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PIEZO-ELECTRICALLY DRIVEN THERMOACOUSTIC REFRIGERATOR

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ABSTRACT

The study focuses technically on using the piezo-electric materials to get the desired refrigeration effect. Moreover, the added advantage is that piezo-electrical material replaces the electromagnetic speakers which causes disturbances and expensive too. Finally, the positive outcome of this project is that the efficiency rate is higher when compared to other refrigeration systems.

KEY POINTS: piezoelectric effect, acoustic theory, VCR system

1. INTRODUCTION

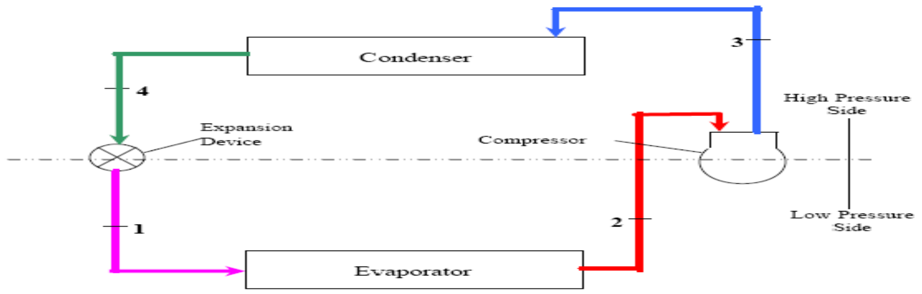
Refrigeration has found plenty of applications now days. The thermo acoustic developments have found suitable for controlling the temperature accurately. The man-machine interface has become un avoidable for the industries to develop. The current system of refrigeration will completely replaced by the thermoacoustic system in coming future. The pressure oscillations when creates from the heat is called a forward effect while opposite to it is called a reverse effect.

1.1.Basic Refrigeration theory

The refrigerator is a device that transfers heat from a low temperature medium to a high temperature medium using external work input. The working fluid is called refrigerant. The most commonly used refrigeration cycle is vapour compression cycle.

1.2. Vapour compression cycle

It consists of 4 components compressor, condenser, expansion valve and evaporator. The refrigerant enters the compressor as saturated vapour the compression process takes place. The refrigerant becomes super heated vapour at the exit of the compressor. The heat transfer takes place in the condenser at constant pressure as a result there is a small decrease in temperature of the refrigerant at the exit of the condenser.



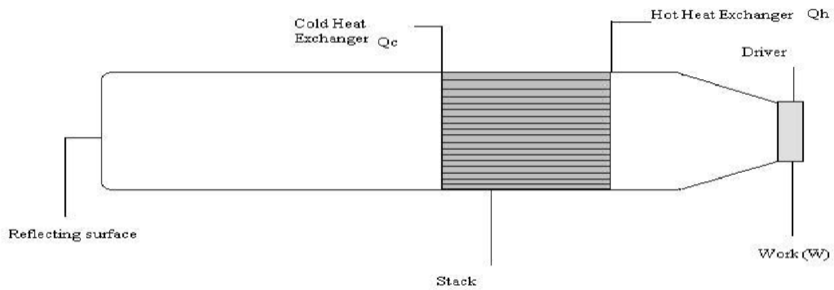
2. DESIGN

2.1. Overview

The design of thermoacoustic refrigerator is growing field of research purposes. The major components of the system are as below:

2.2. Driver

The driver is responsible for creating acoustic waves. Usually electromagnetic speakers are used but when high frequency is desired piezoelectric material is often used. There are several things that need to be kept in mind to decide which speaker should be used. Firstly (BI^2) / ($R_E R_M$) where, I represents the length of the coil, B is the inductance of the coil, RE is the electrical resistance, RM is the mechanical resistance..



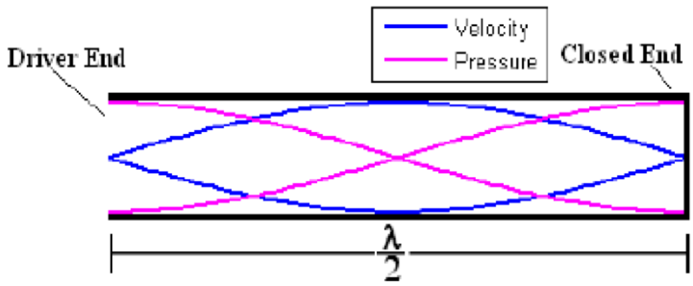
2.3.Resonator

Resonator contains working fluid in the thermoacoustic refrigerator and to cause it to have desired natural frequency. This means that natural frequency of such a resonator will have wavelength 4 times the resonator wavelength. Half wavelength resonators have their natural frequency 2 times that of the resonant frequency. The real resonators are closed to ideal half or quarter wavelengths. The validity of this depends on this driver and also on it is attached to resonator.

