DESIGN & FABRICATION OF THERMOACOUSTIC REFRIGERATION

[1]T.KIRANMAYEE
M.Tech, Mechanical Engineering
JNTUA College of Engineering
Ananthapuram, A.P, India

[2]Dr.M.L.S.DEV KUMAR
professor,Mechanicalengineering
JNTUA College of Engineering
Ananthapuram, A.P, India

ABSTRACT: ***This paper deals with design and fabrication of thermo acoustic refrigeration, a theory of using sound waves as a coolant. A thermo acoustic refrigeration device (TAR), which includes an acoustic wave generation device arranged to the channel of a hollow tube, and a regenerator is provided at a predetermined position in the channel of the tube. The main aim is to design and fabricate a small thermo acoustic refrigerator from inexpensive and readily available parts and analyses the result. This design includes dimension of stack, selection of acoustic driver, and acoustic resonator. This Experiment shows that, thermo acoustic cooling is possible, but high efficiency is beyond to reach due to materials restrictions. The temperature gradient of*** 5^0 ***C is obtained by constructing this simple device. Experiment shows the performance can be improved by using a better material which having a high heat carrying capacity and the working fluids like inert gases.***

KEYWORDS: ***Acoustic resonator, stack, working fluid Thermo acoustic refrigeration***

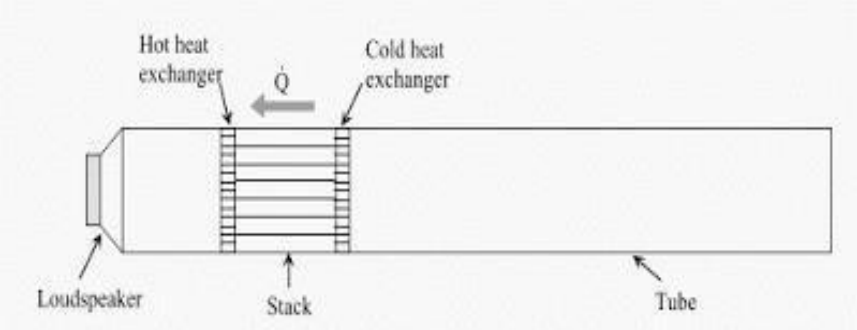
INTRODUCTION

Refrigerators are used for many purposes for preserving foods to keep things which are supposed to be cold. Refrigerator has many applications in almost every field. Conventional refrigerators use Ozone Depleting Substances (ODS) like Chlorofluorocarbons (CFCs) and Hydro fluorocarbons (HFCs) as refrigerants, which depletes the ozone layer. To overcome this problem an alternative is needed for refrigeration purpose. One of the alternatives is Thermo acoustic refrigerator, which doesn't use any unfriendly-environmental refrigerants like CFCs and HFCs. Instead, of that it uses the principle of the power of sound to generate oscillations required to compress working gas. Thermo acoustics combines both branches of acoustics and thermodynamics together to move heat by using sound. Thermo acoustic mainly consist of acoustic driver (loudspeaker) which will be attached to a resonator tube and carries a working medium as air in this case. In the Resonator tube the stack are installed. The loudspeaker will generates acoustic standing waves in the resonator tube at the fundamental frequency of the resonator. This standing wave displaces the working medium in resonator tube across the stack while compressing and expanding. This cyclic compression and expansion of working medium will provide a thermal interaction between the oscillating gas and the surface of the stack generates an acoustic heat pumping. The main disadvantage of this Thermo acoustic refrigerator is low efficiency as compared to a Vapour Compression Refrigeration.

DESIGN AND FABRICATION OF THERMO ACOUSTIC REFRIGERATION SYSTEM

Design considerations

This work deals with the design and development of the thermo acoustic refrigerator. The thermo acoustic theory will be used for the design analysis. Some parameters along with a group of dimensionless independent variables are used.



Thermo acoustic refrigeration system

RESONATOR

A resonator is a device, exhibit resonant behavior, which oscillates naturally at some frequencies, and called as resonant frequencies (with greater amplitude than other). The oscillations in a resonator can be either electromagnetic or mechanical (including acoustic). Resonators are used to either generate waves of specific frequencies or to select specific frequencies from a signal. A musical instrument uses acoustic resonators which is used to produces sound waves of specific tones.

A cavity resonator is preferred for electromagnetic resonators; waves will exist in a hollow space inside the device. An acoustic cavity resonator produces sound by air in a cavity with one side opening (hollow), known as Helmholtz resonators.

STAKE

Stake", is a piece of wood or other material, pointed at one end so as to be easily driven into the ground as a support. Where temperature gradient is obtained. Selection of Stack should be high heat capacity and low thermal conductivity as compared to working medium. Low thermal conductivity is essential for minimize the losses through conduction from hot side to cold side of stack. Length and shape of stack will determines how much the sound waves will propagate through it.

