Virtual Product Qualification for Polymer Parts
ViPQuali

Project in the frame of
“Key innovations for sustainability in economy“

Dr.-Ing. Thomas Reichert

Fraunhofer-Institut für Chemische Technologie
ICT

76327 Pfinztal

thomas.reichert@ict.fhg.de

Bundesministerium für Bildung und Forschung

Projektträger im DLR

Fraunhofer ICT Institut Chemische Technologie

ATLAS MATERIAL TESTING SOLUTIONS

BAM

Clariant

Dr. Axel Müller - HTCO

Fraunhofer WKI Wilhelm-Klauditz-Institut Holzforschung

FEMLAB Multiphysics in MATLAB

Fraunhofer ISE Institut Solare Energiesysteme

What is Virtual Product Qualification?

Innovative combination of CAE-Tools (FEM, CFD, CESORA)

<u>and</u>

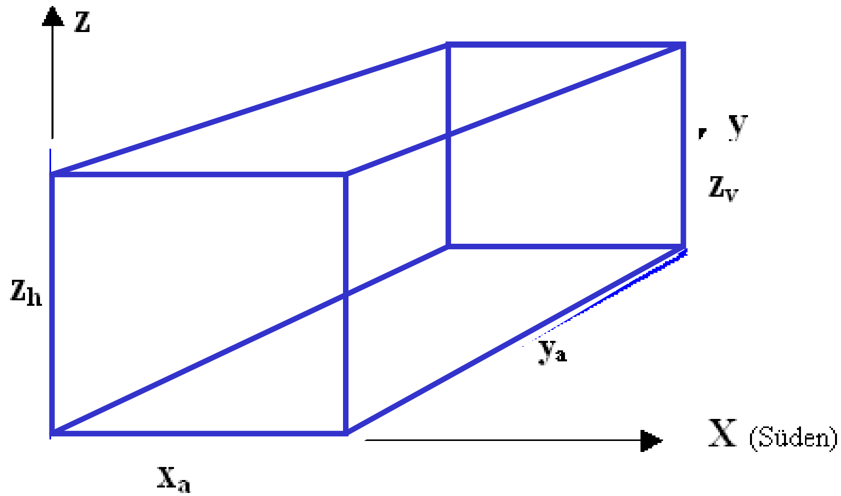
experimental analysis and identification of the material properties

for the improvement of products <u>and</u> the service „Environmental

Qualification of Products“.

Archivierungsangaben

Instrument Panel / Dashboard Box IP/DP-Box



Archivierungsangaben

Main Goals

- Dose Response Functions
- Models for material deterioration
- Incorporation in CAE tools
- Program development
- Visualisation

CAD → Simulation of the Part → CAD → ViPquali → CAD

State of the Art

- Deterministic models
- Probabilistic models
- Extrapolation with temperature- time – transformation

Goals

- New models based on results from Solarheating and Cooling Programme (Carlsson 94)
- Dose Response Functions for Polymers/ Reichert 2003

Goal

For complete the Virtual Product Qualification you need the dose-response-function and calculation of the environmental conditions at every place and surface on the part.

Partners

Institutes:
Fraunhofer-ICT, Fraunhofer-WKI, Fraunhofer-ISE, BAM

Firms:
ATLAS, Prof. Dr. Manier, CLARIANT, HTCO Dr. Axel Müller, FEM-LAB

Alliances and Lobbyists/Further Education:
Gesellschaft für Umweltsimulation GUS e.V.

