IMPACT SYUDY ON ACOUSTIC WAVES AS A REFRIGERANT

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ABSTRACT

This paper examines the effectiveness of thermo acoustic refrigeration, which is the theory of using sound waves as a coolant. The work reported here deals with the design and optimization of a thermo acoustic-refrigerator (TAR) as an attempt to address the future generation environment friendly energy systems.

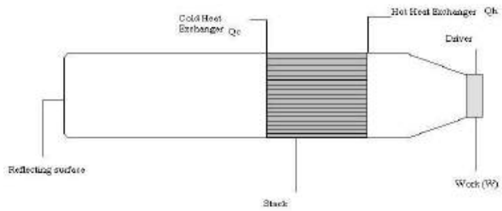
INTRODUCTION

Recent developments in the field of thermo acoustics promise to revolutionize the way that many machines currently operate .By manipulating the temperature-changes along the acoustic longitudinal waves , a machine can be created that can replace current refrigeration and air conditioning devices. These machines can be integrated into refrigerators, hot water heaters, or space heaters and coolers. The thermo acoustic devices contain no adverse chemicals or environmentally unsafe elements that are characteristics of current refrigeration systems.

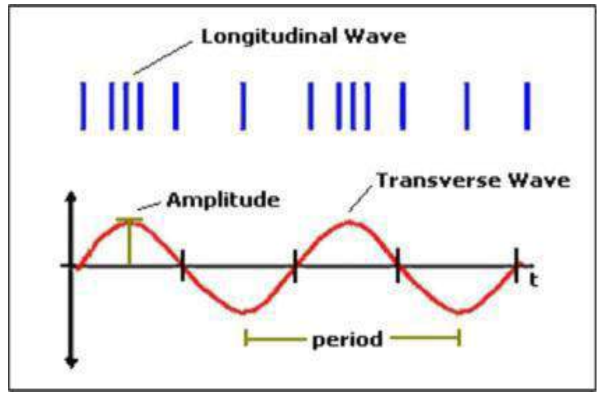
Thermo acoustics deals with the conversion of heat energy to sound energy and vice versa. There are two types of thermo acoustic devices: thermo acoustic engine (or prime mover) and thermo acoustic refrigerator. In thermo acoustic engine, heat is converted into sound energy and this energy is available for useful work. In this device, heat flows from a source at higher temperature to a sink at lower temperature. In a thermo acoustic refrigerator, the reverse of the above process occurs, i.e., it utilizes work (in the form of acoustic power) to absorb heat from a low temperature medium and reject it to a high temperature medium.

THERMODYNAMIC DESIGN CONSIDERATION & ACTUAL WORKING

The configuration of standing-wave thermo acoustic refrigerators is simple. A standing-wave TAR comprises a driver, a resonator, and a stack. The practical device also utilizes two heat exchangers; however, they are not necessary for creating a temperature difference across the stack.



The driver, which is often a modified electro dynamic loudspeaker, is sealed to a resonator. Assuming the driver is supplied with the proper frequency input, the resonator will respond with a standing pressure wave, amplifying the input from the driver. The standing wave drives a thermo acoustic process within the stack. The stack is so called because it was first conceived as a stack of parallel plates; however, the term stack now refers to the thermo acoustic core of a standing-wave TAR no matter the core's geometry. The stack is placed within the resonator such that it is between a pressure antinode and a velocity antinode in the sound wave. Via the thermo acoustic process, heat is pumped toward the pressure antinode. The overall device is then a refrigerator or heat pump depending on the attachment of heat exchangers for practical application. A temperature gradient can be created along the stack with or without heat exchangers. The exchangers merely allow a useful flow of heat. If the hot end is thermally anchored to the environment and the cold end connected to a heat load, the device is then a refrigerator. If the cold side is anchored to the environment and the load applied at the hot end, the device operates as a heat pump. In ;p any case, a few simple parts make up the thermo acoustic device, and no sliding seals are necessary.



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 hydro fluorocarbons (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.

VAPOUR-COMPRESSION REFRIGERATION CYCLE

The vapour-compression refrigeration cycle is the most widely used cycle for refrigerator, air-conditioning systems, and heat pumps. It consists of four thermodynamic processes, and involves four main components: compressor, condenser, expansion valve, and evaporator. The refrigerant enters the compressor as a saturated vapour at a very low temperature and pressure. The compression process takes place inside the compressor. Both the refrigerant becomes superheated vapour at the exit of compressor. The heat transfer process takes place in the condenser at a constant pressure, where heat is transferred from the refrigerant to the high-temperature medium. As a result is a small decrease in the temperature of the refrigerant as it exits the condenser.

