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A STUDY ON THERMO ACOUSTIC REFRIGERATOR SYSTEM

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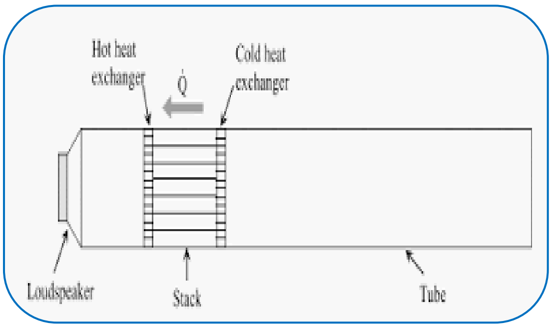
ABSTRACT :

Thermoacoustic cooling is a modern, eco-friendly and cheap alternative to cooling. The development of a practical model will show that the new concept of modern cooling is successful. Two primary thermodynamic concepts form the basis for the cooling period. Thermoacoustic cooling is a modern, eco-friendly and cheap alternative to cooling. The development of a practical model will show that the new concept of modern cooling is successful. Two primary thermodynamic concepts form the basis for the cooling period. This article explains how thermoacoustic cooling is planned, built, controlled and modeled.



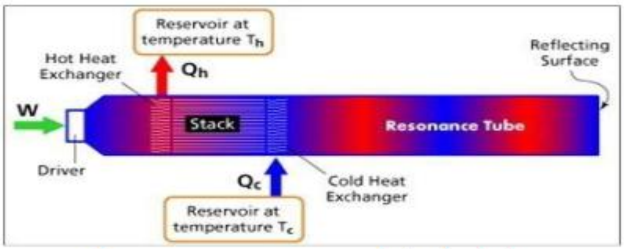
KEYWORDS : *Thermoacoustic Refrigeration System, Refrigeration, Thermo-Acoustics, Thermal Acoustic Effect.*

INTRODUCTION :

Modern cooling technology was introduced in the world in the 19th century. The use of these has increased considerably over the last decades. The vapour compressor system that uses a certain refrigerant mainly cools today. In recent years, conventional refrigerators have been found to have a detrimental effect on the climate. The concept of thermoacoustic refrigerators was created to discourage the use of dangerous materials. A special kind of system using sound wave energy or acoustic energy to pump heat from low-temperature reservoir to high-temperature reservoirs is the thermo acoustic cooling unit. The "driver" that can be a speaker is the source of Acoustic energy. In a long pitch packed with high pressure gas, the driver emits sound waves.The long hollow tube is known as the "resonance tube." Cooling is the science of creating and holding temperatures below those of the environment. It can be used for temperature control in nearly all fields. CFC'S are commonly used as a refrigerant until the beginning of the 21st century. It is prohibited to use CFC's to consider its adverse environmental consequences. This led to HCFC and HFC innovations. These too, however have inconveniences. All of these have high production costs and lead to global warming. The future has therefore become a priority for the production of alternative cheap and green cooling technologies. Thermo Acoustic Cooling (TAR) is one of these green cooling concepts.

A team made up of Gregory W Swift, J at Los Alamos National Laboratories (LANL). In the event of a heat pump with the aid of a Stirling engine, C. Wheatley and Thomas J. Hofler accidentally developed the first modern Tar.

Thermoacoustic deals with sound wave thermal effects as well as sound energy and heat interconversion. A spatial travel of sound waves. The medium in which they fly is consequently compressed and rarefied (in this case, gaseous medium). This compression and expansion contributes to the gas heating and refrigeration respectively. The theory is used to achieve the cooling effect in a thermoacoustic cooler.[1-6]



Temperature variation in device

The acoustics of thermocouple combine acoustics and thermodynamics to transfer heat through sound.

Construction and Working of Thermoacoustic Refrigeration System:

The Thermoacoustic Cooling System consists mostly of a loudspeaker connected to a gas-filled acoustic resonator (tube). A stack of multiple parallel plates and two heat exchangers is mounted in the resonator. The loudspeaker serving as driver assists the acoustic standing waves in the gas at the resonating frequency. The acoustic standing wave pushes the gas through the stack channels while compressing and expanding, leading to heating and refrigeration of the gas respectively. The gas cooled because of the expansion absorbs the heat from the stack's cold side and then rejects the heat into the stack because of compression as it is moving on the warm side.