Injection moulding machine and manufactured parts

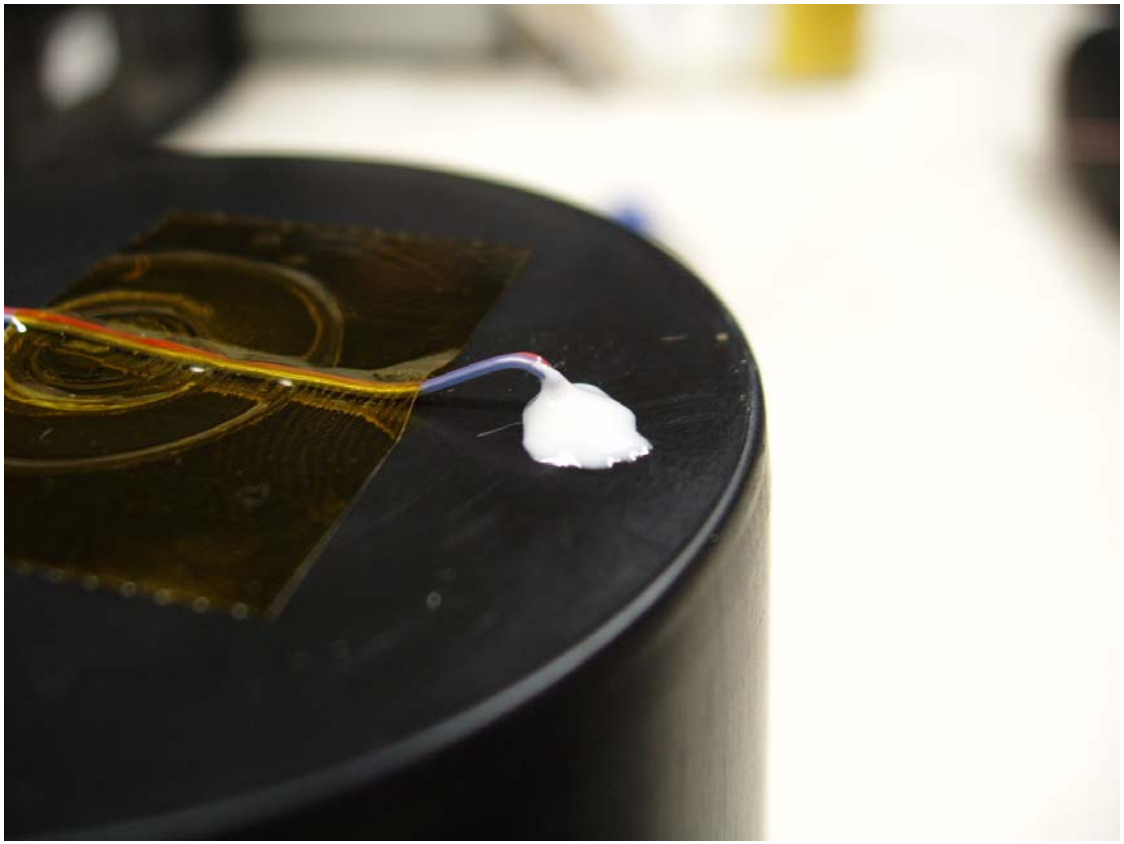
height circa 150 mm

ICT
Fraunhofer Institut
Chemische Technologie

Projektträger im DLR

Outdoor Weathering in the IP/DP- box in Arizona

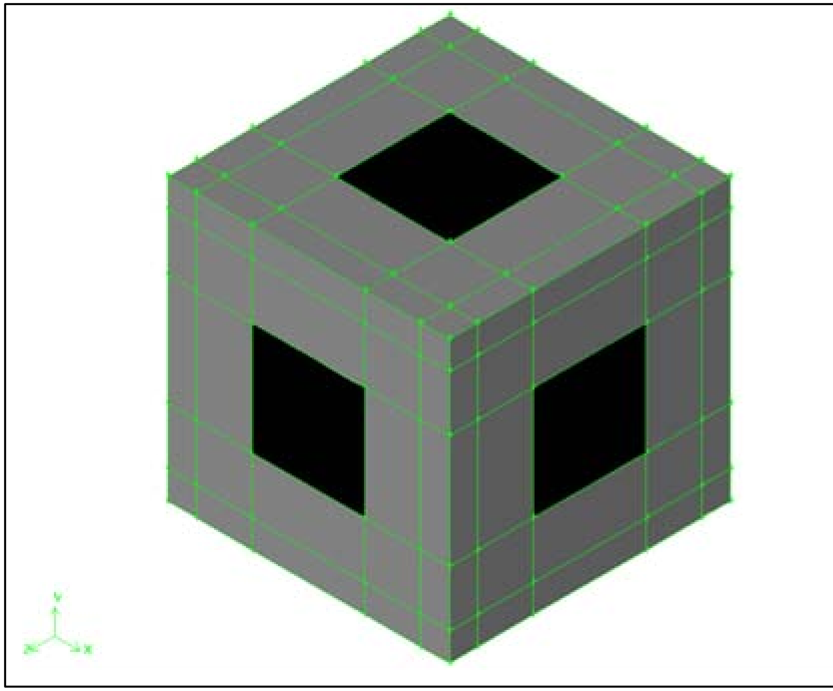
Measurements of the temperature of the specimen surface with the aid of thermo elements

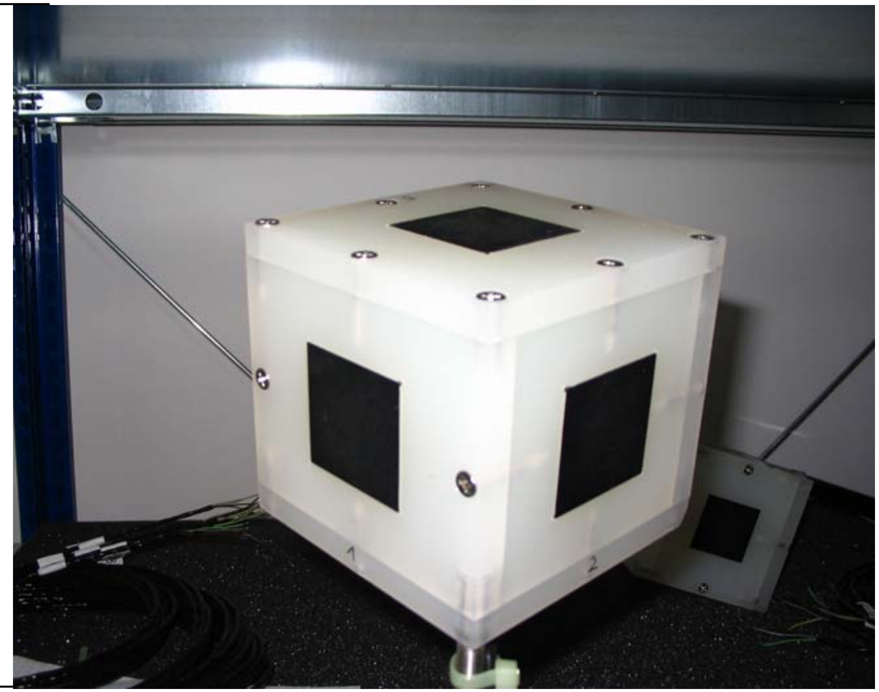


Fraunhofer Institut Chemische Technologie
ICT

Projektträger im DLR

Measuring cube construction and real measuring cube for the validation of the simulation

