

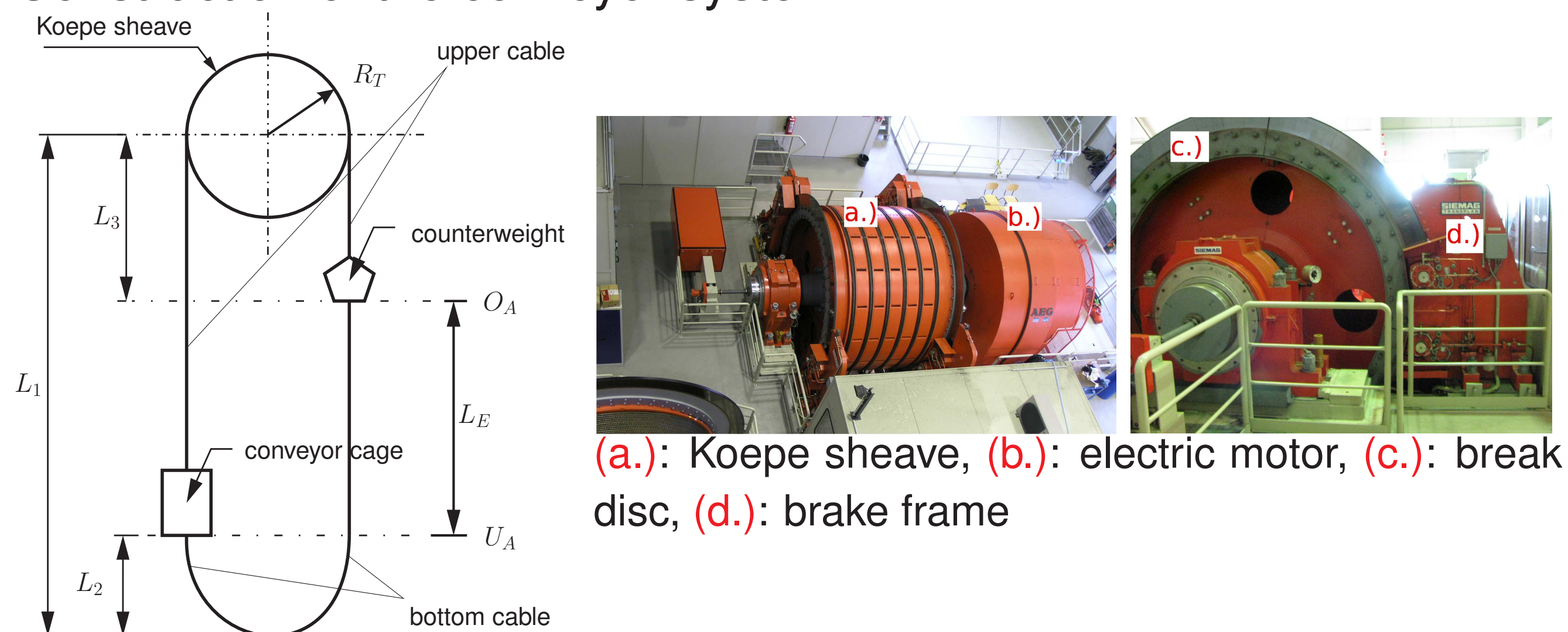
Analysis of the temperature development within a brake disk

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Motivation

- Determination of the peak temperature and the core temperature
- Distribution of thermal energy between the brake disc and brake pad
- Determination of the heat conduction and material parameters

Construction of the conveyor system



Derivation

- First law of thermodynamics

$$Q + P = \frac{d}{dt}[T + E]$$

- Heat energy is obtained from dissipated mechanical energy

$$Q_{fric} = -P_{fric}$$

- Thermal balance equation (strong formulation)

$$c_p \rho \dot{\theta} - k \Delta \theta = 0$$

- Weak formulation

$$\int_{\Omega_0} \delta \theta c_p \rho \dot{\theta} dV + \int_{\Omega_0} k \nabla(\delta \theta) \nabla \theta dV - \int_{\partial \Omega_N} \delta \theta h dA - \int_{\partial \Omega_R} \delta \theta \alpha (T_{flu} - \theta) dA = 0 \quad (1)$$

