TECHNISCHE UNIVERSITÄT DRESDEN

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ImpactGas: Experimental Investigation of Plate Heat Exchangers

Effects of Atmospheric Gases on the Efficiency of Heating and Cooling Supply Components

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Are Gases a Problem?

It is widely known that the atmospheric gases N_2 and O_2 affect the operational safety and service life. These gases enter the systems, e.g. due to a lack of care during commissioning or maintenance, circulate there and impair the function of the main components.

But how serious is the effect on efficiency?

- Pressure losses (auxiliary energy demand)
- Heat transfer (efficiency or COP)

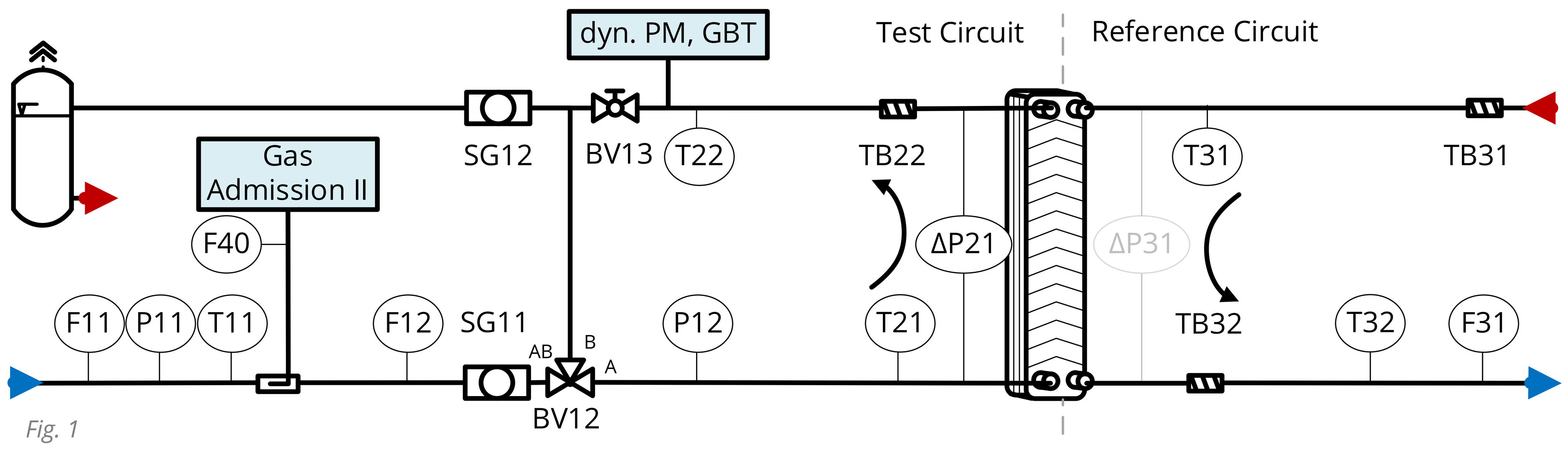

Fig. 1

Concept/Methodic

The experiments took place at the ImpactGas component test stand (see Fig. 1 and 2). The gas-free Reference Circuit serves as the heat source for the Test Circuit. Tempered water circulates in both circuits as heat transfer medium. A bubble flow with a defined gas volume fraction ε can be generated via Gas Admission II (cf. Fig. 3).

A **Test Case** (TC) always refers to the associated gas-free **Reference Case** (RC) and the related pressure losses and the related heat transfer coefficients are formed. Since test boundary conditions do not correspond exactly with regard to volume flow and temperature, an **empirical model** was created on the basis of the measurement data of the gas-free Reference Cases. This is used to map the corresponding Reference Case for each Test Case.