Thermo-acoustic is an acoustical and thermodynamic branch that studies the heat movement of sound waves. The acoustics studies the effects of sound transmission, such as pressure changes and motion oscillations, while thermoacoustics study oscillations in temperature. Thermo-acoustic deals with how heat converts sound energy or vice versa. Fundamental awareness of sound and heat transfer is important to better understand the TAR.

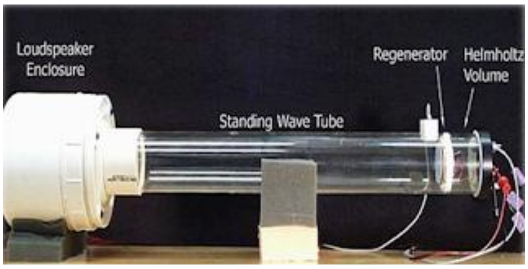


Figure.1. Thermo-acoustic refrigerator setup

The thermoacoustic cooling system is composed mainly of a loudspeaker connected to a gas-filled acoustic resonator (tube). A stack of multiple parallel plates and two heat exchangers is mounted in the resonator. The loudspeaker, the motor, helps sound waves in the gas at the fundamental frequency of resonance of the resonator.

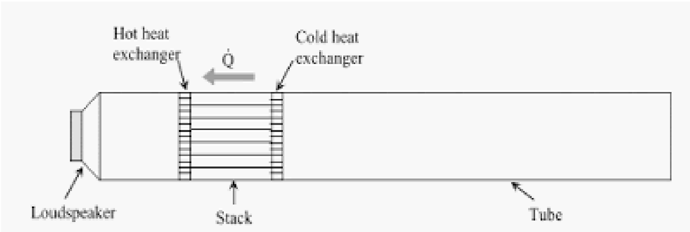


Figure.2 Schematic representation of construction of thermoacoustic refrigerator.

The figure above shows a scheme of the thermoacoustic cooler construction, in which the loudspeaker is used as a carrier, while the resonant tube carries the stationary wave.

The heat starts from one end of the stack to the other because of the thermal acoustic effect (which is explained in detail in the animation). One end begins to heat up and another continues to refresh. The cold end of the pile can be cooled to lower and lower temperatures by regulating the temperature of the hot side of the pile (by extracting heat via the heat exchanger). At the cold end, a heat exchanger can then be used to add a cooling load.

METHODS AND PROCEDURES

A. Thermoacoustic Refrigerator Design

A lot of research is under way nowadays in the construction of thermoacoustic coolers. This book includes many ongoing discussions on the best strategies for design. This chapter begins with a simple technique for the design of thermoacoustic refrigerators, and then explores the various elements in depth.

B. Working Cycle

The cooling is a two stage process. Vapor Absorption The coolant is absorbed by the vapour and is regenerated externally by the coolant. It is cooled to the necessary pressure level and cyclerepeats in the condenser. Like the vapours, the adsorption systems are also focused on the removal of heat from the air during an evaporation process.

Case Study:

A. Specifications of Thermoacoustic Refrigeration System

Resonators tube with plastic tubing on the inside has been designed to minimize heat loss by conductivity. As the working solvent, helium was used. For this analysis, thermoplastic parallel form stack was used. The Fig. 3 Depicts geometry and various stack views of parallel arranged plates.

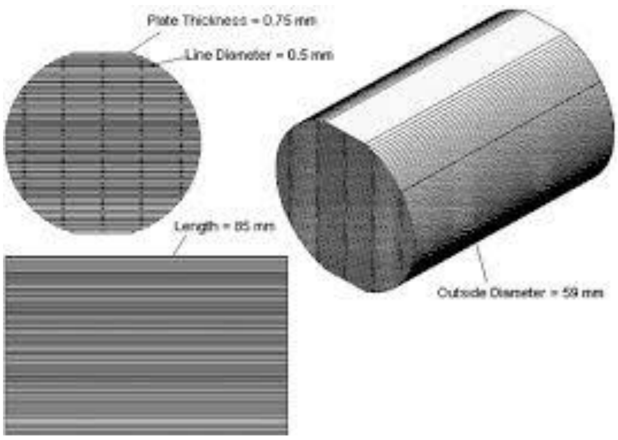


Figure. 3 Views of parallel plate stack arrangement

The following parameters are used for the design and operation of this thermoacoustic cooling system.