- Discretization (spatial, semi-discrete)

$$\mathbf{C} \dot{\Theta} + \mathbf{K} \Theta - \mathbf{f} = 0$$

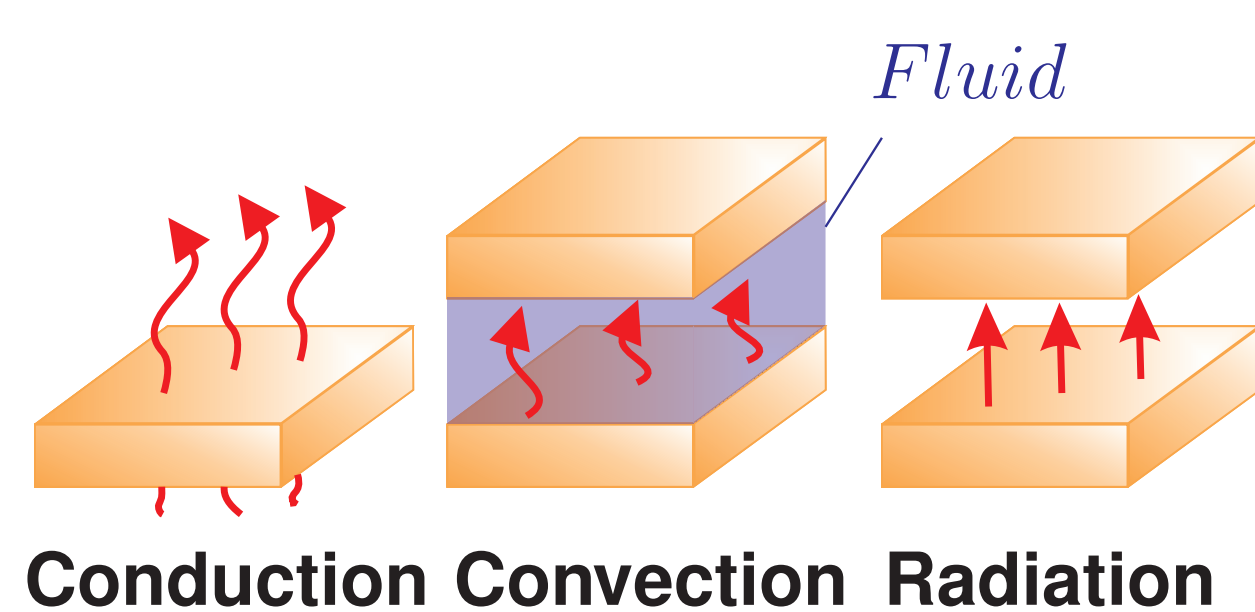
- Discretization in time: $\dot{\theta} = (\theta_{n+1} - \theta_n) / \Delta t$

$$\left[\frac{1}{\Delta t} \mathbf{C} + \mathbf{K} \right] \Theta_{n+1} - \left[\mathbf{f}(t_{n+1}) + \frac{1}{\Delta t} \mathbf{C} \Theta_n \right] = 0$$

