Thermoacoustic Refrigeration

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Abstract - **The Thermoacoustic refrigerator is a machine which potentially can replace the current refrigerating devices in a large scale. One of the very foremost reasons for that is it is environment friendly. Also due to less moving parts it is very reliable and has a long life span. Conventional refrigerators use refrigerants to carry heat from lower temperature reservoirs to higher temperature reservoirs. The refrigerants generally used are CFC's, ammonia etc., which are harmful to the environment. In Thermo-acoustic refrigerators these harmful CFC's are not used which makes it eco-friendly. The term thermo-acoustic represents conversion heat energy into sound energy and vice versa. The basic working principle of this device depends on sound waves to generate pressure waves that will alternately expand and compress the gas particles within a tube. This will further lead to a cooling effect. The basic design outline, components and working principle of the thermoacoustic refrigerator are discussed in this paper.**

keywords - **Refrigerator,Thermo-acoustic**

I. INTRODUCTION

Late advancements in the field of thermo acoustics guarantee to alter the manner in which that numerous machines at present work .By controlling the temperature-changes along the acoustic longitudinal waves , a machine can be made that can supplant current refrigeration and cooling gadgets. These machines can be coordinated into fridges, boiling water warmers, or space radiators and coolers. The thermo acoustic gadgets contain no unfavorable synthetic concoctions or ecologically perilous components that are attributes of current refrigeration frameworks.

Thermo acoustics manages the change of warmth vitality to sound vitality and the other way around. There are two sorts of thermo acoustic gadgets: thermo acoustic motor (or prime mover) and thermo acoustic fridge. In thermo acoustic motor, heat is changed over into sound vitality and this vitality is accessible for helpful work. In this gadget, heat streams from a source at higher temperature to a sink at lower temperature. In a thermo acoustic fridge, the turn around of the above procedure happens, i.e., it uses work (as acoustic capacity) to retain heat from a low temperature medium and reject it to a high temperature medium.

II. THERMOACOUSTIC PHENOMENON

Acoustic waves experience displacement motions, and temperature motions in relationship with the weight varieties. So as to deliver thermo-acoustic impact, these motions in a gas ought to happen near a strong surface, with the goal that warmth can be moved to or from the surface. Pile of firmly divided parallel plates is set inside the thermo-acoustic gadget so as to give such a strong surface. The thermo-acoustic wonder happens by the cooperation of the gas particles and the stack plate. At the point when huge temperature angles are made over the stack, sound waves are created for example work is delivered as acoustic power (framing a thermo-acoustic motor). slope at the divider is little or zero, this procedure is called heat siphoning (or refrigeration). The figure follows the fundamental thermo-acoustic cycle for a parcel of gas, an assortment of gas particles that demonstration and move together. Beginning from point 1, the bundle of gas is compacted and moves to one side. As the parcel is compacted, the sound wave works on the bundle of gas, giving the ability to the cooler. At the point when the gas parcel is at most extreme pressure, the gas discharges the warmth once more into the stack since the temperature of the gas is currently higher than the temperature of the stack. This stage is the refrigeration part of the cycle, moving the warmth more distant from the base of the cylinder. In the second period of the cycle, the gas is come back to the underlying state. As the gas bundle move back the sound wave extends the gas. Albeit some work is extended to restore the gas to the underlying state, the warmth discharged on the highest point of the stack is more prominent than the work extended to restore the gas to the underlying state. This procedure brings about a net exchange of warmth to one side of the stack. At last in stage 4, the parcels of gas reabsorbed heat from the cold reservoir.The heat move rehashes and henceforth the thermoacoustic refrigeration cycle happens as follows.

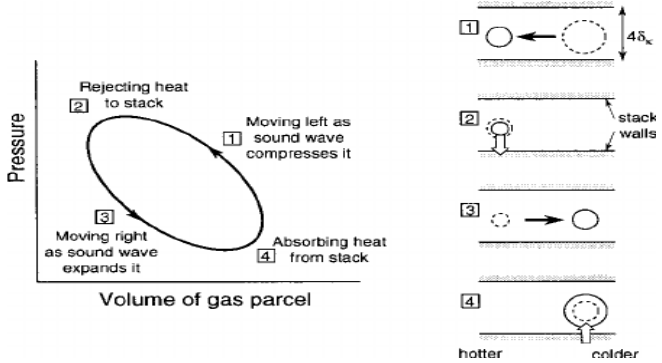

Fig.2.1.Thermoacoustic Cycle

At the end of the third process, the temperature of the gas parcel is less than the wall temperature.

III. PROBLEM DESCRIPTION

In today's world refrigerator has become the need of common society. Basically modern refrigerators operate on VCR system which is quiet efficient but utilizes harmful refrigerants [once chlorofluorocarbons (CFCs), now hydrofluorocarbons (HFCs)] which are ozone depleting chemicals which are major cause of concern. Also it possesses moving parts which reduces its service life & undoubtedly increases its maintenance life. So here we have made an attempt to not only replace the existing refrigeration system but also to make it suitable w.r.t environment affability and provide efficient means of refrigeration which would be not only cost efficient but also maintenance free at its most suitable level.