SPEAKER

Speakers are transducers which convert electromagnetic waves into sound waves. The speaker's takes audio input from a device which may be either in analog or digital form .The main purpose of speakers is to generate sound waves into resonator of desired frequency.

The sound which produces by speakers is defined by frequency and amplitude. The frequency determines how the sound is i.e. high or low pitch

Amplitude, or loudness, is determined by the change in air pressure created by the speakers' sound waves. Speakers that can amplify the sound input are often called active speakers.

AMPLIFIER

An electronic amplifier, or (informally) amp is an electronic device that increases the power of a signal.

Working of amplifier is to take energy from a power supply and controlling the output to match the input signals with larger amplitude.

TEMPERATURE SENSOR

Temperature sensors are used to display the temperature readings of the experiment. Depends upon Temperature sensor it may produces an analogue or digital output. Therefore a board-mounted IC sensor is used for measuring the temperature in this experiment.

Working Fluid

Air is chosen as a working fluid for the present design. The Lighter gases such as H2, He, Ne have the higher sound velocity. Lighter gases are necessary for the refrigeration application because heavier gases condense or freeze at low temperatures, or exhibit non ideal behaviour

LIST OF PARTS

Sl. No.	PARTS	Qty.	MATERIAL
1	The Resonator	1	
2	The Stake	1	
3	Speaker	1	
4	Amplifier	1	
5	Plexi Glass Tube	1	Glass
6	Aluminum Stopper Film	1	Aluminum
7	Temperature Sensor	1	-
8	Control unit		

Fabrication of Thermo acoustic refrigeration system

The components of thermo acoustic refrigerators and the design parameters are selected and discussed above. Based on the selection of components the fabricated model is designed

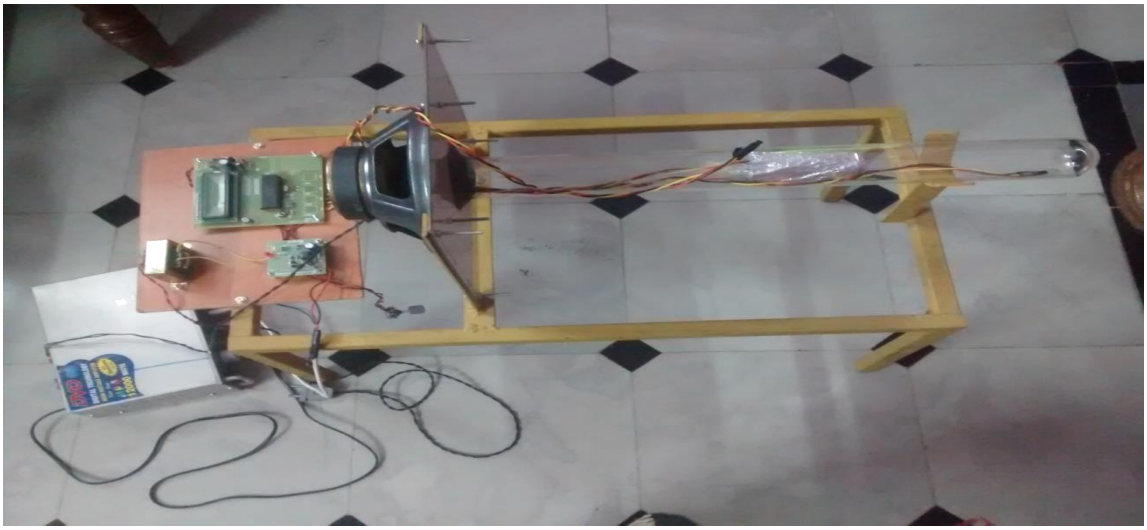


Figure: Fabricated model

EXPERIMENTATION

The experimental procedure is described below:

- A loudspeaker generates sound waves and passed inside the resonator tube with a frequency of 300Hz.
- Setup was kept running for some time.
- The temperature and time was measured with the help of digital temperature and stopwatch.

