THERMOACOUSTIC REFRIGERATION

Description of technology

Thermoacoustic refrigeration systems operate by using sound waves and a non-flammable mixture of inert gas (helium, argon, air) or a mixture of gases in a resonator to produce cooling. Thermoacoustic devices are typically characterised as either ‘standing-wave’ or ‘travelling-wave’. A schematic diagram of a standing wave device is shown in figure 1. The main components are a closed cylinder, an acoustic driver, a porous component called a "stack, and two heat-exchanger systems. Application of acoustic waves through a driver such as a loud speaker, makes the gas resonant. As the gas oscillates back and forth, it creates a temperature difference along the length of the stack. This temperature change comes from compression and expansion of the gas by the sound pressure and the rest is a consequence of heat transfer between the gas and the stack. The temperature difference is used to remove heat from the cold side and reject it at the hot side of the system. As the gas oscillates back and forth because of the standing sound wave, it changes in temperature. Much of the temperature change comes from compression and expansion of the gas by the sound pressure (as always in a sound wave), and the rest is a consequence of heat transfer between the gas and the stack.

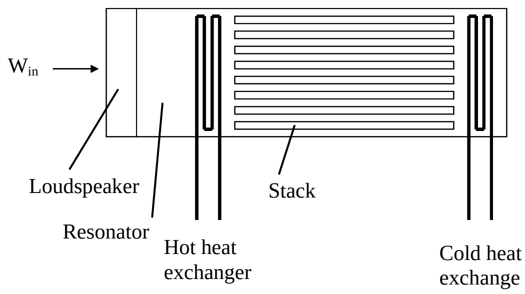

Figure 1 Sound wave Thermoacoustic engine

In the travelling-wave device, the pressure is created with a moving piston and the conversion of acoustic power to heat occurs in a regenerator rather than a stack. The regenerator contains a matrix of channels which are much smaller than those in a stack and relies on good thermal contact between the gas and the matrix. The design is such that the gas moves towards the hot heat exchanger when the pressure is high and towards the cold heat exchanger when the pressure is low, transferring heat between the two sides. An example of a travelling wave thermoacoustic device is the Ben & Jerry ice-cream cabinet, figure 2.

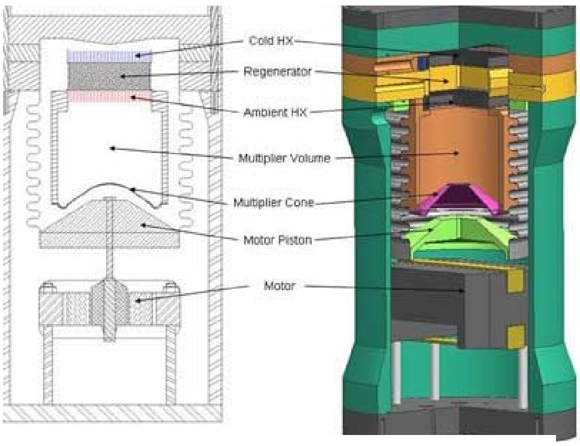

Figure 2. A travelling-wave thermoacoustic refrigerator (Source: Sounds Cool! The Ben & Jerry's Project, 2005)

State of Development

A number of design concepts and prototypes are under development in many research establishments. The technology has the potential to offer another refrigeration option but improvements in design are necessary to increase COPs to the level of vapour compression systems. Research effort is currently directed to the development of flow-through designs (open systems) which will reduce or eliminated the use of heat exchangers.

Potential applications in the food sector

Thermoacoustic refrigerators have the potential to cover the whole spectrum of refrigeration down to cryogenic temperatures. It is likely that potential market for food applications will be in the low capacity equipment such as domestic and commercial refrigerators, freezers and cabinets.

Barriers to uptake of the technology

The main barriers to the uptake of thermoacoustic technology are:

- in their present state of development the efficiency of prototype therrmoacoustic refrigeration systems is lower than that of vapour compression systems.

- systems operating on the thermoacoustic principle are not yet commercially available.

Key drivers to encourage uptake

The main drivers to encourage uptake of thermoacoustic technology in the food sector are:

- environmental considerations and legislation that significantly limits or prohibits the use of HFCs in small capacity, self contained refrigeration equipment.
- limits imposed on the amount of flammable refrigerant that can be used in self contained refrigerated cabinets.
- development of systems that offer efficiency and cost advantages over vapour compression systems.

Research and development needs

To improve efficiency and reduce cost, developments are needed in the design of stacks, resonators and compact heat exchangers for oscillating flow. Research is also required in the development of flow-through designs (open systems) which will reduce or eliminated the use of heat exchangers and will reduce complexity and cost.