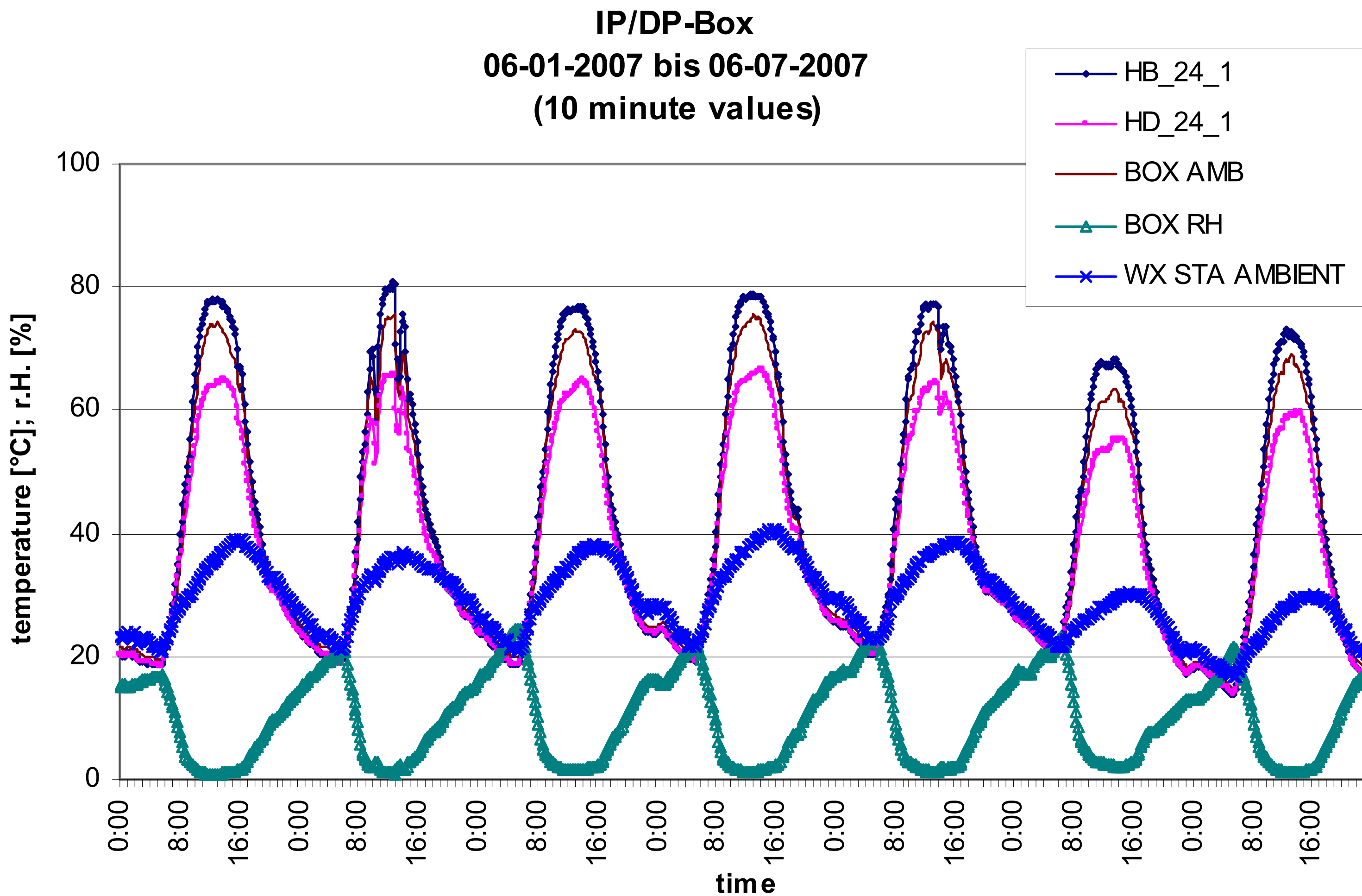




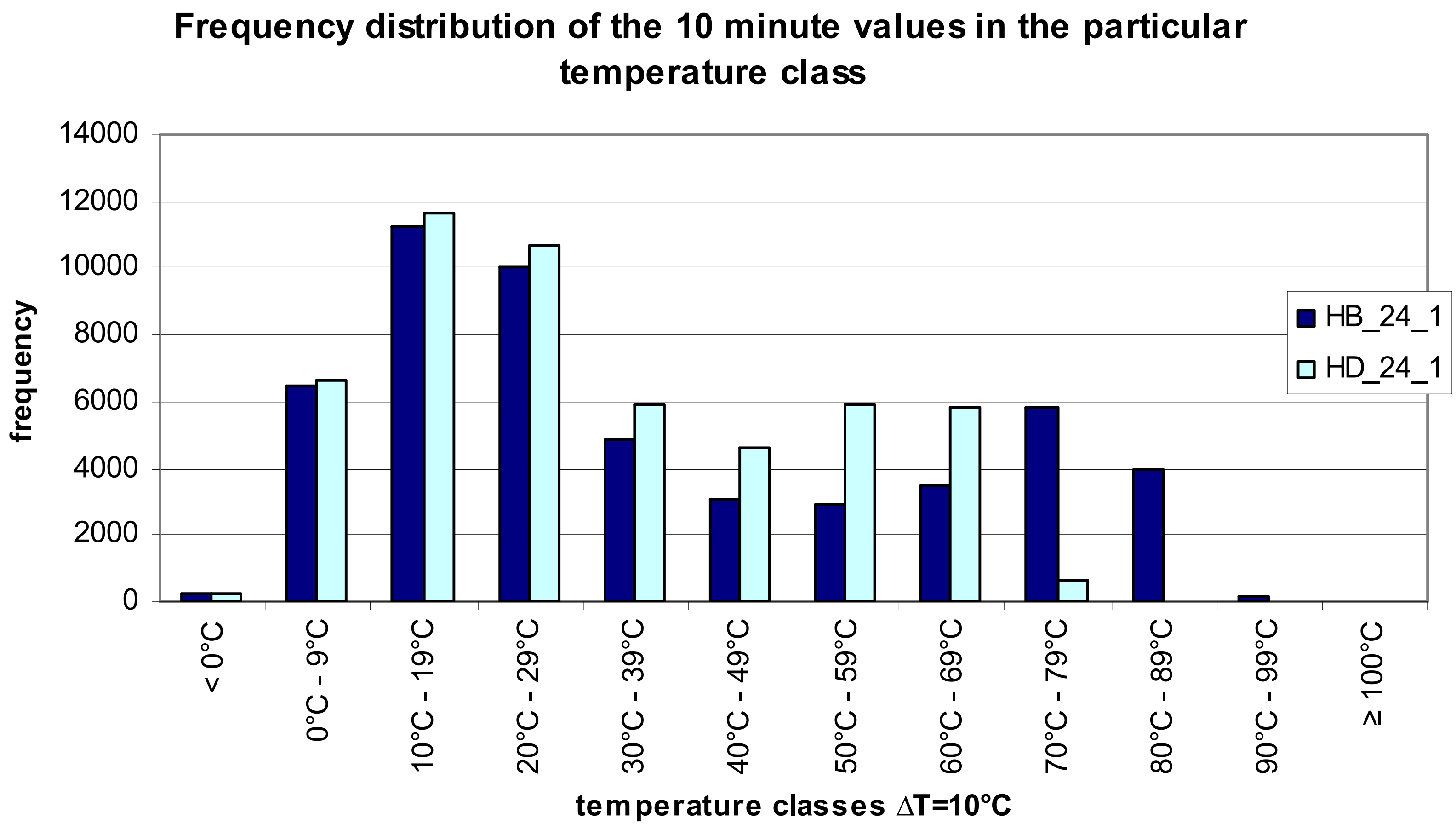
Fraunhofer Institut Chemische Technologie

Projektträger im DLR

