Heat transfer measurements on a sidewall and blade surface of a large scale NGV with leakage flow

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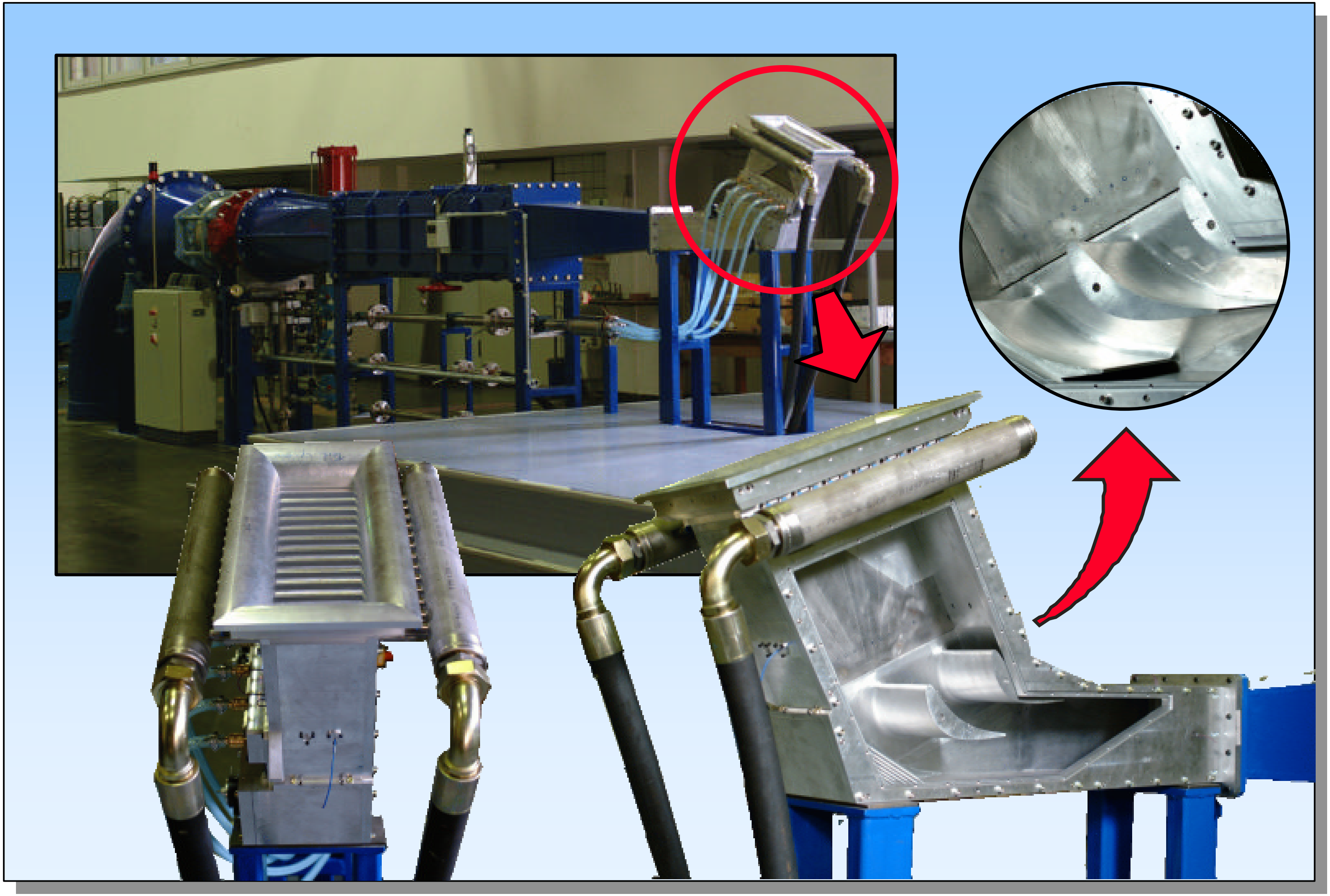
