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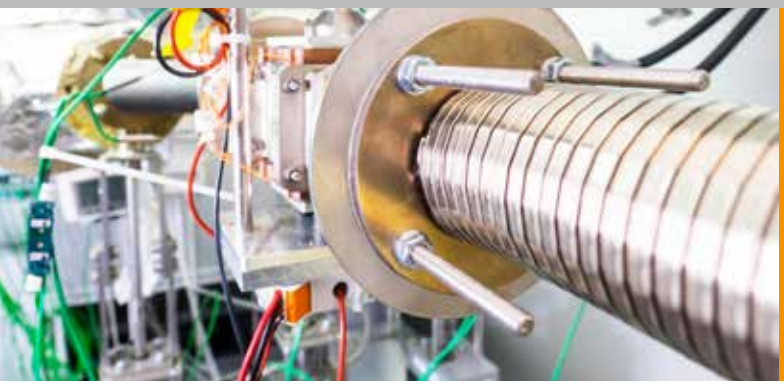
FRAUNHOFER INSTITUTE FOR PHYSICAL MEASUREMENT TECHNIQUES IPM



1 *Using the hot air test stand, heat exchangers are reliably characterized.*
2 *Numerous operating parameters such as air temperature, mass flow rate or coolant temperature can be adjusted*

HOT AIR TEST STAND

MEASURING THE EFFICIENCY OF HEAT EXCHANGERS

Heat exchangers are a key component in many thermal systems. When air or gas flows through the heat exchanger, a pressure difference is generated. For optimum system design, it is crucial to know the heat delivery and thermal efficiency in relation to back-pressure and flow velocity for each heat exchanger. In the conversion of a heat flow to electricity, it is also important to determine the system's efficiency. How much energy is generated in relation to the transferred heat flow?

Validation of simulations by experimental proof

Optimal system design is essential in order to use heat or waste heat as efficiently as possible. To this end, the heat exchanger and waste heat recovery technologies have to be adjusted to the conditions of the waste heat source and heat sink (e. g. cooling circuit). This is frequently done with the help of simulation models and calculations. For novel system designs or optimizations, however, experimental proofs are essential for validation. For this purpose, Fraunhofer IPM has built a hot air test stand that allows to comprehensively characterize the performance of heat exchangers and waste heat recovery technologies. The test stand permits a complete balancing of energy flows and thus creates the basis for system optimizations.

Reproducible adjustment of operating parameters

Using the heat air test stand, heat exchangers and systems for waste heat recovery, such as thermoelectric generators (TEG), are characterized at different operating points. The air volume flow and air mass flow rate, air input temperature,

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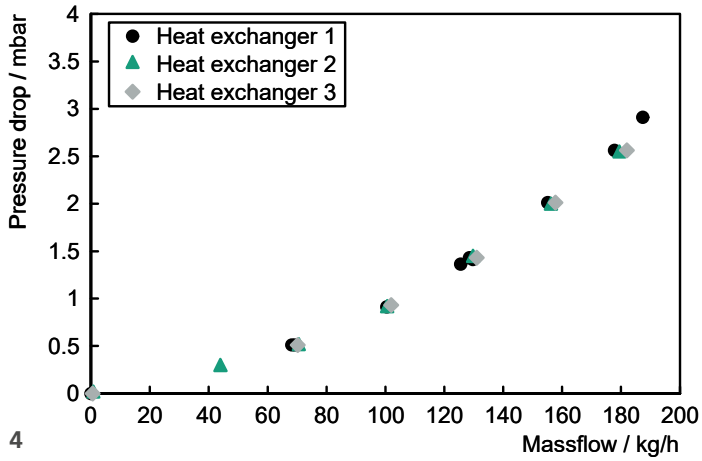

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3 *Heating the air flow using electrical heaters.*

4 *Exemplary measurement: characterization of a hot air heat exchanger with regard to pressure drop at room temperature.*

coolant inlet temperature and also the coolant volume flow can be varied. Measuring is done under controlled laboratory conditions; all relevant operating parameters can be adjusted reproducibly. Suitable ring measurement gauges are used to measure the air input and output temperature as well as the pressure drop over the heat exchanger. The integration of additional thermocouples also allows determination of the temperature distribution, for example, in the longitudinal direction of the heat exchangers.

Typical measurement scenarios

- Balancing air side/coolant side, determining heat flow (W), heat transfer coefficient (W/m²·K), pressure drop (mbar) for a device under test in thermal short circuit and with built-in thermoelectric modules (TEM)
- Measuring hot/cold side temperatures of TEM with additional thermocouples
- Measuring open circuit voltage of TEM within the system
- Measuring maximum electric output power of TEM when using a maximum power point tracker (MPPT)
- Measuring heat transfer in heat pump operation (air/air; air/cooling water)
- Measuring temperature distribution, heat flow etc. – e. g. using a thermal imaging camera or heat flow meter

Technical specifications

Hot air heating power	up to 60 KW
Max. hot air temperature at the device inlet	600 °C (depending on mass flow rate)
Volume flow rate	approx. 40 – 300 m³/h
Cooling/heating power for the device cooling circuit	up to 5,5 kW
Coolant inlet temperatures	5 – 80 °C

All specifications and features are subject to modification without notice.

Cooperation: Our offer

As our customer, you can use our hot air test stand for system optimization and validation. Together with you, our experts will develop test services individually tailored to your needs. Our service includes concept development, implementation and documentation as well as interpretation of the results and the derivation of improvement measures.

In addition, our offer includes:

- Thermal simulations: stationary and dynamic under different boundary conditions – using appropriate software tools (e. g. COMSOL Multiphysics®, Simscape™)
- Prototype construction with modern CAD/CAM systems in an in-house mechanical workshop

Thermoelectric systems

- Design, construction and characterization of thermoelectric modules
- Design, construction and characterization of TEG/TEG systems and heat exchangers and development of customer-specific prototypes