few decades the use of them has increased significantly. Today mostly cooling is achieved by vapour compressor system that use a specific refrigerant. Before some years, it has been discovered that traditional refrigerators affect the environment adversely. So to avoid the use of hazardous materials the idea of Thermoacoustic refrigerators was developed. Over the past two decades, physicists and engineers have been working on a class of heat engines and compression-driven refrigerators that use no oscillating pistons, oil seals or lubricants. These so called thermos acoustic device take advantages of sound waves reverberating within them to convert a temperature differential. 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. Such materials thus can be used, for example, to generate electricity or to provide refrigeration and air conditioning. Because thermos acoustic devices perform best with inert gas as the working fluid, they do not produce harmful environmental effects such as global warming or stratospheric ozone depletion that have been associated with the engineered refrigerants such as CFCs and HFCs.

2. EFFECTS OF THE TRADITIONALREFRIGERANTS

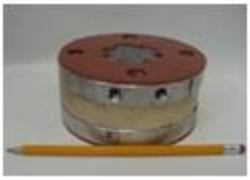
In traditional refrigerators the refrigerants like CFCs are use, which are very harmful for environment as well as human health. These effects are given bellow.

1. **Ozone depletion potential:** Refrigerant containing chlorine or bromine contribute to the breakdown of the ozone layer in the atmosphere. The reaction is as follows Cl + O3 ->O2 +ClO
2. However the ClO molecule is unstable. It breaks down and react with the ozone molecules repeatedly until a more stable compound is created. Ozone depletion effect on the leaving things.
3. this direct sunlight can causes skin cancer. Also increases the contact with the sun's ultraviolet rays can causes cataracts and other eye damage.
4. **Inhaling CFCs:** Inhalation of CFCs affects the central nervous system. Inhalation of CFCs can also disturb heart rhythm, which can lead to death.
5. **Global warming potential:** Due to their stability in atmosphere, CFCs as well as HCFCs are often very effective greenhouse gases. The global warming potential factor is use to reflect their impact on global warming. It effect on the atmospheric changes in the temperature.
6. **Skin cancer and Eye damage:** since CFCs contribute greatly to the loss of the protective Ozone layer, which blocks ultraviolet rays from the sun, spending too much time in

3. Component use in the Thermo acoustic refrigeration (TAR) are as follow


Resonance tube


Acoustic loudspeaker


Heat exchanger


Working gas

Fig-1: Components

4. CONSTRUCTION AND WORKING OF THERMOACOUSTIC REFRIGERATION SYSTEM

Thermoacoustic Refrigeration System mainly consist of a loudspeaker attached to an acoustic resonator (tube) filled with a gas. In the resonator, a stack consisting of a number of parallel plates and two heat exchangers are installed. Helium, Argon and Xenon which are harmless, non-flammable, nontoxic and non-ozone depleting gases or global warming and this gases are inexpensive to manufacture. The loudspeaker, which acts as the driver, sustains acoustic standing waves in the gas at the fundamental resonance frequency of the resonator. The acoustic standing wave displaces the gas in the channels of the stack while compressing and expanding respectively leading to heating and cooling of the gas. The gas ,which is cooled due to expansion absorbs heat from the cold side of the stack and as it subsequently heats up due to compression while moving to the hot side, rejects the heat to the stack. Thus the thermal interaction between the oscillating gas and the surface of the stack generates an acoustic heat pumping action from the cold side to the hot side. The heat exchangers exchange heat with the surroundings, at the cold and hot sides of the stack.

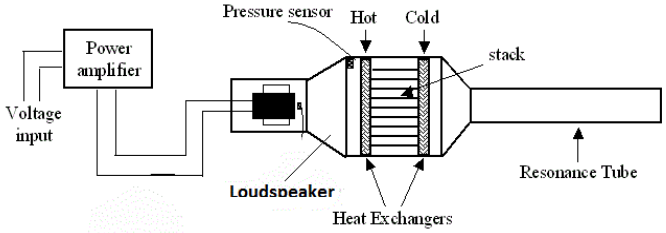


Fig-2: Representation of construction of thermoacoustic refrigerator.

The major parts of a thermo acoustic refrigerator are loud speakers, stack and resonators. Representations of both are given below.