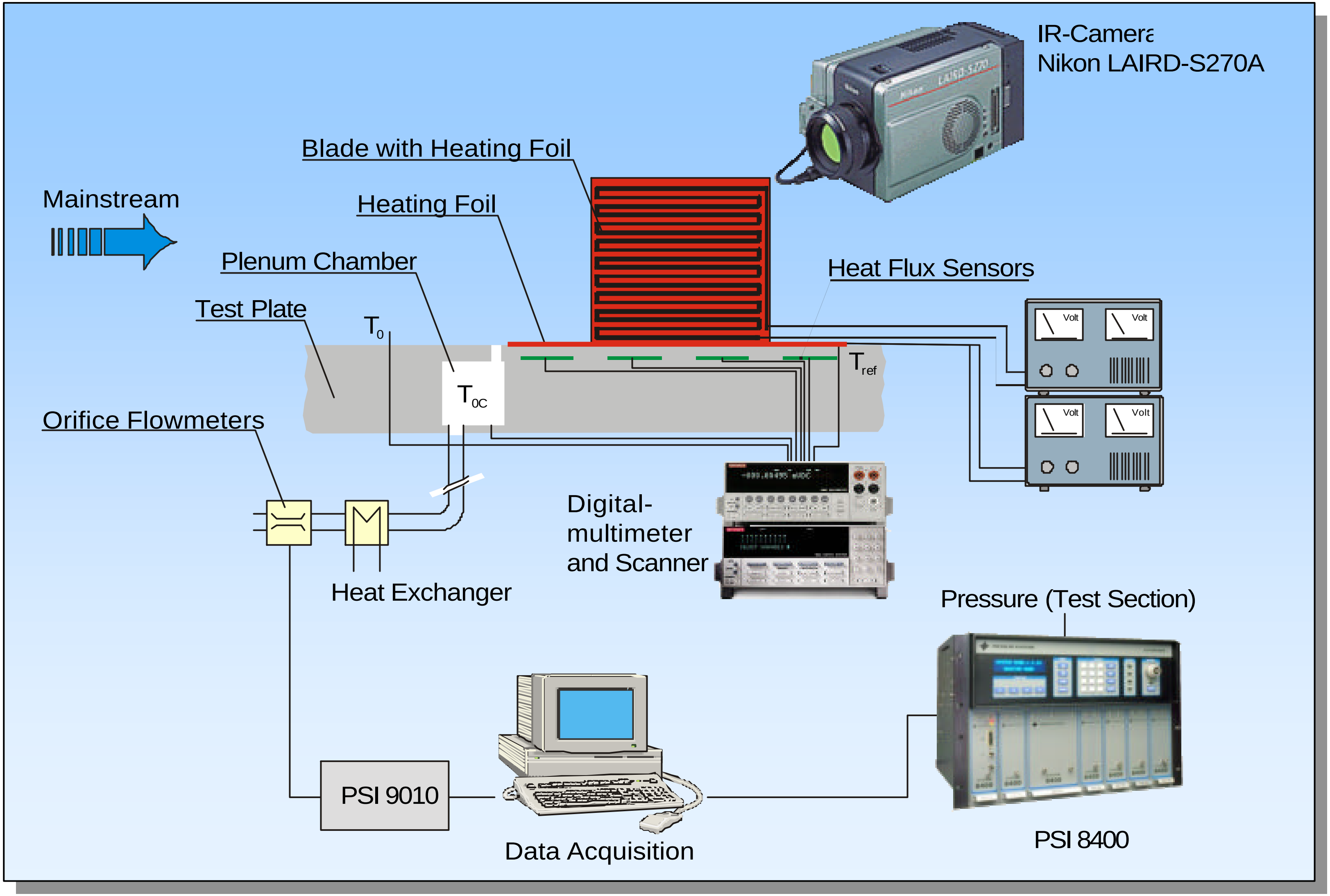
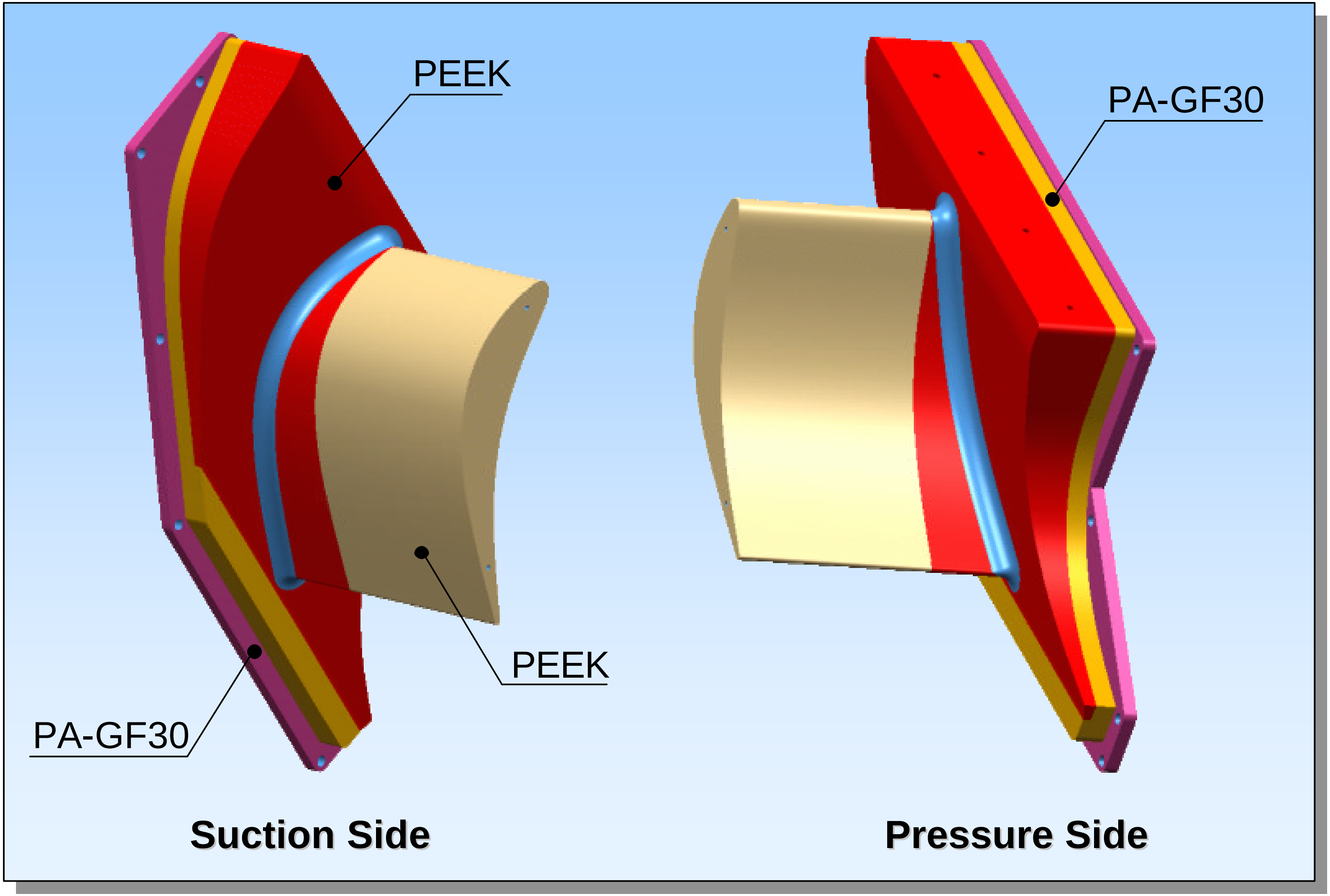
Wind tunnel



