Thermo Acoustic Refrigeration- A Review

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Abstract - Usage of refrigerants in producing cooling effect has been increasing in last few decades. Although their COP is high but their harm to earth is more. Even in some cases they are hazardous materials. Cost is also a major factor in this kind of refrigeration. For these reasons, it is necessary to go for alternative cooling which is non-hazardous, cheap in cost. In this context, thermo-acoustic refrigeration [TAR] is one of the alternative which helps in reducing the usage of refrigerants. In this paper we presented the quality of work that has been done by various authors so far in the field of TAR System .Thermo acoustic uses sound waves for production of refrigeration.

Keywords — Alternate source of refrigeration, Refrigeration, Thermoacoustic, Sound waves, Non-hazardous, Stack.

I. INTRODUCTION

Refrigeration, the science of producing cooling effect and maintaining sub temperatures has been playing a significant role in various fields like comfort, preservation etc., for the past few decades and its demand is increasing is increasing day by day. Due to requirement of cooling, refrigerants have been evolved which shows considerable effect on earth by increasing global warming and by depleting ozone layer. Although, research has been started on refrigerants with no harm but it's still in infant stage. In this context, it is necessary to look for alternative source that produces cooling effect with less harm.

Hence, for producing refrigeration Thermo acoustic refrigeration provides us a way to reduce the use of harmful refrigerants by utilizing sound waves for production of refrigerating effect.

Authors [1-10] have worked on TAR systems by varying different properties to find out the maximum possible performance of the system.

II. PRINCIPLE

A. Principle of sound waves:

Sound waves travels in form of compressions and rarefactions in the medium in which they travel (in Thermoacoustic system medium is gas).

B. Joule-Thomson effect:

When the pressurized air suddenly expands it produces cooling effect. This is because, when a hole is made on air tube due to pressure difference air tries to move from high pressure tube to low pressure atmosphere. Thus, the pressurized air uses its internal energy to come out of small aperture and there by produces cooling effect outside aperture.

III. PARTS

Thermoacoustic refrigeration system essentially consists of acoustic driver, stack, working gas, buffer volume and a resonator.

A. Acoustic Driver

Acoustic Driver is basically an electronic device which produces sound. This is heart of whole-system and without this no refrigeration effect is produced.

B. Working gas

Gas is like blood in body. Typically, gas is inert type which may be Helium or Argon because of its low viscosity. Air with higher pressure can also be used as air exhibits low viscosity at higher pressures but it involves in strong construction of system for safety.

C. Stack

It is the main part which is responsible for creation of cooling effect. It consists of a mesh like structure through which gas expands on expense of internal energy and creates cooling effect. The material used for stack should have low thermal conductivity and high heat capacity as it produces temperature gradient in the system. It is of spiral structure and parallel plate structure.

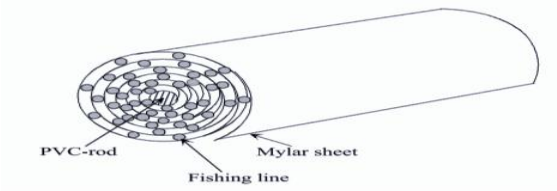
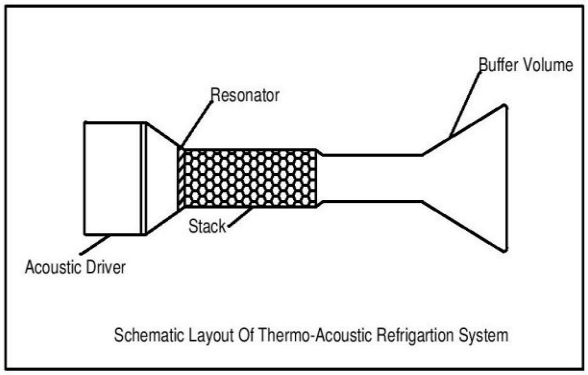


Fig.: Spiral stack structure et al [2]



D. Buffer volume

To sustain energy of sound waves a buffer volume is placed at end of tube. It has property that, for same diameter as tube, it should have long length. For increasing diameter, it is of small length. High frequency sound waves need more volume to make system balanced. Otherwise, the whole construction will fail.

E. Resonator

Resonator is nothing but a vibrator that produces required frequency of waves necessary for gas flow.