Fig. 2

Name	Typ	Design Capacity	Design Volume Flow
Hex20	SWEP B8THx20/1P	20 kW	0,6 m³/h
Hex30	SWEP BX8THx30	30 kW	0,9 m³/h
Hex40	SWEP B8THx40/1P	40 kW	1,2 m³/h

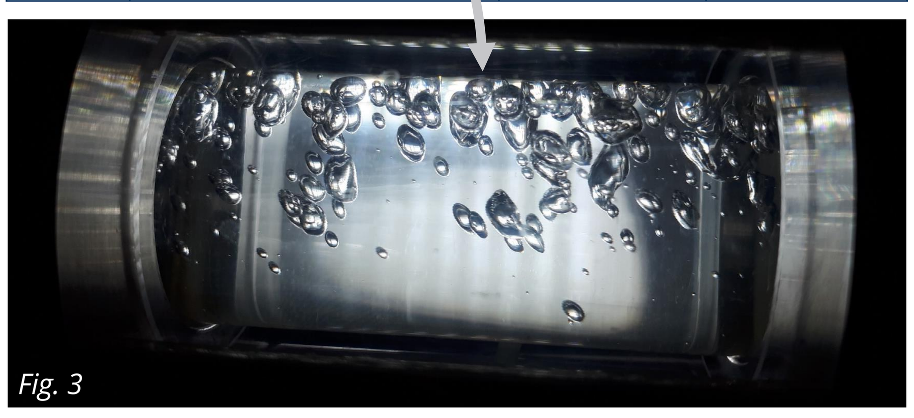
Fig. 3

Effects on Pressure Loss

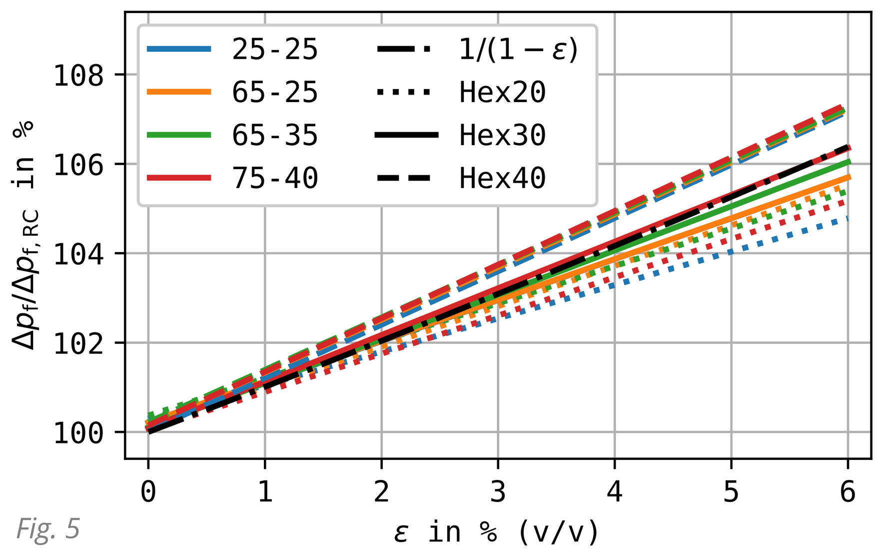

Fig. 5

The results for the related pressure loss and an operating condition without heat supply (25 °C) are shown in Fig. 4. Here the gas volume fraction can be assigned by color and the volume flow by symbol. The derived regressions appear in Fig. 5 for all test objects and temperature levels.

The following simple approach can be derived with the assumption that the pressure loss coefficients, formed with effective fluid properties, depend primarily on the geometry and surface properties of the duct walls. It meets the measurement well.

$$\frac{\Delta p_f}{\Delta p_{f,RC}} = \frac{\zeta}{\zeta_{RC}} \cdot \frac{1}{1-\varepsilon} \approx \frac{1}{1-\varepsilon}$$

The pressure losses increase by about one percentage point per volume percent of gas.