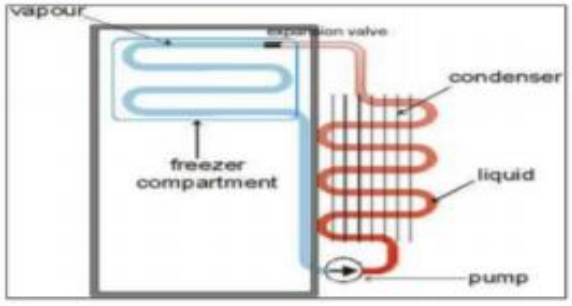

Fig.3.1.Conventional VCR System

IV. ENVIROMENTAL AFFABILITY

No environmental hazardous refrigerants are required and just dormant gases that are naturally protected and reasonable are utilized. The worldwide limitation on the utilization of CFC (chlorofluorocarbon) and incredulity over the substitutions of CFC, gives thermoacoustic gadgets an extensive favorable position over customary fridges. The gases utilized in these gadgets are (for example helium, xenon, air) innocuous to the ozone and have no nursery impact. It is normal that sooner rather than later, guidelines will be harder on the ozone depleting substances. The mindfulness about the damaging impacts of CFC on the consumption and the restricting of the CFCs generation, lead the specialists to locate an elective answer for this issue. In this situation, thermo-acoustic fridge could be the most reasonable possibility to supplant the ordinary fume pressure refrigeration frameworks. Likewise, the thermo-acoustic cycle additionally loans itself well to a more proficient corresponding control instead of the crude parallel control that ordinary coolers as of now utilize. These reasons make thermo-acoustic fridge conceivably alluring for far reaching use.

V. OVERVIEW OF DESIGN

Thermo acoustic refrigerator mainly consists of a medium as a working gas, a speaker (sound generator), resonator, stack, heat exchangers.

5.1. Working Medium gas

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.

5.2. Acoustic Driver

Acoustic Driver is the source of acoustic waves which is also known as Acoustic driver. The acoustic driver produces high pressure sound waves. Just like a compressor in vapour compression cycle (VCR), acoustic driver is heart of thermo acoustic refrigerator. Sound waves are produce due to vibration of flexible cone or diaphragm. The diaphragm is made up of plastic, paper, metal etc. & narrow end of the coil is attached to the coil which produces sound name as voice coil. The voice coil contains two magnets namely permanent magnet & electromagnet. The audio signal transmits or travels in the form of waves it may be transverse & longitudinal. These waves are further travels through stack.

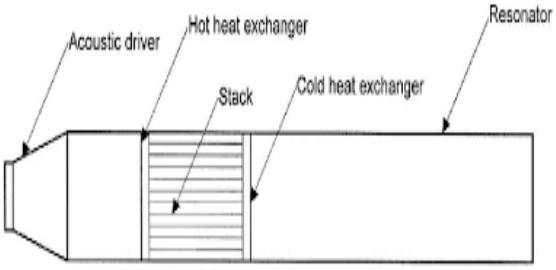

Fig.5.2.1.Acoustic Driver

5.3. Resonator

The resonator is a device which contain working medium in it. There are two types of resonator half wavelength and quarter wavelength. Half wavelength resonators are the resonators which are open at one end and close at one end. Due to closed end the gas inside the resonator cannot move due to which velocity node and pressure anti-node is not form. The acoustic driver creates velocity node and pressure anti-node which causes the natural frequency to be half of acoustic wavelength. Quarter wavelength resonator tubes are made by sealing one end and making the length approximately one quarter of the desired resonant frequency wavelength. A large volume is attached at the open end which creates boundary conditions of zero pressure at the end

which cause velocity node and pressure anti-node at the end of the tube. This indicates that natural frequency of resonator will have wavelength four times the resonator length. Mainly thermo acoustic resonators used are half wavelength or quarter wavelength.