Temperature- and climate values in the IP/DP- Box Arizona



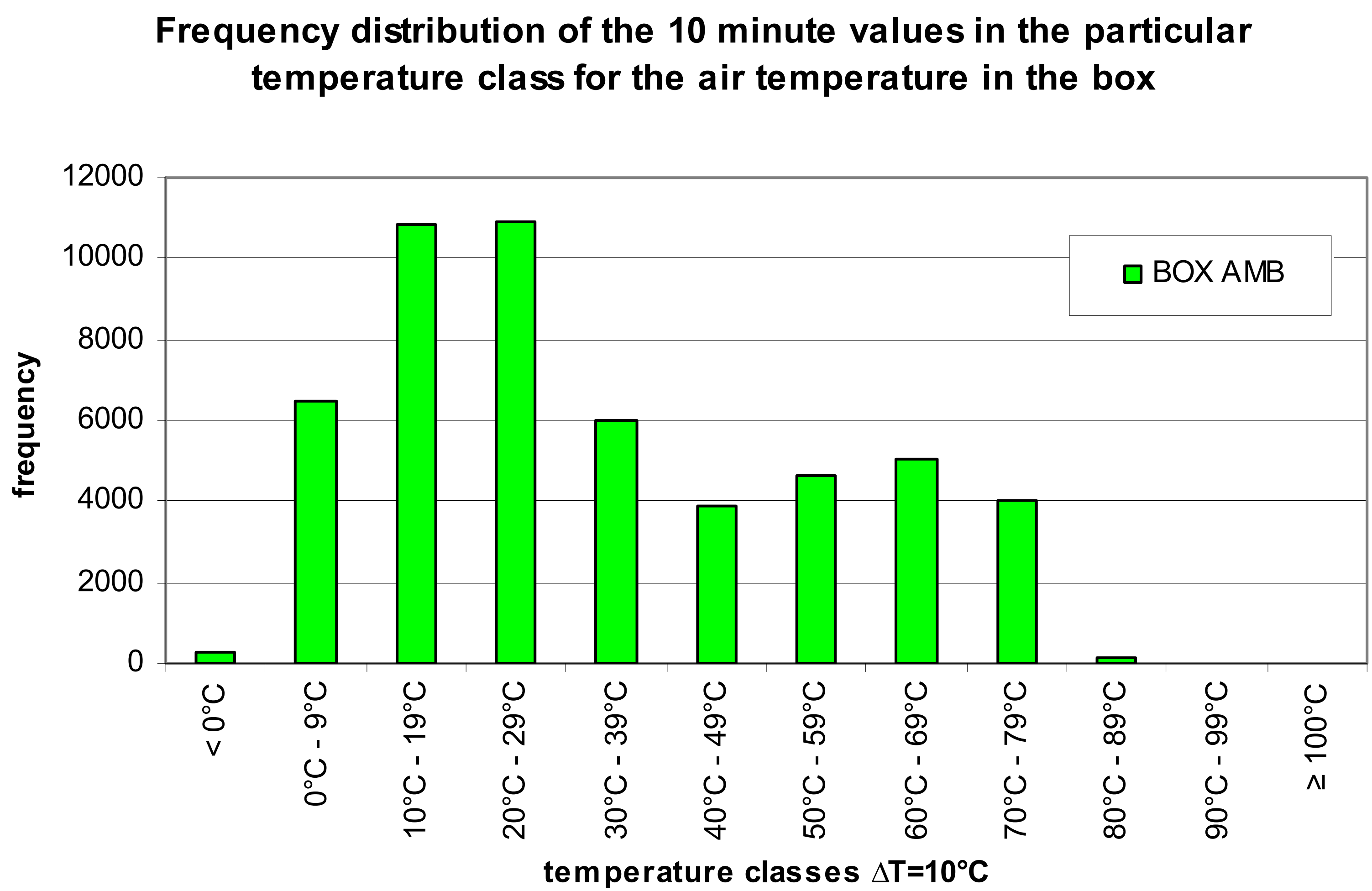
Model hat HB_24_1 (black part) HD_24_1 (white part) HB_24_1



