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Designe of a Thermoacoustic Refrigeration System

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ABSTRACT

This project 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 of a thermo acoustic refrigerator (TAR) as an attempt to address the future generation environment friendly energy systems. From creating comfortable home environment to manufacturing fast and efficient electronic devices, air conditioning and refrigeration remain essential services for both homes and industries. It is becoming increasingly important in the design and development of refrigerating systems to consider environmental impacts. To eliminate the use of environmentally hazardous refrigerants, research efforts are focusing more on the development of alternative refrigerants and alternative refrigeration technologies conventional refrigerator.

Keywords:- Acoustical Theory, VCR System, Cooling agent, Heat Exchanger.

I. INRODUCTION

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. This can be no harmful and friendly with environmental.

Refrigeration is the science of producing and maintaining temperatures' below that of the surrounding temperature. Until the begin of the twenty-first century, CFC's were widely used as refrigerants. The use of CFC's is banned acknowledging its harmful effects on the environmental. This led to the evaluation of HCFC's and HFC's. However these two have disadvantages. Both have high cost of production and contribute to global warming.

Thermoacoustic refrigeration is one such green idea for refrigeration.

Literature Survey

1. M Wetzel-1997.cited by 133

Thermo acoustic refrigeration was developed during the past two decades as anew, environmentally safe refrigeration technology the operation of TAR employs acoustic power to pump heat.

2. LK Tartibu.2015.cited by.4

This work proposes a objective multi objective optimization approach to model and optimize small scale standing wave TAR.

1. METHODALOGY

1.1. ACOUSTIC THEORY

The understanding of acoustic wave dynamics, i.e. the pressure and velocity fields created by an acoustic wave, is necessary to understand the working of a Thermo acoustic device. The acoustical theory deals with the study of the longitudinal acoustic waves. The longitudinal acoustic waves are generated as a result of the compression, and expansion of the gas medium. The compression of a gas corresponds to the crust of a sine wave, and the expansion corresponds to the trough of a sine wave.

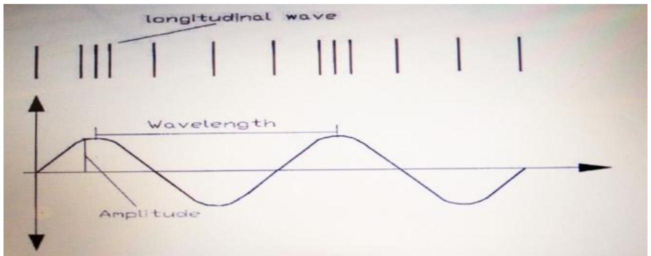


Fig2. Comparison of a longitudinal acoustic wave with a sine wave (thesis, Concordia university)

1.2. 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.

1.2. 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

1.4. OBJECTIVES

Even though thermo acoustic devices have been known for 35 years, there are several aspects which are not well understood. The gas behavior inside the resonator tube, its interaction with the solid surface (e.g. stack plate, Heat exchanger) and its effect on the heat transfer are not known. Better understanding of the fundamental process is necessary to improve the design of these devices. As a first step, which is the objective of this thesis project; analyzing, designing and fabricating a simple and fundamental prototype thermo acoustic refrigerator and test it to study the performance? As far as we know, the work presented in this thesis is the first research on thermo acoustic devices done at any Canadian University.

II. DESIGN AND IMPLEMENTATION STRATEGY

2.1. BASIC REFRIGERATION THEORY

The refrigerator is a device that transfers heat from a low temperature medium to a higher temperature using external work input. The working fluid used in the refrigerator is called the refrigerant. The refrigeration process is based on the first and second law of thermodynamics, and its operation is based on the thermodynamic refrigeration cycles. The most commonly used refrigeration cycles are the vapor compression type.

2.2. VAPOR COMPRESSION REFRIGERATION CYCLE

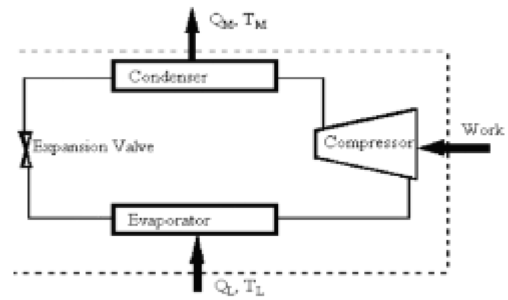
The vapor compression refrigeration cycle is the most widely used cycle for refrigerator, air conditioning systems, and heat pumps. It consists of four thermodynamic processes and involves four main components: compressor, condenser, expansion valve, and evaporator.

The refrigerant enters the compressor as a saturated vapor at a very low temperature and pressure (state 1).

The compression process takes place inside the compressor. Both the refrigerant becomes superheated vapor at the exit of compressor (state 2).

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 (state 3).