- Speed of sound in gas –1013 m/s
- Gas specific heat –5193 J/KgK
- Gas thermal diffusivity –13.2*10-5m2/s
- Gas thermal conductivity –0.155 W/mK
- Gas dynamic viscosity –197*10-7Ns/m2
- Gas density –0.8845 Kg/m3
- Drive ratio –0.02
- Ratio of specific heats –1.67
- Normalized stack length –0.262
- Blockage ratio –0.5

B. Experimental Testing Setup

A thermoacoustic cooling, a test portion, and data acquisition systems are included for experimental purposes.

1. The thermoacoustic cooling system contains a resonator tube, piling, acoustic driver and heat exchanger.

1) Thermoacoustic cooling system.

2) The test portion includes calculating temperatures at the heat exchangers inlet and outlet at the center of the resonator and on the surface of the acoustic heater and by means of thermocouples in the immediate vicinity of the heater.

3) The data acquisition system involves thermocouple, transducer, oscilloscope, flow metre, data collection board and personal data display computer.[6-8]

A signal generator and transformer is essential for operation of the TAR model. The signal generator generates a sinew signal of 400 Hz to drive the speaker. In order to bring the signal to the requested amplitude, the amplifier was used. This amplified signal pushes the speaker through the stack to create a temperature gradient.

The thermocouples on either end of the stack calculated the temperature difference. Data acquisition system (DAQ) for real time analyses was provided the thermocouple performance.

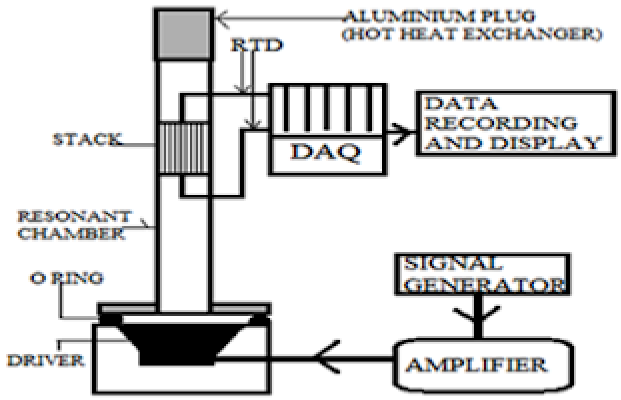


Fig.4. Set up for prototype testing

DAQ-data acquisition system RTD-resistance temperature detectors

List of Materials

The table includes the list of materials used to create the thermal acoustic cooling device.

S1.No.	Parts	Qty.	Material
1	The Resonator	1	Glass tube
2	The Stake	1	Aluminum foil
3	Speaker	1	
4	Amplifier	1	
5	Thermocouples	2	-

Table 1: List of materials

RESULTS AND DISCUSSIONS

The refrigerator in this case has 80 Hz of resonant frequency, a 12 V and 200 mA current, i.e. an input power of 7.6 watts respectively. Figures display the thermocouple data collected at different times during the refrigerator process. It should be noted that the internal temperatures are calculated only above and below the stack. At first, then in the experiment, the graphs are collected. The shift in the stack temperature is seen.

S. no	Time t in Min	Thermocouple Readings in ^{0}c	
		At Hot End	At Cold End
1	0	30.75	30.75
2	10	33.75	30
3	15	36	29.75
4	25	39	29
5	30	41.75	28
6	35	44.75	26.75

Table 2 –Thermocouple readings at various times

CONCLUSION:

No moving parts are used in the thermoacoustic refrigeration system. The maintenance costs are also minimal. The device is space-efficient. It uses no coolant and thus has no contaminating effects. It is also noted that it is important to wisely select operating parameters for the best performance of the system. This paper is a guide for the design, information and improvement of the thermoacoustic cooling system.

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