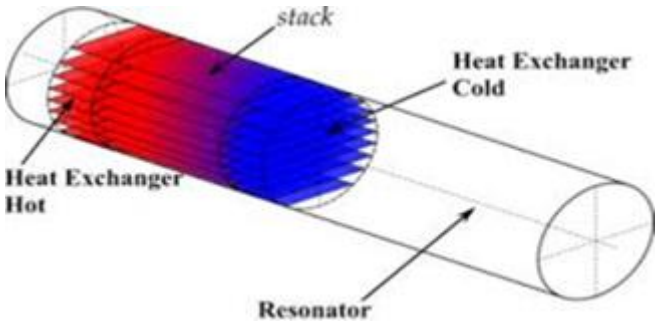

Fig.5.3.1 Resonator

5.4. Stack

Stack is the element where thermo acoustic effect happens. It is the most delicate piece of the plan in thermo acoustic fridge since little change in measurements of the stack can lead enormous contrast it the presentation. The proficiency of the thermo acoustic fridge relies upon the stack. This issue emerges in light of the fact that there is point inside the resonator where speed and weight motions cooperate to amplify thermo acoustic impact. Since this point is imperceptibly little whose cross area is additionally little which would create no cooling impact if stack is worked at just this point. The cooling power and the productivity of cooler is contrarily relative to one another, as the length of stack expands the cooling intensity of thermo acoustic fridge increments however the proficiency diminishes, since the further cross areas of the stack are from ideal point. The stack materials utilized are of low warm conductivity and have high warmth limit. Material utilized for stack is photographic flim or Mylar sheet. There are two sorts of stack arrangement parallel plate stack and winding stack. The another thought while planning stack will be stack thickness, since it ought to give adequate warmth limit yet the thickness must be diminish so that there must no blockage in the stack. On the off chance that blockage would present, at that point the acoustic wave would not go through the stack and in the event that the thickness is excessively thick, at that point there would be development of vortexes close to the stack.

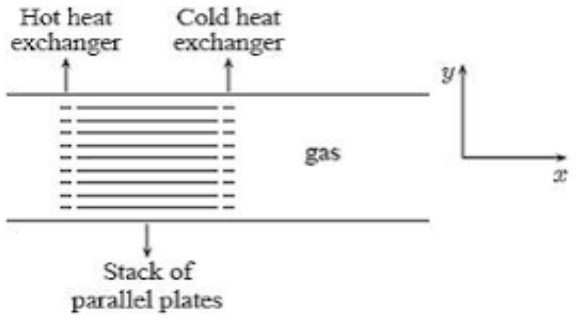

Fig.4.4.1.Stack of Parallel Plates

5.5. Heat Exchanger

Heat exchanger is a component or a device which is use to transfer thermal energy between fluids, it may be two or more than two. There is no external heat or work interaction in heat exchanger. The working of heat exchanger is to remove the heat from high temperature source. In thermo acoustic refrigerator the heat exchanger is used to remove the heat from the stack so that temperature is maintain as per requirement. In thermo acoustic refrigerator two heat exchangers are required one work as hot heat exchanger and other work as cold heat exchanger.

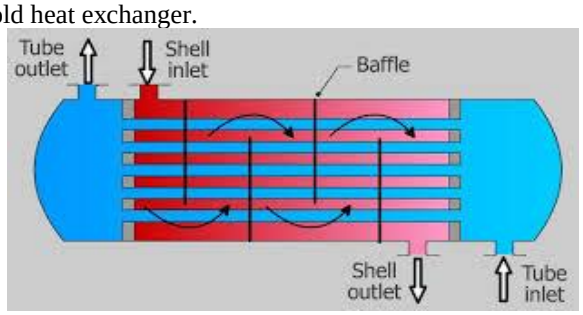

Fig.5.5.1.Heat Exchanger

VI. CONCLUSION

We set out upon this project with the simple goal of constructing a cheap, demonstrative model of a thermo-acoustic refrigerator. To this end we succeeded: this experiment proved that thermo-acoustic refrigerators indeed work. Additionally, this experiment did yield some discoveries regarding the efficiency of thermo-acoustic refrigeration. It was revealed that finding the optimal frequency is essential for the maximization of efficiency. This optimal frequency was found using trial-and-error, because the equation used to calculate frequency was ineffective. Another factor that increased efficiency was the proper sealing

of the apparatus. If the parts are not properly sealed, heat escapes from the refrigerator, and it does not function as well. However, the overall efficiency of such an apparatus is debatable. Our research shows that thermo-acoustic refrigeration has the potential to replace conventional refrigeration.

VII. FUTURE SCOPE

The utilization of cheap, family unit things to develop the coolers could clarify such low productivity materials were utilized, it is conceivable that the factor that could be balanced for streamlining. The stack works best when it is focused on a district in the cylinder where the standing wave delivers the most noteworthy weight (and warm) powers. Exploring different avenues regarding various frequencies and stack arrangements could yield more noteworthy proficiency. We additionally presumed that the shape and length of the resonator tube was a main consideration in the proficiency of the gadget. Enhancements to the resonator cylinder would include further examination into the impacts that contrastingly molded cylinders would have on the thermo-acoustic impact. Maybe a resonator tube which was decreased to center the power of the wave and in this way increment both the weight and temperature most extreme would expand viability. Be that as it may, as expressed above further research is required to find out the resonator tube state of most extreme effectiveness. Other cylinder factors that ought to be investigated incorporate cylinder breadth and length. Because of the relationship between's the resonator tube and the recurrence utilized these two variables would need to be tried different things with at the same time. In the event that pinnacle effectiveness was to be accomplished, the most ideal arrangement is model the acoustic properties by computer simulation and predict efficient tube-frequency combinations in that manner.

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