Modelling of the impulse- and heat transports in flow trough metallic foams based on experimental investigations (Part of the collaborative research center 561)

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Summary

The aim of this project is to model metal foams used for effusion cooling of combustion chamber walls. The basis of this model are measurements of heat conductivity, heat transfer and permeability of the metal foams. First results of measurements on foams produced by the slip reaction foamsintering process (SRFS) are presented.

1 Introduction and Aim

Combined Brayton/Clausius- Rankine cycles today reach the highest efficencies in converting thermal energy. The aim of the collaborative research center 561 (SFB 561, coordinator: IDG, RWTH Aachen) is to raise the efficency up to 65% (today 58%). In order to reach this goal it is necessary to increase the combustion chamber outlet temperature to 1520°C. At this temperature an effective way of protecting the gas turbine blades and the combustion chamber wall is effusion cooling. Porous metal materials are used to ensure a homogeneous cooling at a minimized mass flux of cooling fluid.

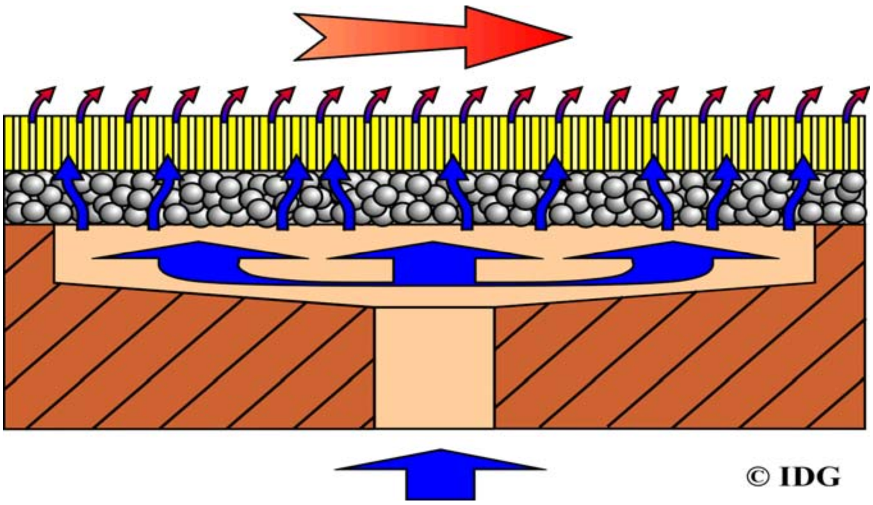

Figure 1: Picture of a combustion chamber shingle, IDG, RWTH Aachen

Shingles (Figure 1) are used to protect the basic structure of the combustion chamber. They consist of a thermal protection layer with tiny channels on a metal foam and the air supply. To design these shingels it is necessary to model the impulse- and heat transport in the metal foam.
Therefore measurements of the thermal conductivity, convective heat transfer and permeability are required. The investigated foams are made by the slip reaction foam sintering (SRFS)[1] of nickel based alloys.

2 Results

The permeability of the metal foams is measured with air as the fluid. The results are obtained by using the Darcy-Forchheimer-equation:

$$\frac{dp}{dx} = \frac{\mu}{K_1} v + \frac{\rho}{K_2} v^2$$

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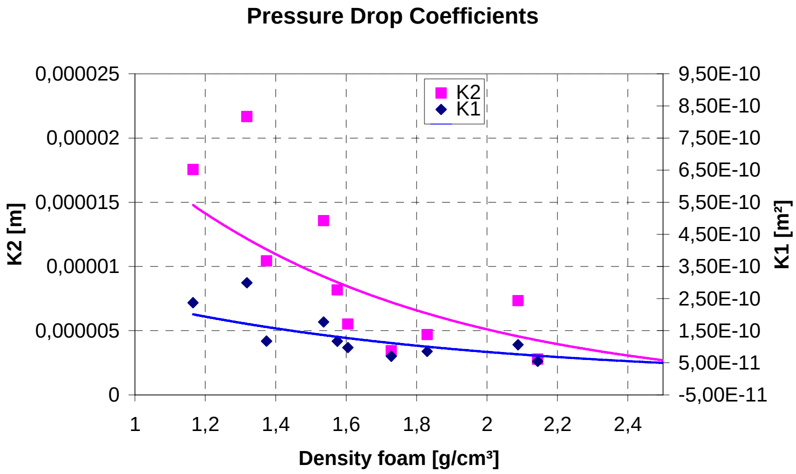

Figure 2: Graph of the permeability of inconel 625 foams.

The transient plane source technique is used to measure the effective thermal conductivity of the metal foam. The foam is considered as a porous matrix, consisting of a packed bed, in which macro pores are embedded.

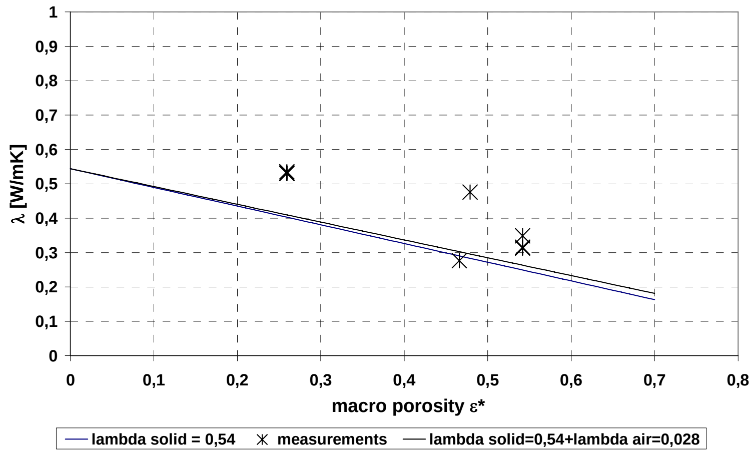

Figure 3: Measured values of the thermal conductivity compared to the phase-segregated-layer model.

3 Discussion

As expected the samples of the inconel 625 metal foams with the higher density show a lower permeability to air.
The effective thermal conductivity of the metal foam depends on the macro porosity. Aggregates (silicates) decrease the conductivity of the ligaments.

4 Summary and Outlook

These first resuts show the order of magnitude of the physical properties of the SRFS-foams. In the next step a model probably based on pores in a material with highly porous walls will be used to describe the foam. This model will help in the optimisation of the design of combustion chamber shingles.

5 Acknowledgment

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Literature

[1] Angel, S.; Bleck, W; Scholz, P.-F.; Fend, T.;Influence of powder morphology and chemical composition on metallic foams produced by Slip Reaction Foam Sintering (SRFS) process, steel research int. 75 (2004) no. 7, 479-484

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