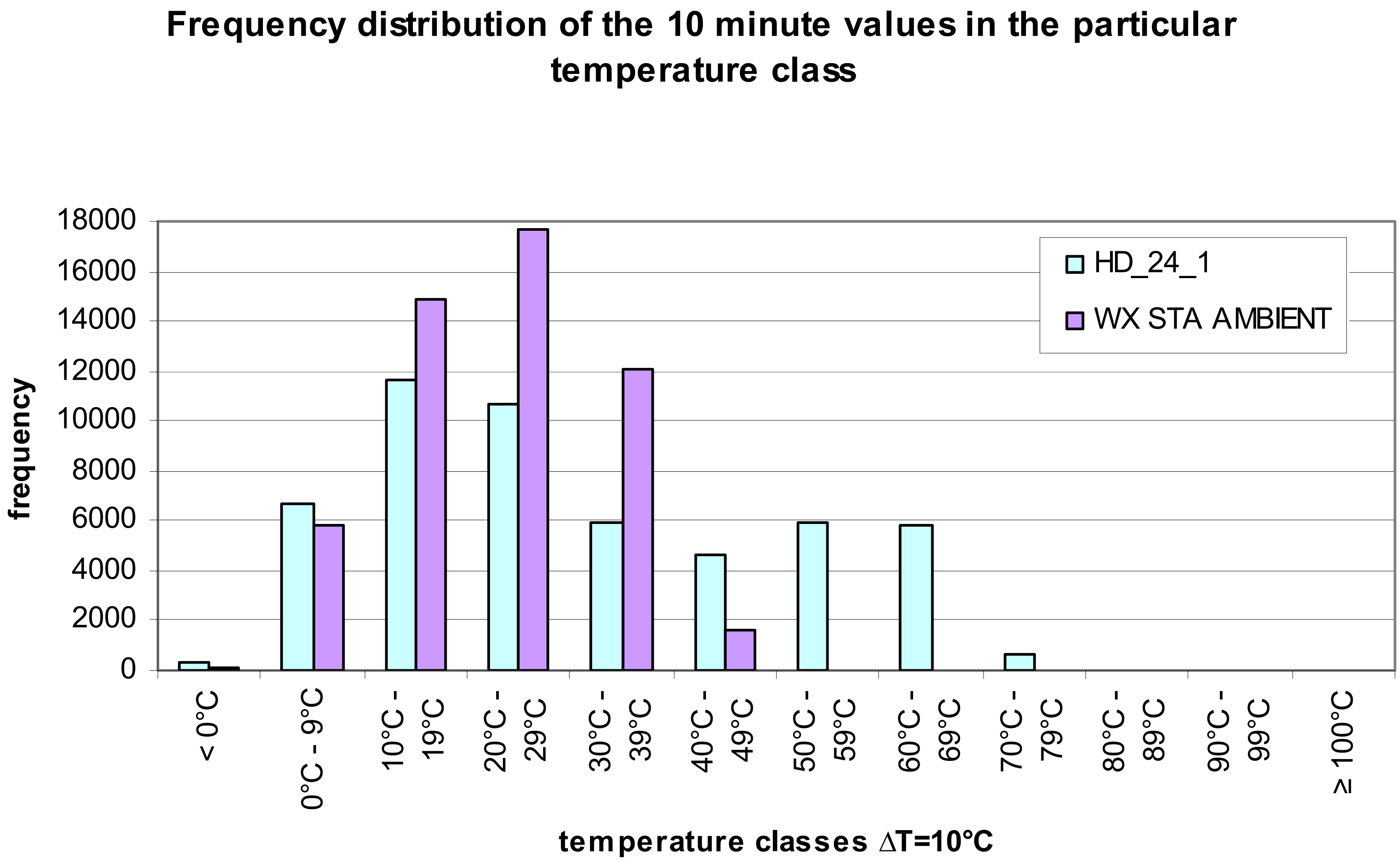
Fraunhofer Institut Chemische Technologie