IV. WORKING

When electricity supplied to acoustic driver, the sound waves are produced. These sound waves are allowed to pass through the resonator which will amplify the sound wave frequency. As the working gas we are using is Helium or Argon, amplified sound waves pushes the gas through the Stack. due to the Joule-Thomson effect, we can obtain cooling effect on Buffer volume side and heat is produced in between Stack and Resonator.

V. APPLICATIONS

Several heat-driven TARS are currently in the design stages for the applications like a refrigerator for storage of medical supplies and vaccines in Bangladesh, a solar driven refrigerated cargo container for transportation of tropical fruits, and a natural gas liquefaction plant. Work on electrically powered TAR has been concentrated on laboratory experiments and spacecraft applications.

At the present time, Ford Motor Company is developing Thermo Acoustic Refrigerators for proprietary applications. Naval Post Graduate school [NPS] is currently developing two refrigerators. One is a third-generation, single-stage thermoacoustic cryocooler (TAR-3) which is designed to reach high-T, superconductor transition temperatures. The other is TALSR, which is capable of producing cooling comparable to commercial domestic refrigerator/freezers. TALSR was also designed for use on-board the Space ShuttleI81. Due to the simplicity of its operation and the use of only one moving part, TAR is also be suitable for cooling the latest generation of computer chips which can run at twice their room temperature design speeds when their temperature is reduced to -50°C. [1]

Two examples of refrigerators that were built and tested at NPS are: The Space Thermo acoustic Refrigerator (STAR), which was designed to produce up to 80K temperature difference over the stack, and to pump up to 4 watt of heat. The STAR was launched on the space shuttle Discovery in 1992. The second setup is the Shipboard Electronics Thermo Acoustic Cooler (SETAC) that was used to cool radar electronics on board of the warship USS Deyo in 1995. It was designed to provide 400watt of cooling power for a small temperature span, which is similar to a domestic refrigerator/freezer system. At Pennsylvania State University, a large chiller called TRITON is being developed to provide cooling for Navy ships. It is intended to produce a cooling power of about 10 kW which means that it can convert three tons of water at 0^0C to ice at the same temperature in one day [5].

VI. LITERATURE REVIEW

AUTHOR	YEAR OF PUBLICATION	ABOUT PAPER	CONCLUSION ABOUT PAPER
Steven L. Garrett, Thomas J. Hofler, and David K. Perkins [1]	1993	The paper gives brief introduction to possibility of Thermoacoustic refrigeration and gives view about how the temperature difference was created in system. The paper also gives the information about basic structure of system and application areas.	This paper gives sufficient evidence that there is an alternate way for production of refrigeration.

M.E.H. Tijani, J.C.H. Zeegers, A.T.A.M. de Waele [2]	2001	In this paper, authors give complete information about the construction of each part of system along with the dimensions and material used. Performance of the system is also calculated and variation in Carnot and actual cycle are observed. It also shows temperature at cool end w.r.t. time.	This experimental analysis proved that Thermoacoustic refrigeration can be used in creation of refrigeration effect and one of the alignments that is to be used for the system.
G.B. Chen, J.P. Jiang, J.L. Shi, T. Jin, K. Tang, Y.L. Jiang, N. Jiang, Y.H. Huang [3]	2002	In this paper, author experimentally analysed that, Buffer volume has a significant impact on frequency of waves. The paper also shows the effect on frequency w.r.t. resonator distance.	This experimental analysis has further gives the information about the system that frequency of waves changes w.r.t. buffer volume as well as resonator distance
N.M. Hariharan, P. Sivashanmugam, S. Kasthurirengan [4]	2013	In this paper, authors experimentally analysed the effect on temperature w.r.t. distance of stack from resonator by using mylar and photographic sheet as stack materials.	This analysis gives us the information about temperature change by changing the stack distance when experimental setup was constructed by a standing wave twin thermoacoustic prime mover.
Ratish Sawant, Sandesh Rasal, Gaurav Yadav, Arunkumar Yadav, Darshan Kadam [7]	2015	In this paper, author gives overall view of parts i.e., part and its characteristics and has given the exact view of experimental setup for Thermoacoustic refrigeration	This paper gives the overall idea about parts of system and actual experimental setup.

VII. CONCLUSION

Thermo-Acoustic refrigeration is one of the refrigerating process in which we will use sound waves. This can be used where there is excess noise. By observing the work done by various respective authors we can understand that Buffer volume , position of stack from resonator are effecting the temperatures' in the system there by performance. But, Further research need to be done on various parts of the system in order to make use of this kind of refrigeration in as many areas as possible.

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