THERMOACOUSTIC REFRIGERATION SYSTEM.

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Abstract: Thermo acoustic is arecent phenomenon which is used to develop the engines and pumps. 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 the conventional refrigerants are eliminated and sound waves are used as a refrigerant. 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. In this paper we are presented a thermo acoustic refrigerator, its principle and functions.

1.INTRODUCTION

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 thermo acoustic devices take advantage of sound waves reverberating within them to convert a temperature differential into mechanical energy or mechanical energy into a temperature differential. Such materials thus can be used, for example, to generate electricity or to provide refrigeration and air conditioning. Because thermo acoustic devices perform best with inert gases as the working fluid, they do not produce the harmful environmental effects such as global warming or stratospheric ozone depletion that have been associated with the engineered refrigerants such as CFCs and HFCs..

The entire features mentioned above is possible only because sound waves in thermo acoustic engines and refrigerators can replace the piston and cranks that are typically built into any machinery. These thermo acoustic devices produce or absorb sound power, rather than the shaft power characteristic of rotating machinery making it mechanically simple.

2.LITERATURE REVIEW

Various Researchers Conducted Study in thermocoustic Field by using different Methods, they Design the System in different way for getting Better COP of system.

A SreeneshValiyandi et al. explained in detail the desiging criteria for Thermoacoustic Refrigeration in order to achieve an optimal system by using the Thermoacoutic theory to describe the design criteria. [1]

A Kaushik S Panara et al. examines the effectiveness of thermo acoustic refrigeration, which is the theory of using sound waves as a coolant. [2]

A Pranav Mahamuniet al. illustrated A Thermoacoustic is deals with thermal effects of the sound waves and the interconversion of sound energy and heat. [3]

A Ashish S Raut et al. explained Thermoacoustic refrigerator is a novel sort of energy conversion equipment which converts acoustic power into heat energy by thermo acoustic effect. [4]A Emmanuel C Nsofor et al. explained the Experimental set up which is consist of Thermoacoustic refrigerating system with appropriate valves for the desired controls, instrumentation and the electronic Data Acquisition system. [5]

3.BASIC FUNCTIONING

In a nut shell, a thermo acoustic engine converts heat from a high-temperature source into acoustic power while rejecting waste heat to a low temperature sink. A thermo acoustic refrigerator does the opposite, using acoustic power to pump heat from a cool source to a hot sink. These devices perform best when they employ noble gases as their thermodynamic working fluids. Unlike the chemicals used in refrigeration over the years, such gases are both nontoxic and environmentally benign. Another appealing feature of thermo acoustics is that one can easily flange an engine onto a refrigerator, creating a heat powered cooler with no moving parts at all.

The principle can be imagined as a loud speaker creating high amplitude sound waves that can compress refrigerant allowing heat absorption. The researches have exploited the fact that sound waves travel by compressing and expanding the gas they are generated in.

Suppose that the above said wave is traveling through a tube. Now, a temperature gradient can be generated by putting a stack of plates in the right place in the tube, in which sound waves are bouncing around. Some plates in the stack will get hotter while the others get colder. All it takes to make a refrigerator out of this is to attach heat exchangers to the end of these stacks.

It is interesting to note that humans feel pain when they hear sound above 120 decibels, while in this system sound may reach amplitudes of 173 decibels. But even if the fridge is to crack open, the sound will not be escaping to outside environment, since this intense noise can only be generated inside the pressurized gas locked inside the cooling system. It is worth noting that, prototypes of the technology has been built and one has even flown inside a space shuttle.

4.CONSTRUCTION AND WORKING OF THERMO ACOUSTIC REFRIGERATION SYSTEM

4.1Basic Refrigeration Theory

The refrigerator is a device that transfers heat from a low – temperature medium to a higher temperature using external work input. The working fluid used in the refrigerator is called the refrigerant. The refrigeration process is based on the first and second law of thermodynamics, and its operation is based on the thermodynamic refrigeration cycles. The most commonly used refrigeration cycles are the vapour compression type.

4.2Vapour-Compression Refrigeration Cycle

The vapour-compression refrigeration cycle is the most widely used cycle for refrigerator, air-conditioning systems, and heat pumps. It consists of four thermodynamic processes, and involves four main components: compressor, condenser, expansion valve, and evaporator, as shown in Fig.1.1. The refrigerant enters the compressor as a saturated vapour at a very low temperature and pressure (state 1). The compression process takes place inside the compressor. Both the refrigerant becomes superheated vapour at the exit of compressor (state 2)

The heat transfer process takes place in the condenser at a constant pressure, where heat is transferred from the refrigerant to the high-temperature medium. As a result is a small decrease in the temperature of the refrigerant as it exits the condenser (state 3). The four processes of ideal vapour-compression refrigeration cycle are plotted on T-S diagram.