Projektträger im DLR

Air temperature



Whiteboard temperature outside – hat temperature inside

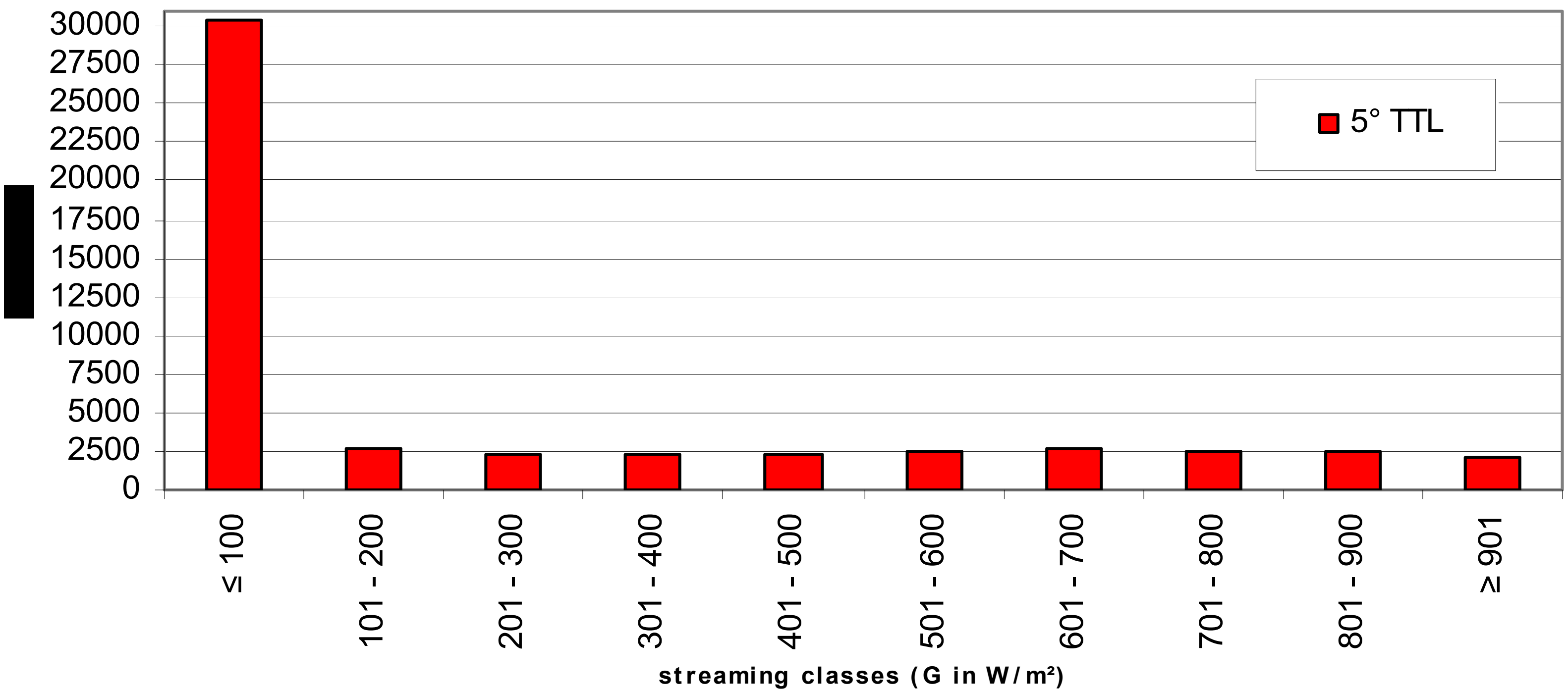


Fraunhofer Institut Chemische Technologie

Projektträger im DLR

Frequency distribution of the global radiation values outdoor in Arizona in year one of the weathering

Frequency distribution of the 10 minute values in the particular radiation classes