RESULT AND DISCUSSION

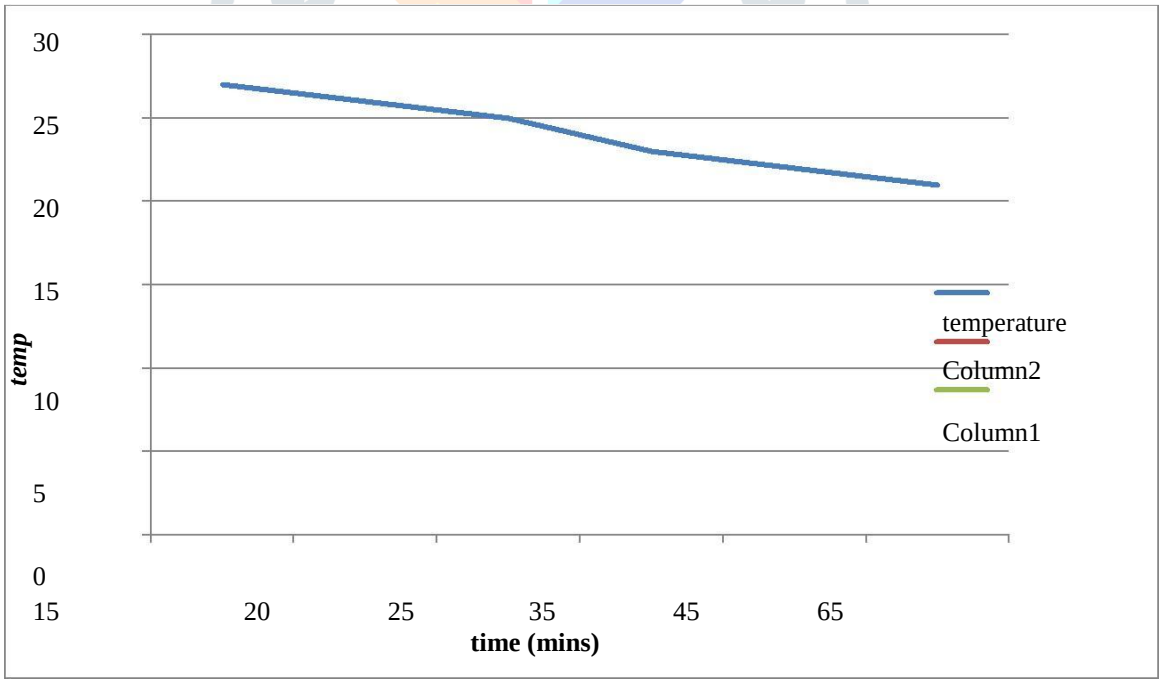
We analyse the performance of thermo acoustic refrigeration system and we get a temperature difference of 5^0 c degree Celsius between the two ends of the stack.

. Ambient Temperature (hot end) $T_h=28^0$ c (degree Celsius)

Time(mins)	T_c cold temperature
15	27
20	26
25	25
35	24
45	23
65	22

Table: Cold end temperature at one end of the stack

The graph shows temperature at the cold end and the time. From the graph it is seen that the temperature at the cold end decreases with time and reaches to a temperature of 22^0 degree Celsius in 65 minute with a drop in temperature of 5 degree Celsius. This simple experiment of thermo acoustic system shows a temperature gradient of 22^0 C and can develop this system to cool industries. The sound produced by working machines in industries can be used for operating the thermo acoustic refrigeration to cool the rooms.



Graph: temp Vs time

In this experiment, the temperature field inside the resonator tube is measured, in the presence of the acoustic wave. The temperature of 3 points inside the resonator along the length of the resonator is measured by using thermocouples.

CONCLUSION

Thermo acoustics is a promising area, if it is properly explored, it may serve as a good refrigeration system. However, the performance of this device is currently very low by comparing with refrigeration system. The main motivation for the present work is to develop a simple thermo acoustic refrigerator that is completely functional. This paper reports on the design and fabrication of a simple thermo acoustic refrigeration system which is inexpensive and readily available material.

The characteristic of the fabricated refrigerator and its performance were analyses experimentally and the result is discussed. For the given Operating condition a temperature gradient of 5^0 degree Celsius is established across the stack. This working device shows that a thermo acoustic device is possible and is able to cool air, for only a short period of time. If we were able to build the device with better materials, such has a more insulating tube; we may have better results in future.

REFERENCES

[1] "Standing Waves." Rod Nave, Georgia State University. Available: http://hyperphysics.phyastr.gsu.edu/hbase/waves/standw.html. 17 July 2006.

[2] http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/carnot.html

[3] http://www.howstuffworks.com/stirling-engine.htm

[4] http://en.wikipedia.org/wiki/Carnot_cycle

[5] Daniel A. Russell and Pontus Weibull, "Tabletop thermoacoustic refrigerator for demonstrations," Am. J. Phys. 70 (12), December 2002.

[6] G. W. Swift, "Thermoacoustic engines and refrigerators," Phys. Today 48, 22-28 (1995)

[7] http://www.rolexawards.com/laureates/laureate-36-lurie_garrett.html

[8] "Thermal Management of Computer Systems Using Active Cooling of Pulse Tube Refrigerators." H.H. Jung and S.W.K Yuan. Available: http://www.yutopian.net/Yuan/papers/Intel.PDF. 17 July 2006.

[9] "Thermoacoustic Refrigeration for Electronic Devices: Project Outline." Stephen Tse, 2006 Governor's School of Engineering and Technology.

[10] "Frequently Asked Questions about Thermoacoustics." Penn State Graduate Program in Acoustics. Available: http://www.acs.psu.edu/users/sinclair/thermal/tafaq.html. 17 July 2006.

[11] "Chilling at Ben & Jerry's: Cleaner, Greener." Ken Brown. Available: http://www.thermoacousticscorp.com/news/index.cfm/ID/4.htm. 17 July 2006.