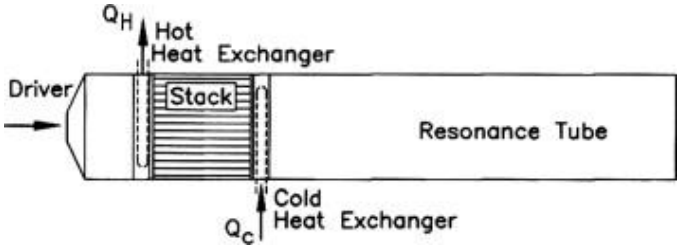


Fig-3:of heat exchanger

stack is connected in between the driver that is loudspeaker and the resonators tube. Stack help to transfer the heat from one end to another as shows in above fig. There Here are two heat exchangers first is cold exchanger and the second is the hot heat exchange. The heat exchangers are used so that heat interaction with the surrounding takes place. Heat is pumped from the Cold end heat exchanger to the hot end heat exchanger

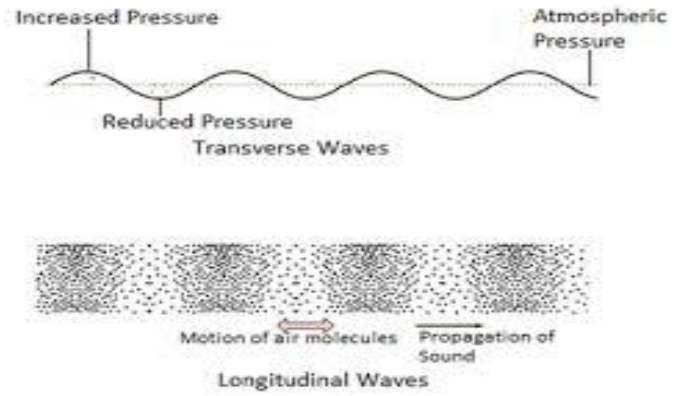


Fig-4:Pressure variation and displacement of sound waves

5.EXPERIMENTAL TESTING SETUP

Data Acquisition system a Thermoacoustic Refrigeration System, Test Section, and Data Acquisition system a Thermoacoustic Refrigeration System, Test Section, and Experimental setup consists of

1)Thermoacoustic Refrigeration System: The Thermoacoustic Refrigeration System includes resonator tube, stack, acoustic driver and heat exchanger.

2) Test Section: Test section involves measurement of temperatures at the inlet and outlet of the heat exchanger, at the middle of resonator, at the surface of acoustic heater and near the electric heater with the help of thermocouples.

3) Data Acquisition System: The Data Acquisition System consists of thermocouples, transducer, oscilloscope, flow meter, data acquisition board and personal computer for the data display.

6.RESULT AND DISCUSSION

1) Effect of Various Frequencies on Performance of Thermoacoustic Refrigeration System This section shows the performance of Thermoacoustic Refrigeration System by changing frequency and taking constant mean

pressure and cooling load. The various frequencies used are as follows: 250 Hz, 300 Hz, 350 Hz, 400 Hz, 450 Hz, and 500 Hz. The Fig. 5 Shows that the graph of temperature at hot end of the stack with time for various frequencies at constant mean pressure and cooling load. From Fig. 5, it is clear that the temperature at hot end of stack initially increased and then became stable. This stability time increased with the increased in pressure, this is because as the mean pressure increases thermoacoustic effect increases.

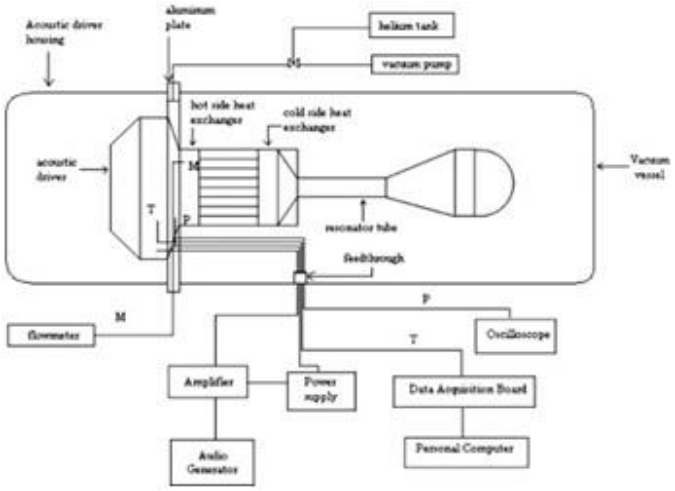
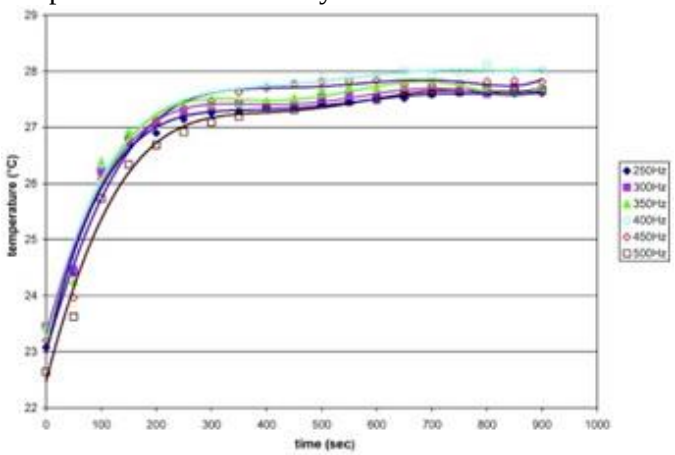


Fig-6: Stack hot end temperature-time history for constant cooling load and mean pressure for various frequencies.