ICT
Fraunhofer Institut Chemische Technologie
Projektträger im DLR

Dose Response Function for Polymer Aging

$$ME = P1\ G \cdot t^{P2} + P_{11}[Gas_1]t^{P12}(D_1(T) \cdot Tp/\ \pi)^{1/2}$$

$$+ \ldots + P_{n1}[Gas_n]t^{Pn2}(D_n(T) \cdot Tp/\ \pi)^{1/2}$$

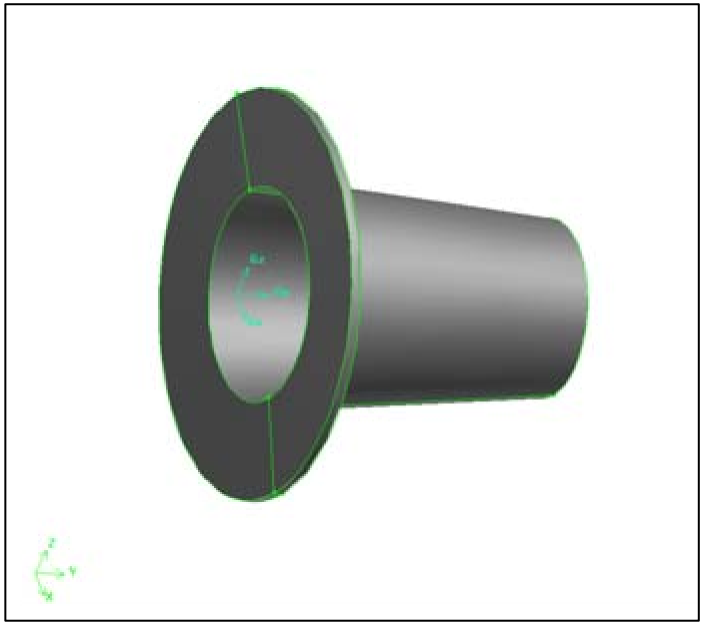
With:
G = Global Radiation
[Gas] = Average of gas concentration or percentage of humidity
t = time
D(T) = Diffusion dependent coefficient
P = Parameters
ME = Material Property

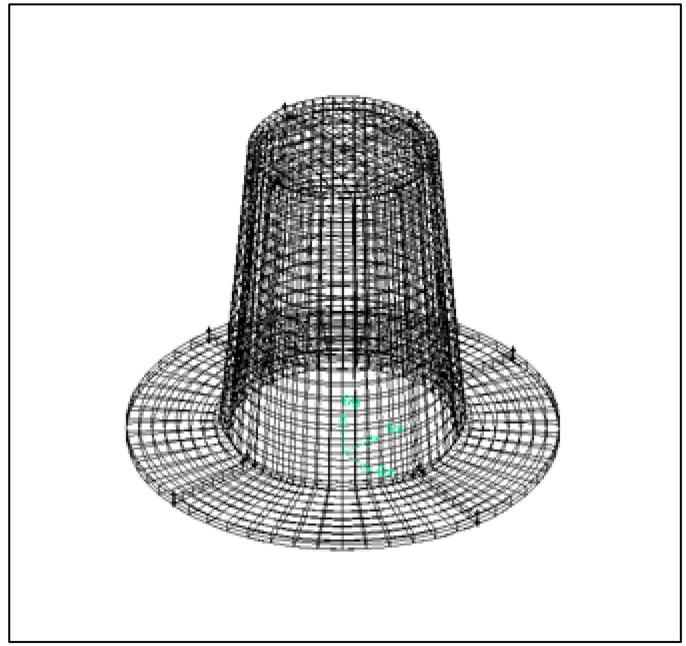
Total Effective Dosage Model

$$D_{total}(t) = \int_{0}^{t} \int_{\lambda_{min}}^{\lambda_{max}} E_o(\lambda, t)\left(1 - e^{-A(\lambda)}\right) \phi(\lambda)\, d\lambda\, dt$$

$D_{total}\ (t)$	=	total effective dosage
$E_o(\lambda,t)$	=	spectral UV irradiance from light source
$1-e^{-A(\lambda)}$	=	spectral absorption of specimen
$\phi(\lambda)$	=	spectral quantum yield of specimen
λ_{min}, λ_{max}	=	min. and max. photolytically effective wavelengths

