Thermoacoustic heat pump for office heating

Within the Netherlands, there is about 35 million m$^2$ of office building area. The energy use for heating these buildings amounts to yearly 20 PJ or 630 million m$^3$ of natural gas.

Energy savings can be realised when use is made of a heat pump. With this concept heat from an environmental source (usually the ground) is upgraded in temperature level for heating purposes.

Existing heat pumps are not able to provide high temperature lifts and must be applied in combination with low temperature (50/30) heating systems.

A thermoacoustic heat pump (TAHP) is able to reach a much larger temperature lift up to 100ºC in an efficient way. This makes it possible to apply a heat pump in combination with an existing high temperature (90/70) heating system. A TAHP works on the physical phenomenon that an acoustic wave can create a temperature difference and pump up heat from a low to a high temperature level. The reverse phenomenon in which an acoustic wave is generated from a temperature difference is called a thermoacoustic (TA) engine.

This scheme shows the application of a TAHP in an office building. The TA-engine is driven by a burner and cooled by the water of the central heating system. The temperature difference between these two creates an intense sound wave. This sound wave drives the TA-heat pump. In this component the heat from the ground heat exchanger is upgraded to the usable temperature level of the return stream of the central heating system.
Although the working principle of thermoacoustic technology is quite complex, the practical implementation is relatively simple. This offers great advantages with respect to the economic feasibility of this technology. Other advantages are:

- No moving parts for the thermodynamic cycle, 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.

ECN is working with her partners on the development of a new thermoacoustic system that is based on the combination of some new components together with a patent on very efficient configuration. This system makes it possible to apply this heat pump in combination with an existing (high temperature) heating system in a cost effective way.

The energy savings that can be realised with this technology depend on the efficiency of the existing installation and the efficiency that can be achieved by the thermoacoustic components. The aim is to reach a saving of about 40% compared to the existing energy use. For an average office of 2000 m² this means a yearly saving of 430 GJ or 12,300 m³ of natural gas.

This principle will be first demonstrated on a 5-20 kW scale. This picture shows a test installation of a TA-engine drive by a natural gas burner. If these tests are successful, the technology will be scaled up to a desired power level of 60 kW till several hundreds of kW.

Want to know more?

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