2) Effect of Changing Cooling Load on Performance of Thermoacoustic Refrigeration System. This section shows the performance of Thermoacoustic Refrigeration System by changing cooling loads and taking constant pressure and frequency. The experiment was done for cooling loads of 1 W, 2 W, 3 W & 4 W. Stack Hot Temperature – Time History



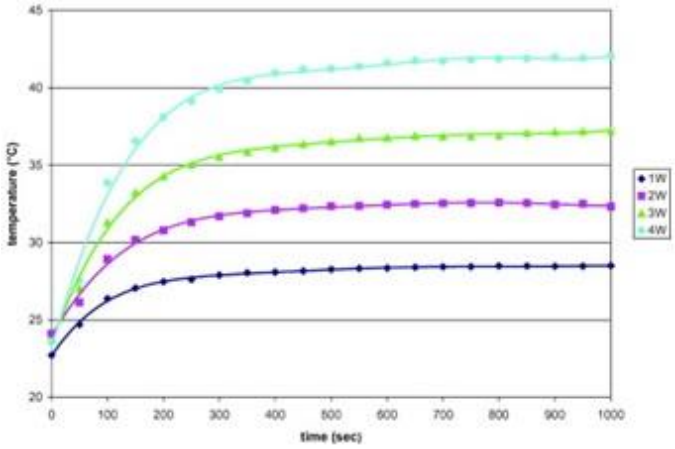


Fig-7: Temperature Vs frequency graph

The above Fig. shows the variation of stack hot end temperature with time for different cooling powers. From Fig, it is concluded that as the cooling load increases more heat is pumped leading to increase in hot end temperature of the stack and more time required to reach equilibrium position in the system.

7. ADVANTAGES OF TAR TECHNOLOGY

1. No moving parts for the process so very reliable and long life span.
2. Environmentally friendly working medium.(Air, noble gas)
3. It can save up to 40% of energy.

4.Thermoacoustic refrigeration works best with inert gases such as helium and argon, which are harmless, non-flammable, nontoxic, non-ozone depleting or global warming

5.The use of air or noble gas as working medium offers a large window of applications because there are no phase transitions.

6.Use of simple material with no special requirements, which are commercially available in large quantities and therefore relatively cheap.

8. DISADVANTAGES OF TAR TECHNOLOGY

1. Efficiency thermoacoustic refrigeration is currently less efficient than the tradition refrigerators.
2. Lack of interest and funding from the industry due to their concentration on developing alternative gases to CFCs.
3. Another problem of the TAR is that it is either fully ON or OFF.
4. It can be leaked an incredible amount of sound that causes ear pain

9. APPLICATION

- **In spacecraft:**
  A new spacecraft cryocooler which uses resonant high-amplitude sound waves in inert gases to pump heat.
- **Electronic equipment cooling on naval ships:**
  In Naval ships thermoacoustic refrigeration is use to cool the electronic equipment.

- **In ice-cream shop:**
  Ben & Jerry's ice-cream has had a thermoacoustic refrigerator fitted to there freezer.
  Theromoacoustic cooling is also use for computer and electronic industry

10.CONCLUSION

Refrigerators were already being considered a few years ago for specialized applications, where their simplicity, lack of lubrication. The Thermoacoustic Refrigeration System consist of no moving parts. Thus the maintenance cost is low. The system is not space consumable. It does not use any kind of refrigerant fluid which is like air, helium etc. and thus has no polluting effects. From the case study by the scientists, it is clear that cooling power is directly proportional on working frequency, cooling load and pressure. It is also observed that for the best performance of the system, it is necessary to choose operating parameters wisely. This latest breakthrough, coupled with other developments in the design of high power, single frequency loud speakers and reciprocating electric generators suggests that thermo acoustics may soon emerge as an environmentally attractive way to power hybrid electric vehicles, capture solar energy, refrigerate food, air condition buildings, liquefy industrial gases and serve in other capacities that are yet to be imagined. In future let us hope these thermo acoustic devices which promise to improve everyone's standard of living while helping to protect the planet. This paper can be used as a reference for the design, understanding and development in the Thremoacoustic Refrigeration System.

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