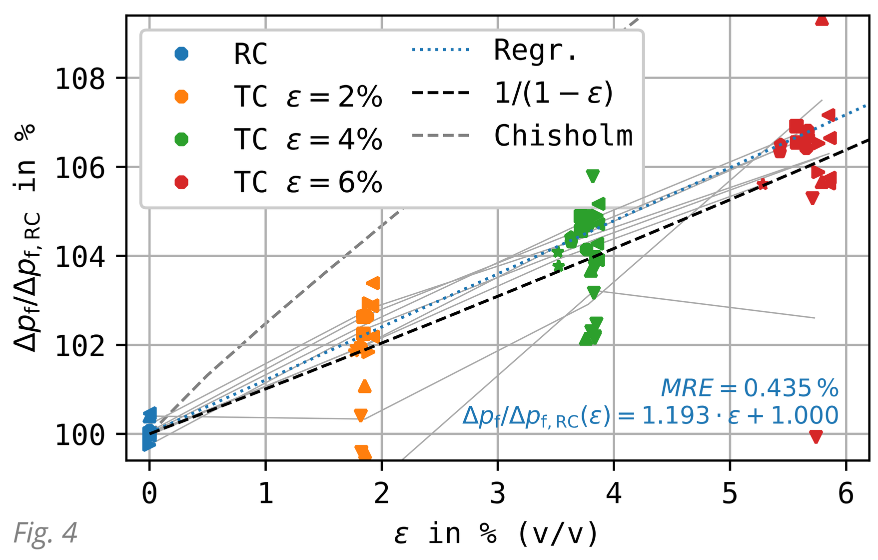

Fig. 4

Effect on Heat Transfer

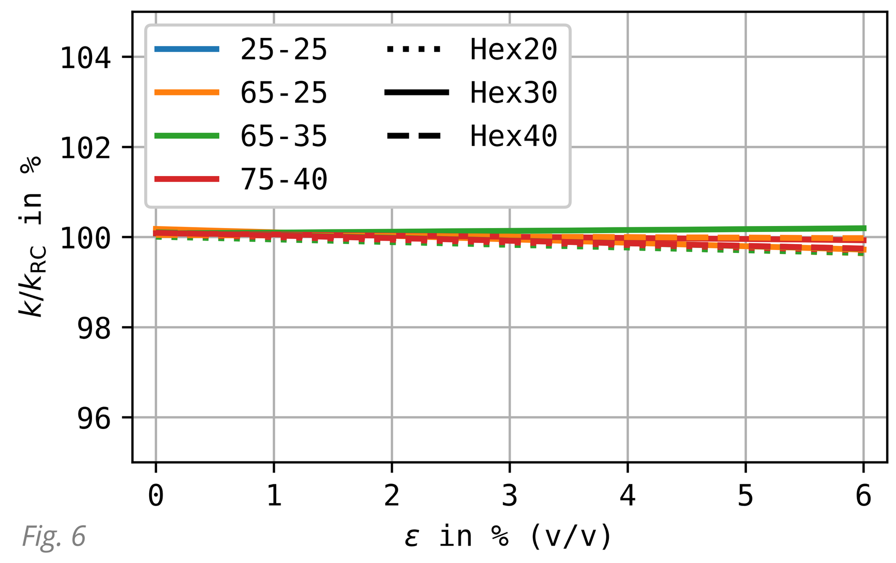

Fig. 6

The results for the related heat transfer k/k_{RC} are shown in Fig. 6 for all test objects and temperature levels.

The measurements cannot prove an influence of free gases on the heat transfer.

Averaged over all volume flows, all regression lines show a gradient close to zero. With a gas volume fraction of 6 %, maximum deviations in the range of ± 0.2 % are to be expected.

Effects on Entire System

Effects of the free gases on thermal heating systems are manifold and depend on the control concept used.

In **Scenario 1**, the control system will try to continue to fulfil the supply task despite a disturbance by free gases. For example, it will increase the heat capacity rate via the pump speed to such an extent, that the target temperature and thus the necessary transmission capacity are reached. The results shown above apply.

In **Scenario 2**, the control system cannot compensate for the disturbances caused by the free gases. This can be the case, for example, if the system is already working close to the maximum point or the control only takes into account environmental influences but not process variables. In this case, the total volume flow remains the same, but the heat capacity rate decreases. For this scenario the flow pressure losses and the heat transfer decrease accordingly due to the lower water volume flow.

References

ImpactGas — *Research project, FRN: 020E-100362657, research partners Hochschule Zittau/Görlitz and Fraunhofer IFAM Dresden*

Figures

Fig. 1: *Component test rig for water-to-water heat exchangers*

Fig. 2: *Photo of the component test rig*

Fig. 3: *Bubble flow in sight glass, ε = 4 % (v/v), Re=17000, ©GEWV*

Fig. 4: *Related pressure drop $\Delta p_f / \Delta p_{f,RC}$, in test object Hex40 depending on gas volume fraction ε, measurement data and modelling approaches*

Fig. 5: *Related pressure drop $\Delta p_f / \Delta p_{f,RC}$, all heat exchanger test objects and temperature pairings*

Fig. 6: *Related heat transfer coefficient k/k_{RC}, all heat exchanger test objects and temperature pairings*

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For further information on the project, see
https://tud.de/mw/impactgas