The four processes of ideal vapor compression refrigeration cycle are plotted on TS diagram in Fig. 2.1



III. DESIGN CONSIDERATIONS

3.1. Thermal conductivity of different metals

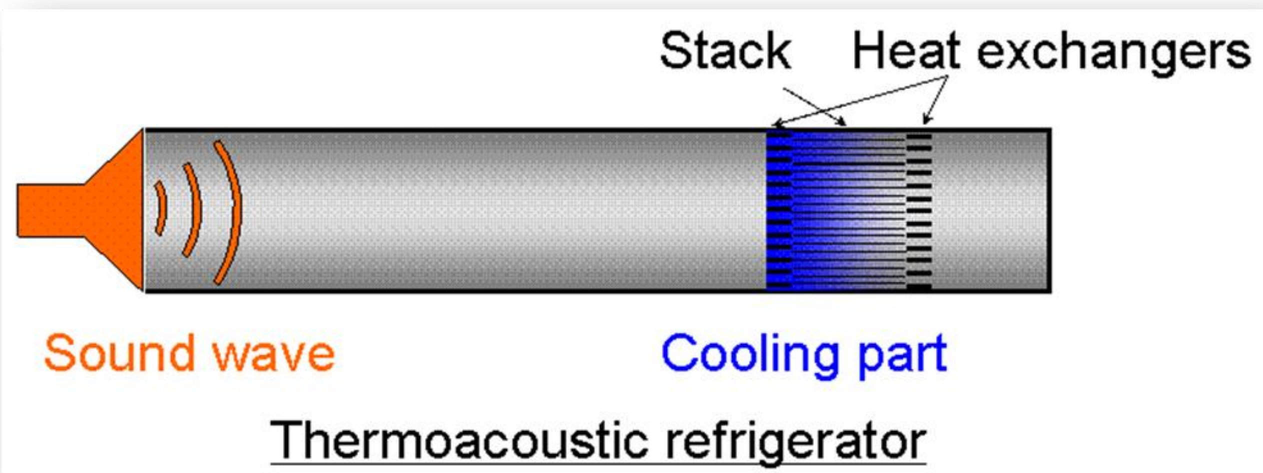
Material	Thermal conductivity(cal/sec)(cm^2c/cm)	Thermal conductivity (w/my)
Copper	0.96	385.0
Gold		314.0
Brass		109.0
Aluminum	0.50	205.0

3.2. Dimensions of a parts

Shapes	Outside diameter(mm)	In side diameter(mm)	Thickness(mm)	Length (mm)	Height (mm)
Straight pipe	40	30	5	1000	40
Nozzle-diffuser	40	30	5	93	40
Throttle	30	20	5	5	30
T-coupling	40	30	5	82	60
Stacks	_	_	0.5	56	20

3.3. Construction and Working of TAR

The configuration of standing wave thermo acoustic refrigerators is simple. 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 pressure antinodes and velocity antinodes in the sound wave. Via the thermo acoustic process, heat is pumped toward the pressure antinodes. 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 the environment and the load applied at the hot end, the device operates as a heat pump. In any case, a few simple parts make up the thermo acoustic device, and no sliding seals are necessary. Behavior of Gas Molecules First, the gas parcel undergoes adiabatic compression and travels up the channel due to the acoustic wave. The pressure increases by twice the acoustic pressure amplitude, so the temperature of the parcel increases accordingly. At the same time, the parcel travels a distance that is twice the acoustic displacement amplitude. Then the second step takes place. When the parcel reaches maximum displacement, it is has a higher temperature than the adjacent walls, assuming the imposed temperature gradient is sufficiently small. The parcel adiabatically expands as the pressure becomes a minimum, reducing the temperature of the gas. The gas reaches its maximum excursion in the opposite direction with a larger volume and its lowest temperature.



IV. EXPERIMENTAL PARTS

4.1. ACOUSTIC DRIVER

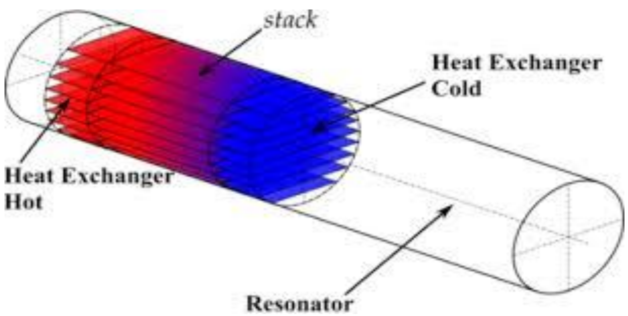
Acoustic driver is loud speaker It is an electro acoustic loud transducer that produces sound in response to an electrical audio signal input. It was invented in the mid1820'sby the scientist John Philipp Reis. The magnet or coil in the speaker vibrates to produce waves of required frequency.

4.2. Stacks

Materials that have a low thermal conductivity is desired because heat conducting across the stacks works against the refrigeration. The material must also have a heat capacity much larger than the heat capacity of the working fluid so that sustained temperature gradient may be created.

4.3. Heat Exchanger

Heat exchangers are a devices used to transfer heat energy from one fluid to another. The media may be separated by solid wall, so that they never mix.



V. CONCLUSION

In future let us hope that this thermo acoustic device it promise to improve standard of living while helping to protect the plan by completely eliminating the use of refrigerants. Thermo acoustic and refrigerates were already been considered a few years ago for specialize application, where there simplicity, lack of lubrication and there use of environmentally harmless working fluids were adequate compensation for their lower efficiencies.

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