Measurement set-up



Blade construction



Material properties

Material: Polyetheretherketon (PEEK)

Mechanical properties:

- Modulus of elasticity (tensile): 3600 MPa
- Modulus of elasticity (flexural): 4100 MPa
- Bending strength: 170 Mpa

Thermal Properties:

- Thermal conductivity: 0,25 W/Km
- max. temperature: 250 °C

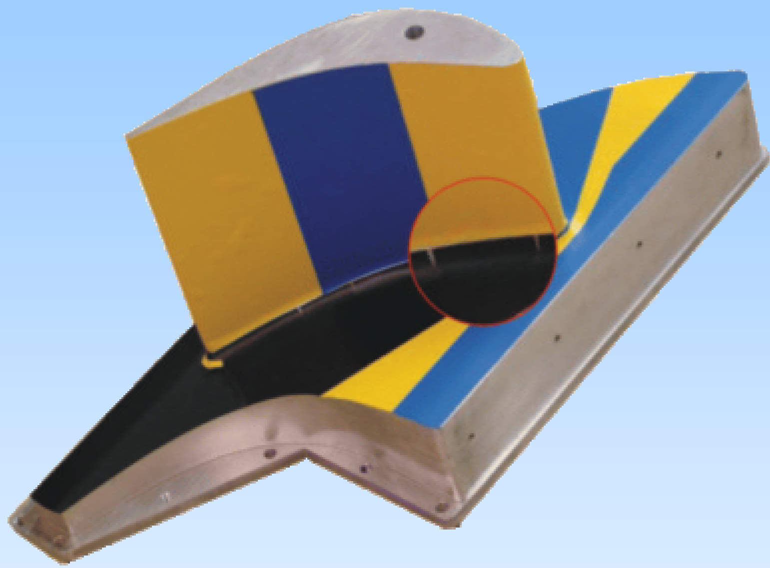
Material Trials

With thixotrope Agent

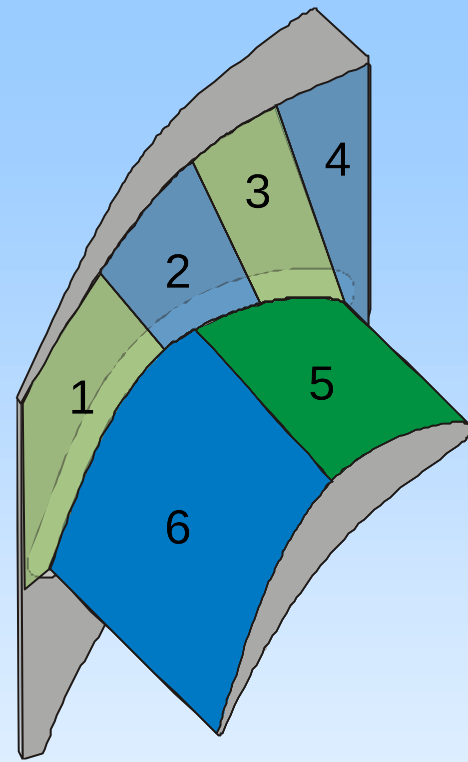
Without thixotrope Agent

Micro Glass-Bubbles reinforced Epoxy Resin

Heating set-up



First Trials with adhesive films

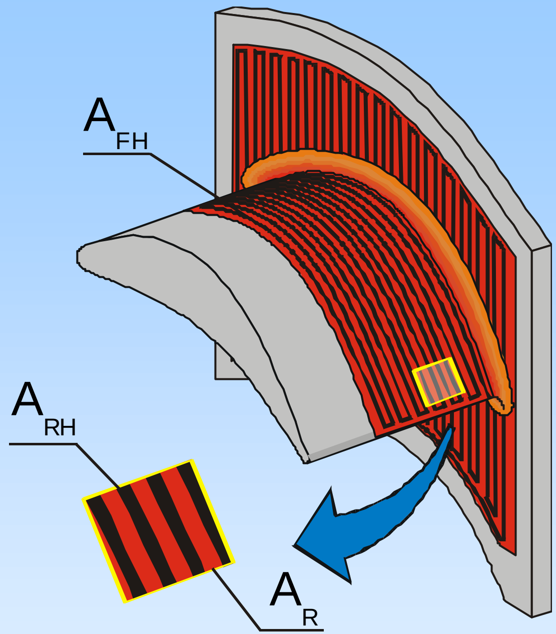


Possible Layout

Heat foils are covering the entire range of the test vane

Evaluation of the heat foils

Determination of the specific heat flux:

