Recovering low-temperature waste heat and converting it into electricity

August 26 2015

Heat loss is one of the main challenges in power production—whether from conventional or renewable sources. The trouble is that the wasted energy often stems from limitations of the power conversion process. In a typical gas or coal-fired power plant, about 40% to 50% of the input energy from the fuel is wasted as heat. In a typical combustion engine, the loss is even larger: almost 65% is lost in exhaust gases and in the engine cooling circuit. In industrial processes, a lot of heat is also wasted under the form of hot fumes or liquids.

Now, part of the solution may lie in recovering waste heat. This is a cheap way of increasing the overall efficiency of power generating and industrial processes and, ultimately, to lower fuel demand. Industrial processes often produce enough waste heat to generate electricity. If the waste heat is relatively low-temperature, a technology called organic rankine cycle (ORC) comes into the picture. Here, Vincent Lemort, assistant professor at the Thermodynamics Laboratory at the University of Liege, Belgium, explains how an ORC-unit can make a difference; particularly in renewable energies.

Why is ORC especially interesting for low-temperature waste heat?

Low-temperature heat (below 100 degrees Celsius) is produced massively, for example in industrial processes, internal combustion engines, geothermal sources and solar ponds. The low-temperature heat is converted into useful work, which can itself be converted into electricity.

The organic rankine cycle is based on the principle as a conventional steam cycle: a working fluid is pumped up, evaporates, passes through an expander and finally re-condenses. It typically relies on an organic fluid with a high molecular mass, which means that the liquid-to-vapour transition is occurring at lower temperature than the water-to-steam change (more or less 100 degrees). In our case, the working medium we use is a chlorine free substance, which is not susceptible to deplete the ozone layer.

How much power can this approach generate?

One ORC unit is capable to generate a power output ranging from a few kilowatts to more than 90 megawatts. Waste heat with a temperature above 100°C is just enough to drive the ORC cycle process.

The heat recovery process will add to the efficiency of the overall process. In turn, this will decrease the costs of fuel and energy consumption needed for that process. Besides waste heat recovery, ORC units are typically used in combined heat and power (CHP) units in geothermal power plants. Solar applications are still a more limited market.

Is this technology likely to be applied to energy efficiency buildings?

We are a partner in BRICKER, a European Project which aim is to reduce energy consumption of existing public buildings, by using cutting-edge technology. We participate in one of the three demonstration projects, namely the renovation of the Institut Supérieur Industriel

Liégeois, a department of the Haute Ecole de la Province de Liège, in Belgium. There, an ORC unit (supplied by the Spanish company Rank) fed by a biomass boiler will be installed, after which it will generate both heat and electricity as a means to get primary energy savings.

Which buildings are more likely to benefit from such technology?

Usually, CHP units in buildings are economically profitable provided they are run more than 4,000-5,000 hours per year. This number of hours is function of the ratio of the prices of electricity and gas or biomass and of the electrical efficiency of the CHP unit. Meeting this criterion, in terms of number of hours, it all depends on the annual heating demand curve of the building and on the size of the unit. The building types covered in BRICKER are typically large public buildings with centralised heat production – the ORC units used in the demo project are not designed for individual households.

What kind of challenges does this technology present before it can be more widely adopted? Are there also limitations to its adoption?

The economical profitability of such a CHP system compared to a conventional heating plant is certainly a big challenge. This profitability will be impacted by the performance of the CHP unit integrated into the building. Besides the design of the unit itself, appropriate control strategies will have to be implemented. They are investigated in the frame of the project.

How can the ASME ORC Event help you develop this technology?

This event is the opportunity to meet specialists of the development of

ORC systems, components and controls as well as specialists of the integration of ORC systems in diverse applications, including CHP systems. Their feedback in relation to our research will be really valuable.

Provided by Youris.com