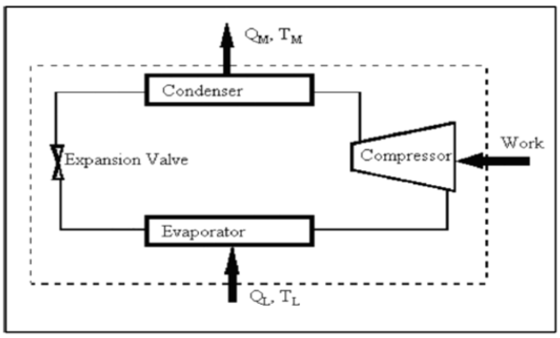

Fig:3.2 Basic Componant of Refrigeration System working on VCR cycle

4.3Thermo Acoustic Theory

The understanding of acoustic wave dynamics (pressure and velocity field created by an acoustic wave) is necessary to understand the working of a thermo acoustic device. The acoustical theory deals with the study of the longitudinal acoustic waves. The longitudinal acoustic waves are generated as a result of the compression and expansion of the gas medium. The compression of a gas corresponds to the crest of a sine wave, and the expansion corresponds to the troughs of a sine wave. In a longitudinal wave the particle displacement is parallel to the direction of wave propagation i.e. they simply oscillate back and forth about their respective equilibrium position. The compression and expansion of a longitudinal wave result in the variation of pressure along its longitudinal axis of oscillation. A longitudinal wave requires a material medium such as air or water to travel. That is they cannot be generated or transmitted in a vacuum. All sound waves are longitudinal waves and therefore, hold all the properties of the longitudinal waves discussed above. Three properties are necessary for the understanding of the thermo acoustic process. These properties are amplitude, frequency and wavelength. The displacement of a wave from its equilibrium position is called the wave amplitude. It is also a measure of the wave energy. The time period of a wave is the time required for the complete passage of a wave at a given point. The fundamental wave frequency is the inverse of the time period. In other words, it is the number of waves that pass a given point in a unit time. It is measured in Hertz (Hz), that is, the number of wave that pass in a given point in one second. The wavelength is defined as the horizontal distance from the beginning of the wave to the end of the wave. It can also be measured as the distance from one wave crest to the next wave crest, or one wave trough to the next wave trough. In acoustics, We can define wavelength as the distance between the two successive compression and expansions. As mentioned earlier, the compression and expansion of an acoustic wave result in pressure variations along the waveform. This pressure variation is the key process that causes the thermo acoustic phenomenon. From the ideal gas equation of state, $P / \rho = RT$ Where P is the pressure, ρ is the density, T is the absolute temperature, and R is the gas constant. The above equation indicates that if the density variations are very small, the change in pressure causes the change in temperature. That is an increase in pressure causes an increase in temperature and vice versa.

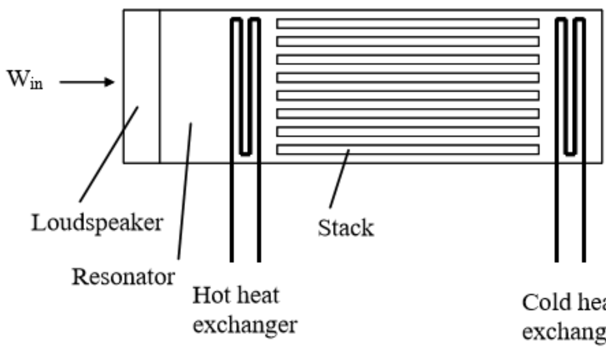

Fig:2Thermoacoustic Refrigeration System Description of technology

A schematic diagram of a standing wave device is shown in figure 2. The main components are a closed cylinder, an acoustic driver, a porous component called a "stack, and two heatexchanger systems. Application of acoustic waves through a driver such as a loud speaker, makes the gas resonant. As the gas oscillates back and forth, it creates a temperature difference along the length of the stack. This temperature change comes from compression and expansion of the gas by the sound pressure and the rest is a consequence of heat transfer between the gas and the stack. The temperature difference is used to remove heat from the cold side and reject it at the hot side of the system. As the gas oscillates back and forth because of the standing sound wave, it changes in temperature. Much of the temperature change comes from compression and expansion of the gas by the sound pressure (as always in a sound wave), and the rest is a consequence of heat transfer between the gas and the stack.

CONCLUSION

Thermo acoustic engines and refrigerators were already being considered a few years ago for specialized applications, where their simplicity, lack of lubrication and sliding seals, and their use of environmentally harmless working fluids were adequate compensation for their lower efficiencies. 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.

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