ENVIRONMENTAL AFFABILITY

No environmentally hazardous refrigerants are needed and only inert gases that are environmentally safe and suitable are used. The international restriction on the use of CFC (chlorofluorocarbon) and skepticism over the replacements of CFC, gives thermo acoustic devices a considerable advantage over traditional refrigerators. The gases used in these devices are (e.g. helium, xenon, air) harmless to the ozone and have no greenhouse effect. It is expected that in the near future, regulations will be tougher on the greenhouse gases. The awareness about the destructive effects of CFC on the depletion and the banning of the CFCs production, lead the researchers to find an alternative solution to this problem. In this scenario, thermo acoustic refrigerator could be the most suitable candidate to replace the conventional vapor-compression refrigeration systems. In addition, the thermo acoustic cycle also lends itself well to a more efficient proportional control rather than the primitive binary control that conventional refrigerators currently employ. All of these reasons make thermo acoustic refrigerator potentially attractive for widespread use.

EXPERIMENTAL SETUP

The components of the thermoacoustic refrigerator are designed, and the many design parameters are selected in current chapter. In this chapter fabrication of the thermoacoustic refrigerator is described, which is followed by the description of the experimental setup, instrumentation and methods for the measurements in the fabricated refrigerator.

ACOUSTIC DRIVER

A thermoacoustic cooling device requires an acoustic driver attached to one end of the resonator, in order to create an acoustic driver attached to one end of the resonator, in order to create an acoustic standing wave in the gas at the fundamental resonant frequency of the resonator. The acoustic driver converts electric power to the acoustic power. In this study, a loudspeaker with the maximum power of 15 watts, and impedance of 8Ω at the operating frequency (450 Hz) is used as the acoustic driver (G 50 FFL, VISATON). The loudspeaker is driven by a function generator and a power amplifier to provide the required power to excite the working fluid inside the resonator. Efficiency of this type of loudspeaker is relatively low, and their impedances are poorly matched to gas when the pressure inside the resonator is high. Consequently, the range of pressure amplitudes inside the resonator is limited

STACK

The most important component of a thermoacoustic device is the stack inside which, the thermoacoustic phenomenon occurs. Thus, the characteristics of the stack have a significant impact on the performance of the thermoacoustic device. The stack material should have good heat capacity but low thermal conductivity. The low thermal conductivity for the stack material is necessary to obtain high temperature gradient across the stack and a heat capacity larger than the heat capacity of the working fluid. In addition, the stack material should minimize the effects of viscous dissipation of the acoustic power.

The stack is made from mylar sheet of thickness 0.13 mm. The mylar sheet was cut into pieces each of 3 cm wide. The spacing between the layers is filled by fishingline spacers (0.36 mm thick) glued onto the surface of the sheet. The mylar sheet is wound around a 4 mm PVC-rod to obtain a spiral stack as shown in above figure.

WORKING FLUID

Many parameters such as power, efficiency, and convenience are involved in the selection of the working fluid, and it depends on the application and objective of the device.

Thermo acoustic power increases with an increase in the velocity of sound in the working fluid. The lighter gases such as 2, He, Ne have the higher sound velocity. Lighter gases are necessary for refrigeration application because heavier gases condense or freeze at lower temperature, or exhibit non ideal behavior.

ACOUSTIC RESONATOR

The acoustic resonator is built from a straight acrylic tube of length 70 cm. The internal diameter of the tube is 6.3 cm and the wall thickness is 6 mm. One end of the tube has a plate attached to install the speaker frame. At the other end, a movable piston is placed inside the resonator. The reason for having a movable piston is to adjust the length of resonator so as to change the fundamental frequency of the resonator.

ELECTRONIC DEVICES

An amplifier (MPA-25, Realistic) with the maximum power output of 20 watts is used to amplify the power input to the loudspeaker to increase power input.

THERMOCOUPLE

J-type thermocouples is used for the temperature measurements in this study. They are used to measure the temperature at different locations inside the resonator and the temperature of heat exchanger fluids. The specifications of the thermocouple are given below:

Thermocouple grade :- 0 to 150 ℃

Limits of Error:-1.0 ℃ or 0.75% above 0℃.

TEMPERATURE INDICATOR

50 Hz, 200-240V temperature indicator

PVC CAP SEALINGS & ALUMINIUM END PLUG

PVC pipes are made to contain the speakers, along with threads to make air tight zones. Aluminium eng plug is placed at the end of the resonator tube to dissipate the heat generated.

FUTURE SCOPE

The use of inexpensive, household items to construct the refrigerators could explain such low efficiency. If other materials were used, it is possible that the factor that could be adjusted for optimization. The stack works best when it is centered on a region in the tube where the standing wave produces the highest pressure (and thermal) forces. Experimenting with different frequencies and stack placements could yield greater efficiency. We also concluded that the shape and length of the resonator tube was a major factor in the efficiency of the device. Improvements to the resonator tube would involve further research into the effects that differently shaped tubes would have on the thermo-acoustic effect.

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-acousticrefrigeration.

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