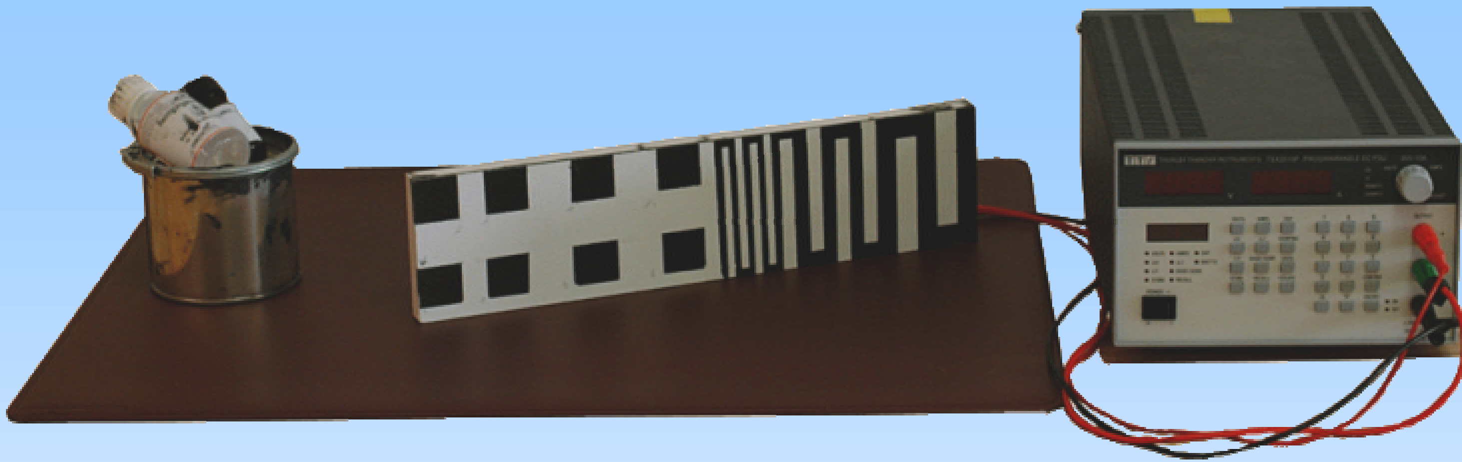


$$\Phi = \frac{A_{RH}}{A_{FH}}$$

Þ $$L_R = L_H \cdot \Phi$$

Þ $$\dot{Q}_R = \frac{L_R}{A_R}$$

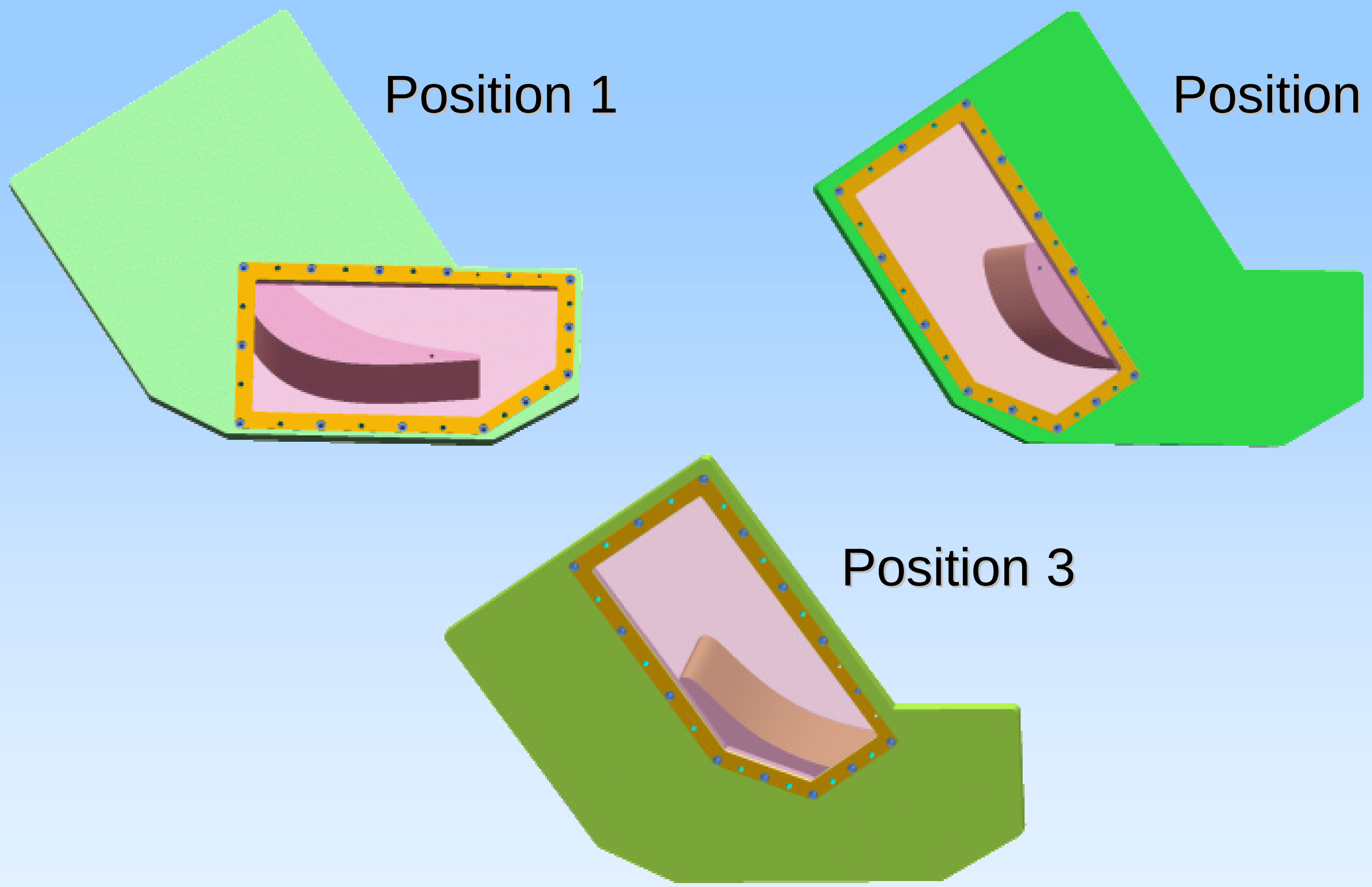
Carbon conductive ink



- Max. service Temperature: 120°C
- Already established as heater for driving mirrors
- Homogeneity problematic

