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Thermo Acoustic Refrigeration and Cooling Effects

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ABSTRACT

This paper will discuss the development of a thermo acoustic setup to create cooling effect by utilizing sound energy, and its performance, thermoacoustic refrigeration is an emerging refrigeration technology which does not require any moving parts or harmful refrigerants in its operation. This technology uses acoustic waves to pump heat across a temperature gradient.one of the applications is thermo acoustic refrigeration. It is a technology in which it does not contain any harmful and moving parts. This system works on temperature gradient of sound waves. It has two subcategories one is forward effect which deals with pressure oscillations by generation of heat. This helps in producing thermo acoustic engine. another one is reversed effect which deals with acoustic waves to heat pump. This effect is used to create thermo acoustic refrigerator.

Keywords : Thermal Acoustic Effect, Working Fluid, Thermo Acoustics, Piezo Electric effect, Drivers

I. INTRODUCTION

Thermoacoustic deals with the study of the inter relationship between heat and sound. A Thermoacoustic refrigerator is an arrangement that brings out the effect of cooling by means of using high intensity sound waves. The sound waves of high intensity are regarded to be pressure pulsations. These pressure pulsations come in contact with the stack material that is placed inside a resonator tube. The sound waves travel inside the resonator tube leading to the formation of standing wave. The interaction between the original wave and the wave reflected back causes expansion and rarefaction of the sound waves.

This causes the heat transfer across both the ends of the stack. By the usage of proper heat exchangers on.

II. DESIGN OVERVIEW

2.1 Speaker:

Fig.2.1 Speaker

The driver of the Thermoacoustic refrigeration system is one of the major components as it creates the sound waves of high intensity. The frequency of the sound waves to be sent into the resonator is set by means of using the function generator. After amplifying the waves in the amplifier, it is sent through the loudspeaker. The driver is connected with the resonator tube such that the sound waves from the loudspeaker at the pre-set frequency are passed into the resonator. The loudspeaker must be properly insulated to avoid anyleakage ofthesound waves.

2.2 Resonator:

The high intensity sound waves from the loudspeaker travel through the resonator. The resonator contains the working fluid. The waves interact with the stack inside the tube, where the heating and cooling across the ends are produced. There should be minimal losses at the resonator. The resonator may be of half wavelength type and quarter wavelength type and with or without buffer volume of various geometries of the stack is essential to get maximum difference in temperatures.

Fig 2.2. Resonater

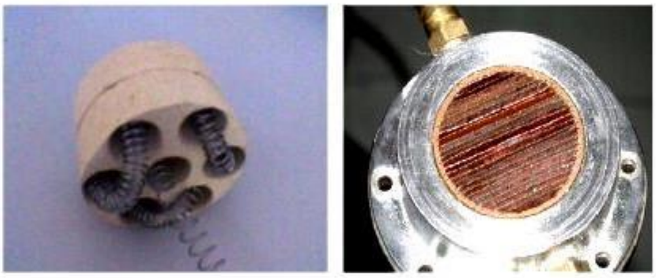
2.3 Stack

The stack is the part of the system placed inside the resonator where the thermoacoustic effect takes place. In the stack, the acoustic power is converted into heat. The amount of heat produced is predominantly dependent on the material properties of the stack such as the thermal conductivity, heat carrying capacity, the porosity and the length of the stack. The position of the stack in the resonator also decides the amount of refrigerant that can be obtained.

Fig 2.3 Stack

2.4 Heat Exchangers

Heat exchangers are placed on the stack at either ends of the stack and enable the transfer of heat produced from the stack ends. Optimal design of the stack is essential to get maximum difference in temperatures.



(b) (hot heat exchanger) (c) (cooling heat exchanger)

2.5 Working Fluid

The working fluid is filled inside the resonator. Generally, noble gases are used as the working fluid. The fluid is usually filled with high pressure. Atmospheric air can also be used as the working fluid.

To achieve high efficiency gas with low kinematic viscosity is preferred this viscosity is shown by inert gases like Xenon, Helium etc. Due to low kinematic viscosity the gas molecules are free to vibrate even in a small portion which results in high utilization of gas molecules to participate in heat transfer. Since inert gases has issue like cost, refilling, leakages etc. High pressure air can also use as working medium. Thermal penetration depths & the natural frequency of the resonator are also dependent on the choice of working fluid.

III. WORKING

Thermo acoustic refrigerator is a special kind of device that uses energy of sound waves or acoustic energy to pump heat from low temperature reservoir to a high temperature reservoir. The source of acoustic energy is called the „driver which can be a loudspeaker. The driver emits sound waves in a long hollow tube filled with gas at high pressure. This long hollow tube is called as 'resonance tube' or simply resonator. The frequency of the driver and the length of the resonator are chosen so as to get a standing sound wave in the resonator. A solid porous material like a stack of parallel plates is kept in the path of sound waves in the resonator. Due to thermo acoustic effect (which will be explained in detail in the animation), heat starts to flow from one end of stack to the other. One end starts to heat up while other starts to cool down. By controlling temperature of hot side of stack (by removing heat by means of a heat exchanger), the cold end of stack can be made to cool down to lower and lower temperatures. A refrigeration load can then be applied at the cold end by means of a heat exchanger.

