Fraunhofer IPM

RO-TEG

Thermoelectric waste heat recovery directly on the pipe

Round design – cost-effective, compact and efficient

Thermoelectric modules perfectly adapted to the geometry of pipes are able to convert waste heat into electricity or act as Peltier coolers to control the temperature of media flowing in pipes with high precision.

When it comes to reaching ambitious energy saving targets, the use of waste heat plays a key role in many industrial sectors and applications. Thermoelectric generators (TEGs) are capable of converting waste heat directly into electrical energy, with no mechanical motion. However, most TEGs are plate-shaped, whereas heat-carrying fluids flow through round pipes. With the launch of the RO-TEG, Fraunhofer IPM now offers a TEG that is optimally designed to be built directly around the pipes.

Thermoelectric waste heat recovery

Waste heat accumulates in industrial settings, private households, and transportation, and all too often it goes unused. Particularly large amounts of waste heat are generated by furnaces, foundries, hardening plants, forges and industrial incineration and drying plants. Thermoelectric generators (TEGs) convert this heat directly into electricity very efficiently, meaning they are capable of making a key contribution to the energy transition.

Thermoelectric systems are very robust and operate without any need for moving parts. Their modular structure makes them easily scalable and adaptable to different sources of waste heat. These systems provide an alternative to turbines and generators, particularly when it comes to applications involving fluctuating loads and varying operational conditions, with average outputs of up to a few kilowatts. Their use in furnaces is another particularly promising application. In this case, thermoelectrically generated electrical power can be used to operate self-powered control systems, fine dust separators, or other system components such as circulation pumps.

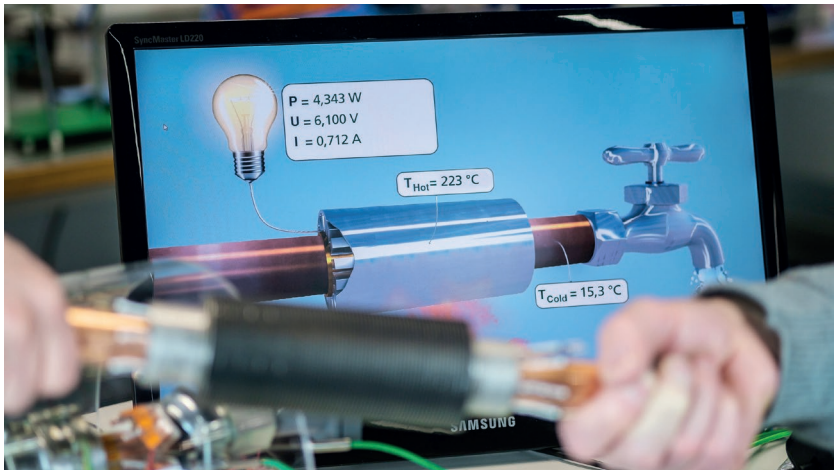
Round design for optimized, cost-effective pipe integration

TEGs are traditionally plate-shaped, whereas heat-carrying fluids flow through round pipes in many industrial processes. In practice,

Our offer

Tailor-made thermoelectric modules and systems for waste heat recovery and temperature control

- Customized consultation and studies
- Simulation and development: from mW to kW
- Structural characterization of modules and structures, using techniques such as 3D computed tomography
- Thermoelectric characterization, e. g. measuring performance of modules and systems at defined temperatures and heat flows (also as long-term tests)



Performance data of a first RO-TEG prototype during operation. A temperature difference of approximately 200 K between the hot and cold sides generates 4.3 W of electricity.

pipes (e. g. in the conventional, robust shell-and-tube heat ex changers) are being replaced by expensive, flat, high-maintenance heat exchangers and pressed against the thermoelectric modules resulting in a large solid structure. With RO-TEG Fraunhofer IPM offers a TEG with a new, round design. The assembly method (patent pending) is cost-optimized and enables waste heat recovery with minimum construction effort and low costs. RO-TEG was developed as a ready-to-use demonstrator.

Flexible and adjustable for maximum waste heat yield

The core component of the TEG is the legs made from semiconductor material. These are positioned in a star shape between an inner and an outer pipe. The manufacturing process means it can be used on pipes with additional heat transfer structures such as finned outer pipes. The RO-TEG marks a paradigm shift in waste heat recovery, with its compact structure and prospective investment costs of less than one euro per watt of producible electrical power.

A further advantage of the RO-TEG is that the thermal resistance can be very flexibly adapted to external heat transfer resistances (impedance adjustment), as the number of thermoelectric legs per surface can be easily altered. For every specialized application, an optimum system can be developed to maximize waste heat usage.

Thermoelectric systems based on the RO-TEG can be used for waste heat recovery in a wide variety of ways:

- In shell-and-tube heat exchangers, such as those used in central heating, small-scale furnaces, combined heat and power plants and ships
- In pipelines in process chemistry, plastic production, and the pharmaceutical industry, to achieve an electrically self-sufficient and resilient supply of cost-effective sensor technology, including wireless data connection
- In domestic and industrial heat meters

Wood-burning stoves are one application example that has already been implemented at Fraunhofer IPM. Their emissions (fine dust, harmful gases) are subject to ever stricter regulations for environmental reasons. Thermoelectrically generated electricity can be used to power electrostatic separators and / or combustion control systems, without any need for an external power supply connection. The furnace itself delivers the energy required for low-emission operation.

Peltier cooling

The structure of the RO-TEG means it can also be used as a Peltier cooler to very precisely, quickly and locally control the temperature of media flowing in pipes. This has all the same benefits, including a compact, low-cost structure, small thermal transfer resistances due to being directly connected to the pipe, and the ability to be flexibly adjusted.

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