Boundary conditions

- Overfall heat flux on boundary

$$Q = \gamma Q_{fric} + Q_{con}$$



Neumann boundary

- h is introduced across the surface of the brake pads

$$\gamma Q_{fric} = \int_{\partial \Omega_N} h dA$$

Robin boundary

- Heat transfer

$$Q_{con} = \int_{\partial \Omega_R} \alpha (T_{flu} - \Theta) dA$$

- Forced convection

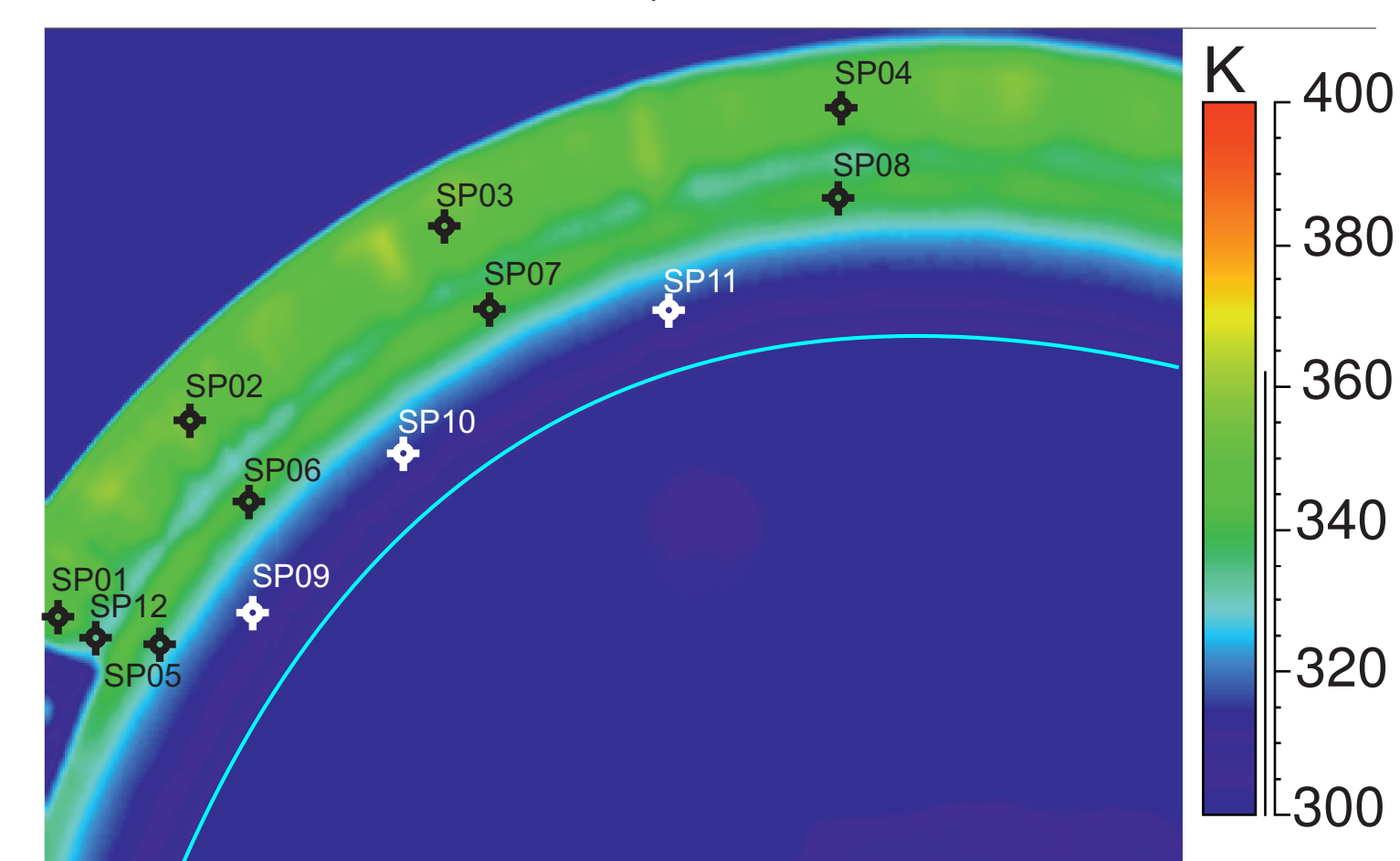
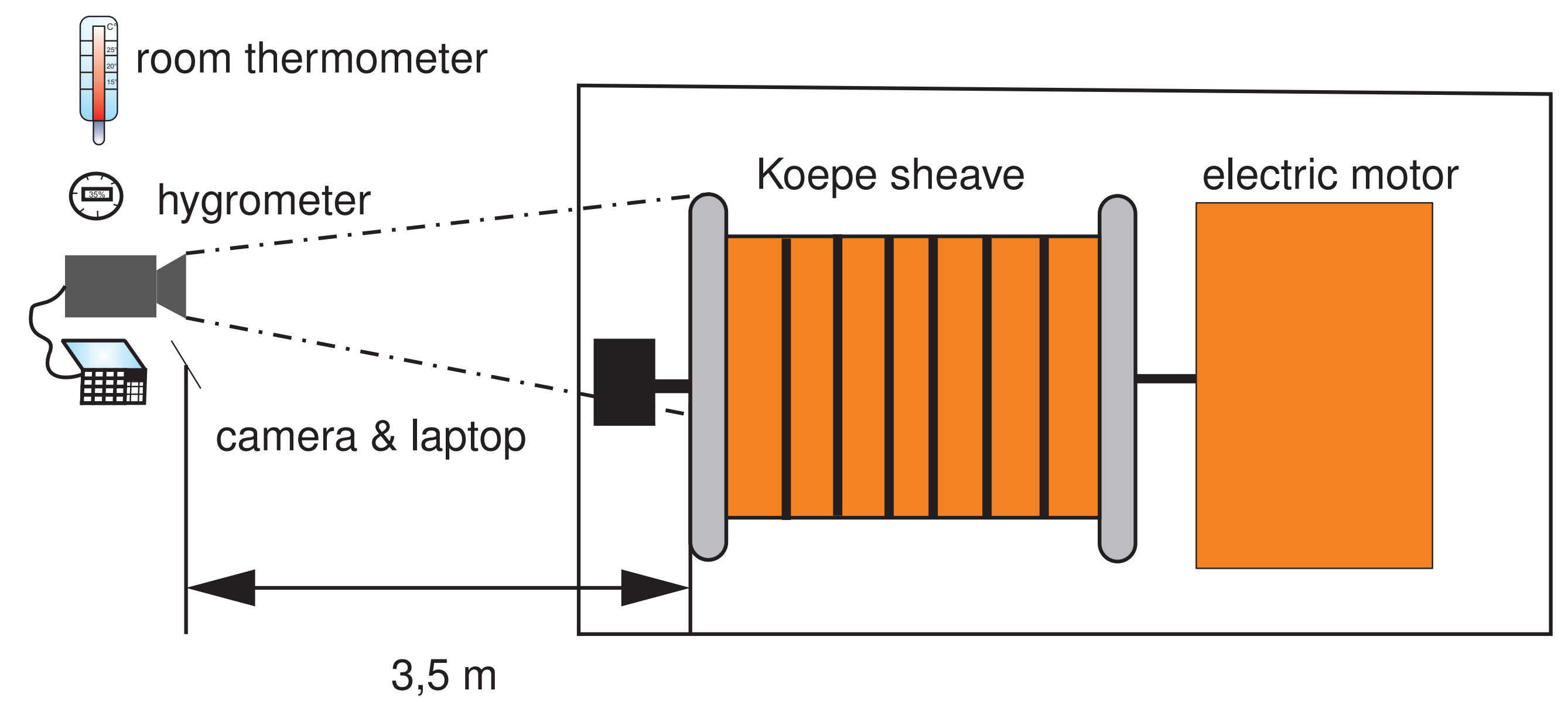
$$\alpha = \frac{Nu(Re, Pr) k}{L}$$