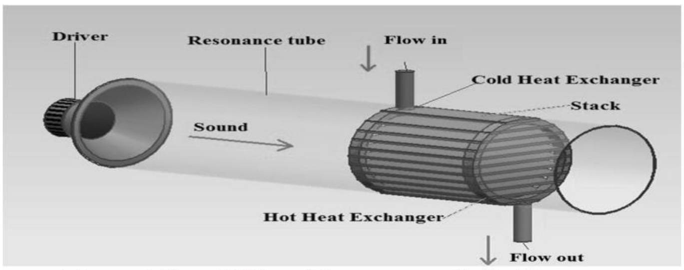


Figure 1 Sound Wave Thermoacoustic Refrigerator

Fig 3.Working of thermoacoustic refrigerator

IV. COOLING EFFECT

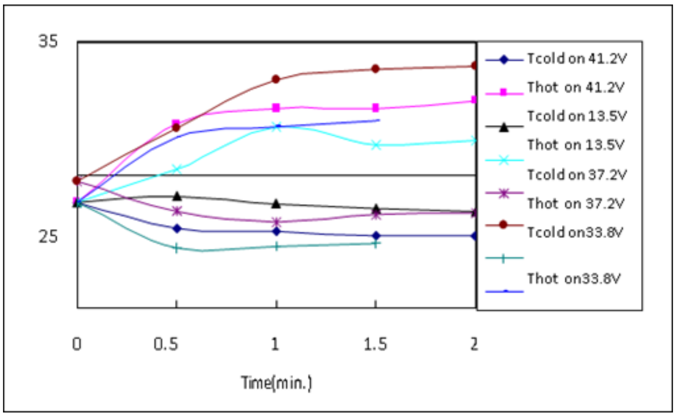
Production of the thermo acoustic cooler has started after long periods of design work. Large portions of time were spent understanding the complex behavior and interaction between the thermo acoustic elements of the cooler. Using cheaper materials and lower tolerances for thicknesses of the stack we should have a cooler that is near enough to the optimal design and significantly cheaper, with new understanding of thermo acoustics now appreciate the relative simplicity of important elements irrespective of the mathematical complexity. In light of this device that are constructed

and able to produced cooling effect. The device can able to reduce the temperature up to 4-5°C and produce 10-12°C temperature difference between the cold and hot end. Thermo acoustic cooling is a relatively new technology and has only been investigated by a relatively small number of researchers. Industry has been reluctant to fully develop thermo acoustics without a clear demonstration of the competitive performance of actual prototypes and without a broader understanding of the best applications. One of the next steps to spur development of this technology is to demonstrate the performance potential for a range of applications and to identify the most promising applications for this technology. These are the long-term goals associated with the ongoing research activities.

V. EXPERIMENTAL RESULTS

shows typical results for the temperatures above the stack (T hot) and below the stack (T cold) as a function of time. The starting temperatures were normalized to 23°c, so the plot shows the changes in temperature as measured by each thermocouple. To produce this plot the thermocouple leads were connected to a two-channel digital oscilloscope with a

1.5 minute capture time. The plot shows that the temperature below the stack (T cold) begins decreasing immediately after the sound is turned on, dropping
2 °C in the first 30 seconds, with the rate of temperature change decreasing with time. After 1.5 minutes of operation the temperature below the stack has dropped by 2.3°C and is still decreasing. The temperature above the stack (T hot) increases, also more rapidly at first, as the heat is being pumped through the stack. After approximately 0.5 minutes the temperature above the stack has increased by 5 °C. After that it stops increasing as the rate at which heat is moved through the stack equals the rate at which heat is conducted through the Perspex plate into the surrounding room. After 1.5 minutes of operation, the temperature difference between the top and bottom of the stack is about 9.9 °C, a difference large enough to be detected by touching a finger along the outside of the acrylic tube. Figure 4 shows typical results for the variation of the temperature with the applied voltage. When the variation of the temperature increases the applied voltage will also increases.



VI. ADAVANTAGES AND DISADVANTAGES

Adavantages :

- ✓ No moving parts for the process,so very reliable and a long life span.
- ✓ Environmentally friendly working medium (air,nobale gas).
- ✓ Use of simpal materials with no special requirements,which are commercially available in large quantities and therefore relatively cheap.
- ✓ Haemful chemicals like CFC's,HFC's, and HCFC's are not released in to atmosphere.
- ✓ Mechanically simple.
- ✓ Relatively compact and light in weight.

Disadvantages:

- ✓ COP is less when compared with the present cooling systems.
- ✓ Tharmoacoustic cooling system is currently less efficient then the traditional system

VII. CONCLUSION

It has been built a thermoacoustic cooling system with two stacks in a straight resonance tube. The tube is a half-wavelength resonator with one end is closed by a rigid plug and the other end is closed by a plastic diaphragm. It wasfound a range of operating frequency of sound which give a maximum temperature decrease. This operating frequency was slightly below the calculated resonance frequency for ahalf-wavelength tube. The magnitude of temperature decrease was roughly proportional to the input electric power of the loudspeaker. The temperature decrease of the cooling point near the diaphragm is smaller than that of the cooling point near the rigid end. It is suggested to make abetter diaphragm, or modify the loudspeaker so that it can give a better cooling at cooling point near the diaphragm. The investigation on the influence of stack location yield that the temperature decrease of the cooling points 1 and 2tend to be greater when each of the stacks are placed nearer to each end of the tube.

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