Thermo acoustic refrigeration
Introduction

Basics of Refrigeration

Basics of Thermoacoustic Refrigeration

Thermoacoustics

Main Parts

Advantages, Disadvantages and Applications of TAR

Conclusion
Over the past two decades, physicists and engineers have been working on a class of heat engines and compression-driven refrigerators that use no oscillating pistons, oil seals or lubricants.

Thermo acoustic devices take advantage of sound waves reverberating within them to convert a temperature differential into mechanical energy or mechanical energy into a temperature differential.
A refrigerant is a compound used in a heat cycle that undergoes a phase change from a gas to a liquid and back.
Disadvantages of conventional refrigerator

- Uses harmful refrigerants like ammonia, CFC’s and HFC’s
- Refrigerants if leaked causes the depletion in the ozone layers.
- Refrigerants are costly.
- The moving parts like the compressors require lubrication.
- Leakage of refrigerant may result in adverse human health effects including cancers, cataracts, immune system deficits, and respiratory effects, as well as diminish food supplies and promote increases in vector borne diseases.
Steven L. Garrett

- Leading Researcher
  United Technologies Corporation Professor of Acoustics
  The Pennsylvania State University.
- He invented the thermoacoustic refrigerator in the year 1992 and that TAR was used in the space shuttle Discovery (STS-42).
The principle can be imagined as a loud speaker creating high amplitude sound waves that can compress refrigerant allowing heat absorption.

The researches have exploited the fact that sound waves travel by compressing and expanding the gas they are generated in.

Suppose that the above said wave is traveling through a tube.

Now, a temperature gradient can be generated by putting a stack of plates in the right place in the tube, in which sound waves are bouncing around.
Some plates in the stack will get hotter while the others get colder.

All it takes to make a refrigerator out of this is to attach heat exchangers to the end of these stacks.
THERMOACOUSTIC REFRIGERATOR

resonator tube

hot heat-exchanger sub-system

electric loudspeaker

thermoacoustic stack

cold heat-exchanger sub-system

thermoacoustic cooling device
Standing wave
Thermoacoustic Refrigerator

**Working**

- Hot compressed gas at the right end of stack.
- Heat loss to stack. Stack temperature rises.
Working (contd..)

- Gas expands while moving to left and cools.

- Cold gas takes heat from stack. Stack becomes colder.
Working (contd..)

- Temp gradient across the stack is established.

- Circulating fluid picks up/loses heat at the heat exchangers.
THERMOACOUSTIC CYCLE

1. Releasing heat to stack
2. Moving left as sound wave compresses it
3. Moving right as sound wave expands it
4. Absorbing heat from stack

Pressure

Volume of gas parcel

hotter colder
MAIN PARTS

Two main parts are in the TAR

1. Driver
   Houses the Loudspeaker

2. Resonator
   Houses the gas
   The hot and cold heat
   exchangers
   Houses the Stack
LOUDSPEAKERS
- It is also called as regenerator.
- The most important piece of a thermoacoustic device is the stack.
- The stack consists of a large number of closely spaced surfaces that are aligned parallel to the resonator tube.
- In a usual resonator tube, heat transfer occurs between the walls of cylinder and the gas.
Heat exchangers are devices used to transfer heat energy from one fluid to another.
ADVANTAGES OF TAR

- No moving parts for the process, so very reliable and a long life span.
- Environmentally friendly working medium (air, noble gas).
- The use of air or noble gas as working medium offers a large window of applications because there are no phase transitions.
- Use of simple materials with no special requirements, which are commercially available in large quantities and therefore relatively cheap.
- On the same technology base a large variety of applications can be covered.
**DISADVANTAGES OF TAR**

- **Efficiency**: Thermo acoustic refrigeration is currently less efficient than the traditional refrigerators.
- **Lack of suppliers producing customized components.**
- **Lack of interest and funding from the industry due to their concentration on developing alternative gases to CFCs.**
- **Talent Bottleneck**: There are not enough people who have expertise on the combination of relevant disciplines such as acoustic, heat exchanger design etc.
Liquefaction of natural gas.

Chip cooling

Electronic equipment cooling on naval ships

Electricity from sunlight

Upgrading industrial waste heat
In future let us hope these thermo acoustic devices which promise to improve everyone’s standard of living while helping to protect the planet might soon take over other costly, less durable and polluting engines and pumps. The latest achievements of the former are certainly encouraging, but there are still much left to be done.
THANK YOU

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