- Free convection

$$\alpha = \frac{Nu(Gr, Pr) k}{L}$$

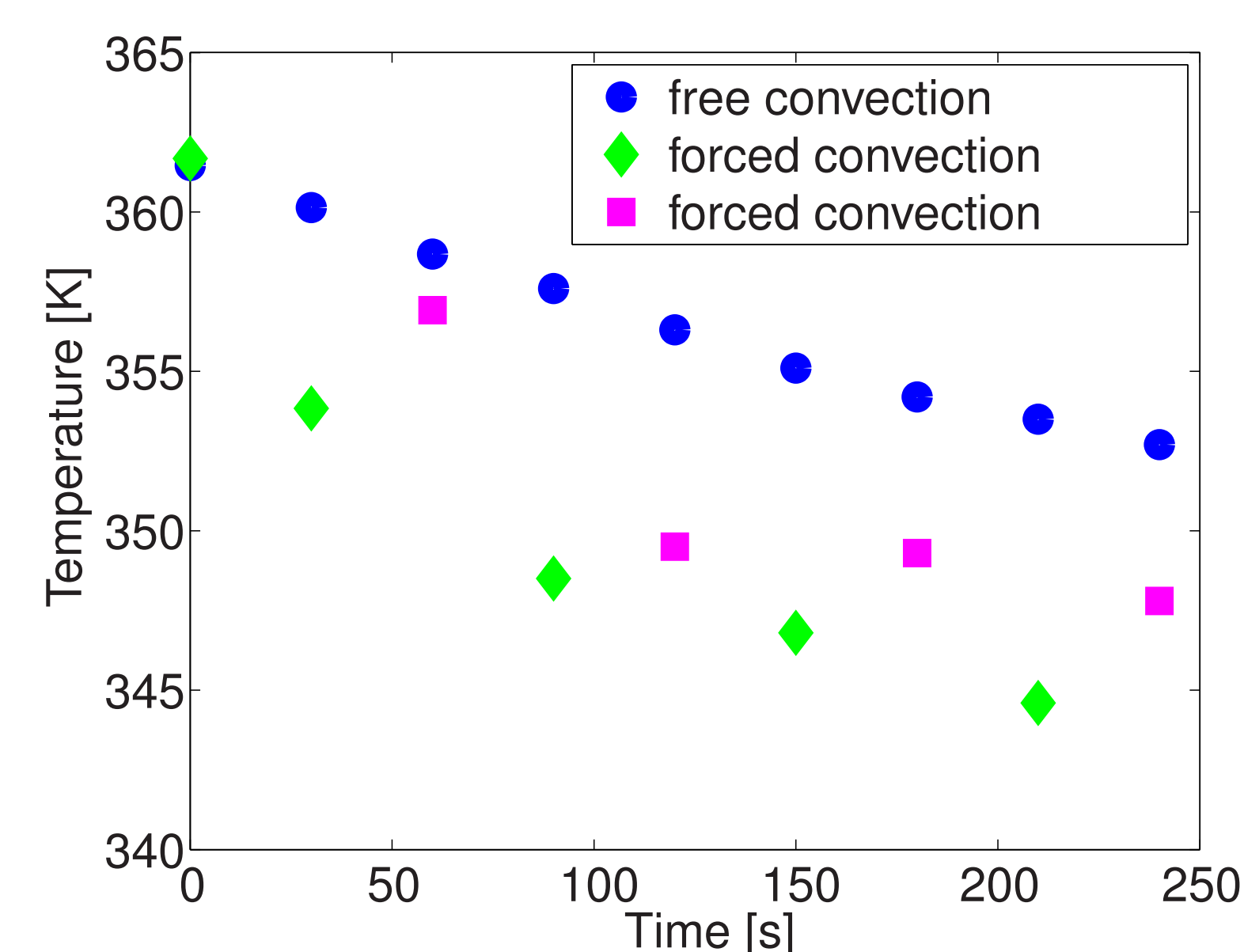
Measurement

Measurement setup

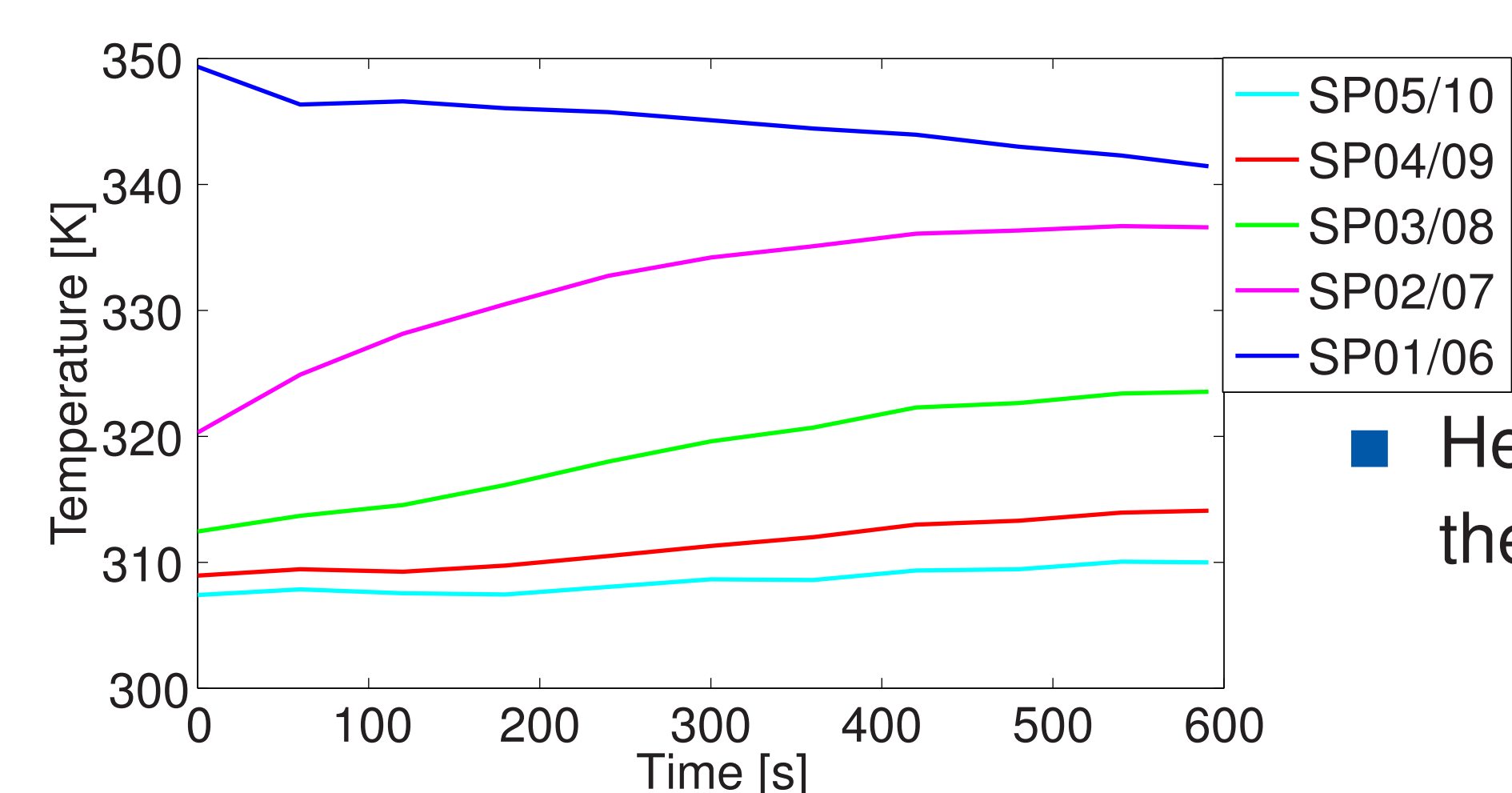


- Thermographic camera from FLIR
- Evaluation software *Researcher Pro 2.10*