Test set-up

Construction of the ZnS-Window



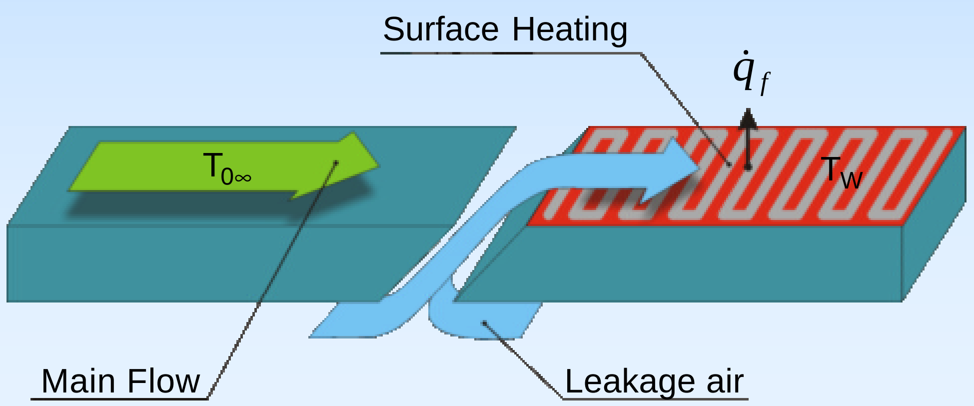
Good accessibility with the help of three mounting positions

Boundary Conditions

The definition of h and $\dot{q}_f$ require different boundary conditions:

$$h = \frac{T_{aw} - T_{0\infty}}{T_{0C} - T_{0\infty}}: \quad \dot{q}_f = 0 \quad \wedge \quad T_{0C} \neq T_{0\infty}$$

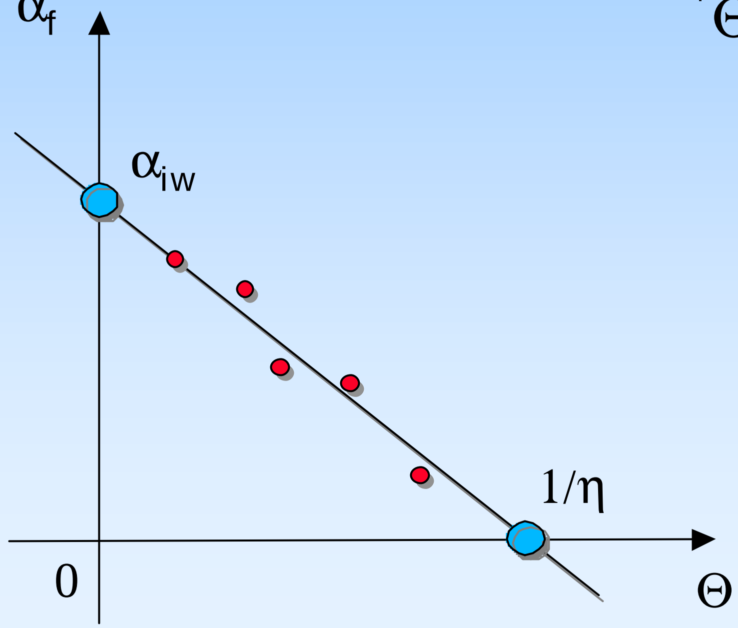
$$\dot{q}_f = a_{iw} \cdot (T_w - T_{0W}): \quad \dot{q}_f \neq 0 \quad \wedge \quad T_{0C} = T_{0\infty}$$



The Superposition Method

$$a_f = a_{iw}(1 - h \cdot \Theta^*)$$

$$^*\Theta = \frac{T_{0C} - T_{0\infty}}{T_W - T_{0\infty}}$$



Advantages of the Superposition Method

➲ **Easy generated Boundary Conditions**

- **No need for a heat exchanger to control the temperature of the leakage air.**
- **No change of properties of the leakage air**

➲ **To adapt the operating point of the engine it is obviously necessary to interpolate the received values.**