2.4.Stack

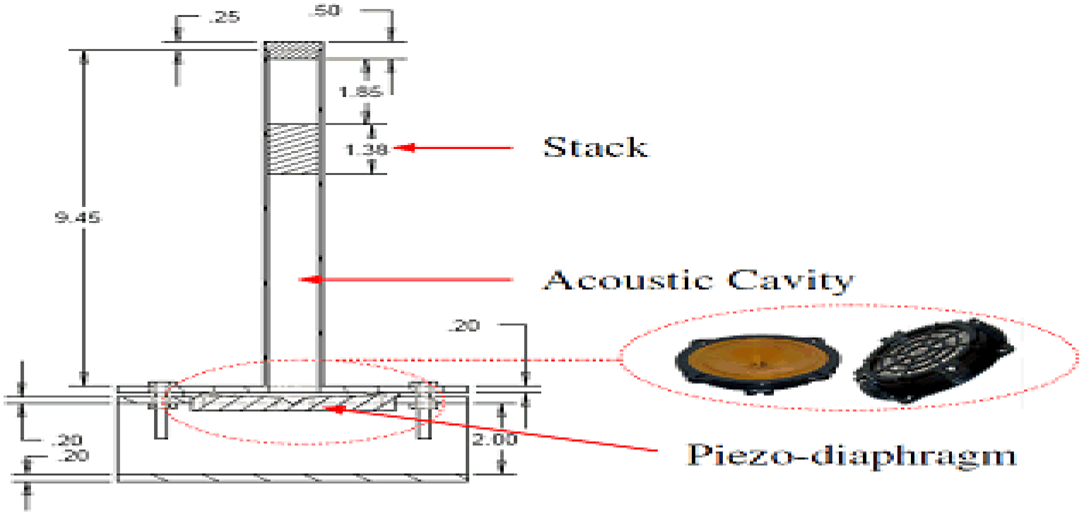
Stack is the heart of the thermo acoustic refrigerator. It effective working and the cooling power can be decided in stack. Spacing is also important in design. As the surface area increases the power density also increases because thermo acoustic effect takes place at the surface.

Other important aspects that need to be considered are the material and thickness. Higher the conductivity of the material better will be the heat conduction. Hence low heat conductivity material is preferred. Above that more the thickness of the material more will be the formation of eddy current at the end of stack which causes loss.



2.5.Heat Exchanger

Heat transfer for constant force has extensively been studied but in thermo acoustic refrigerator the flow is oscillatory and heat exchanger design for such flow is challenging. They are made up of copper and the cross section is made similar to that of the stack. The porosity is also the same as that of the stack to maintain the velocity. The experiments performed by various scientist conclude that heat transfer coefficient of the heat exchanger is the maximum when the mean pressures are high and at the resonant frequencies where the dynamic pressure is maximum.



2.6.Working Fluid

Choice of the working fluid which fills the resonator will depend on the resonant frequency, viscous penetration depth and thermal penetration depth. The most desirable characteristics of the working fluid is high ratio of specific heat and small Prandtl number. Prandtl number is the square of the ratio of viscous penetration depth to the thermal penetration depth and hence smaller the Prandtl number lesser is the viscous penetration compared to the thermal penetration. Several experiments conducted by scientists reveal that design applications should be kept in mind when selecting a working fluid. The working fluid density should also be kept in mind since more the working fluid density lesser is the cooling power of the system and hence there's a trade of between efficiency and cooling power.

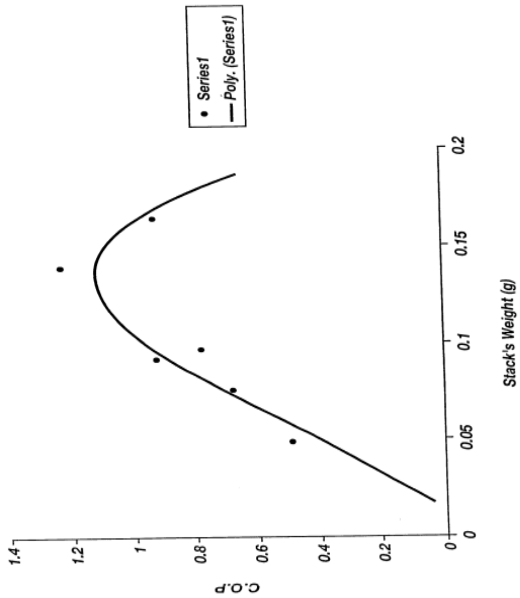


Fig. 17

3. EFFECT OF VARIATION OF PARAMETERS

In order to select and optimum design to produce maximum temperature difference across the stack. The design parameters involved in a piezo-electrically driven thermoacoustic refrigerator have been varied and analyzed under different conditions using delta EC software to pin point the condition under which temperature difference is maximum.

3.1. Frequency of acoustics

As the power in the thermo acoustic device is the linear function of the acoustic resonance frequency an obvious choice is thus high resonance frequency.

RESULT

i. The gas present in resonator tube is deciding the performance of the refrigerator.

1. Resonator tube temperature is constant without stack.
2. Presence of the stack affects the temperature division along resonator.
3. Maximum temperature gradient across the stack is dependent on the position of the stack and input power.

Conclusion

We set upon this project with the simple goal of creating a cheap demonstrative model of a thermo acoustic refrigerator. It was revealed that finding the optimal frequency is essential for maximum efficiency .The optimal frequency was found using trial and error method. Another factor that increased efficiency was the proper sealing of the apparatus. If they are not properly sealed heat escapes from the refrigerator and it doesn't function well. Our research shows that piezo electrically driven thermo acoustic refrigeration has the potential to replace the conventional refrigeration.

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