Measurement results

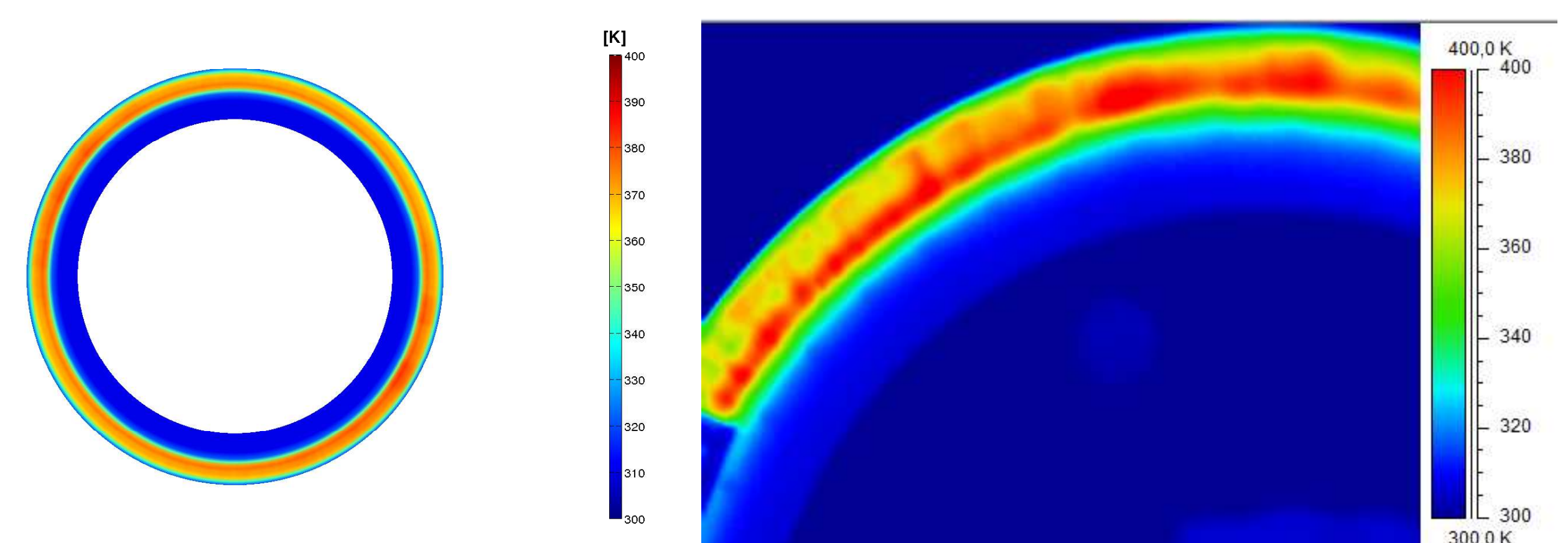


- Cooling curves for free and forced convection



- Heat conduction in the radial direction

Simulation



	Temperature in Kelvin [K]
Measurement	376,4-390,3
Simulation	383,5