CAD- Model and mesh net

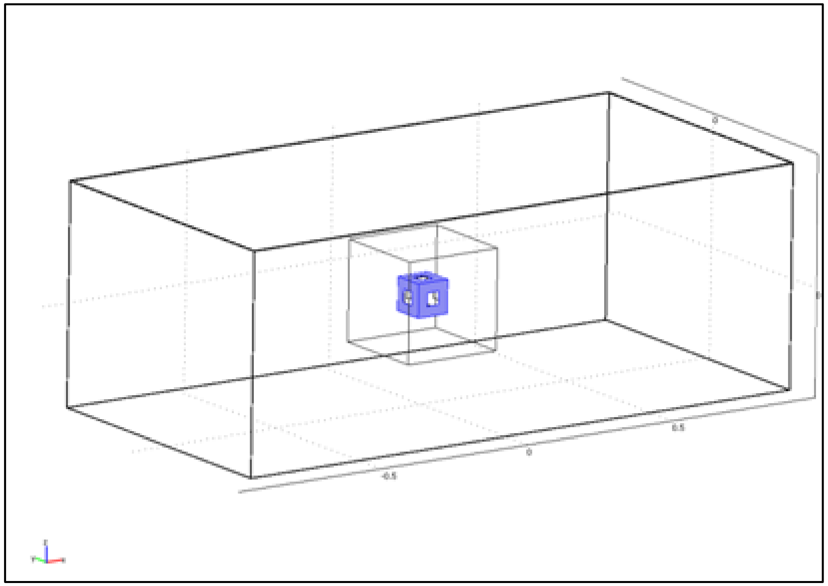


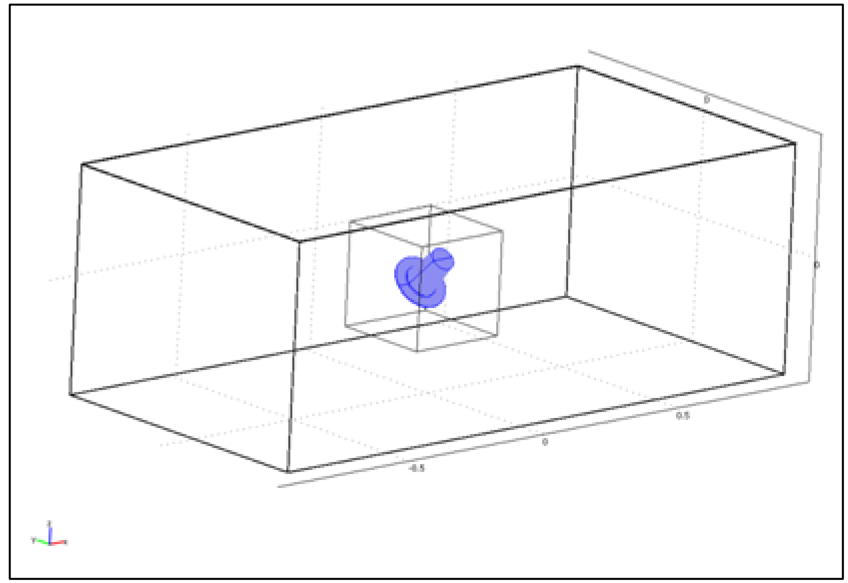


Fraunhofer Institut Chemische Technologie

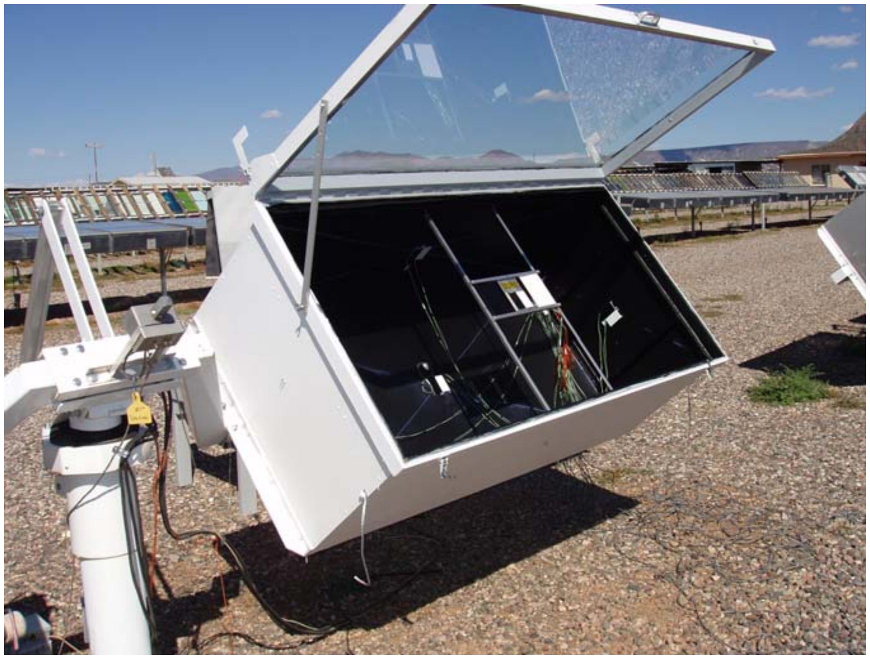
Projektträger im DLR

COMSOL- Model of the parts cube and hat in the box





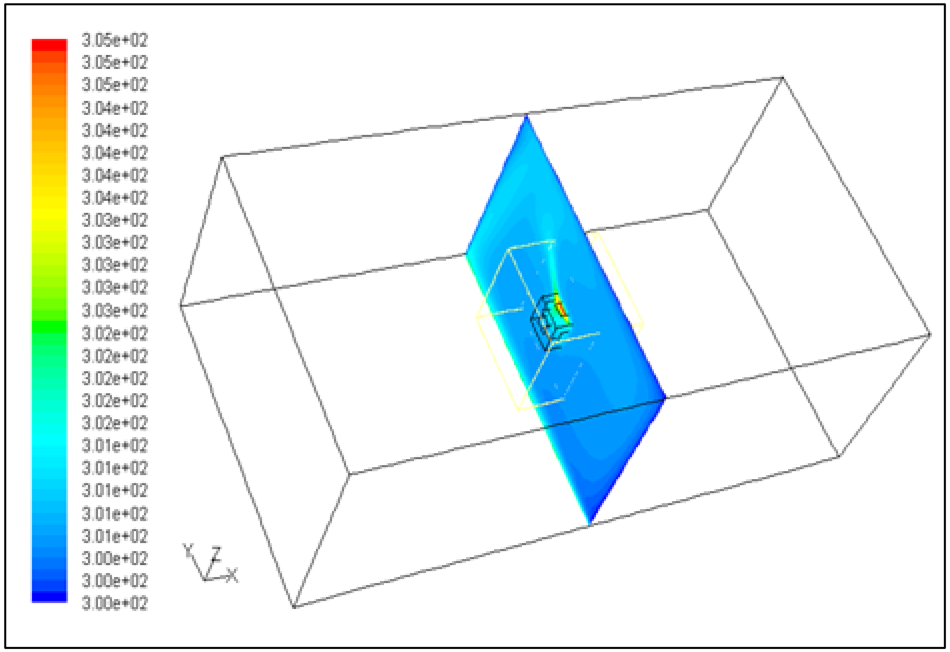
Evaluation scenarios to test the simulation

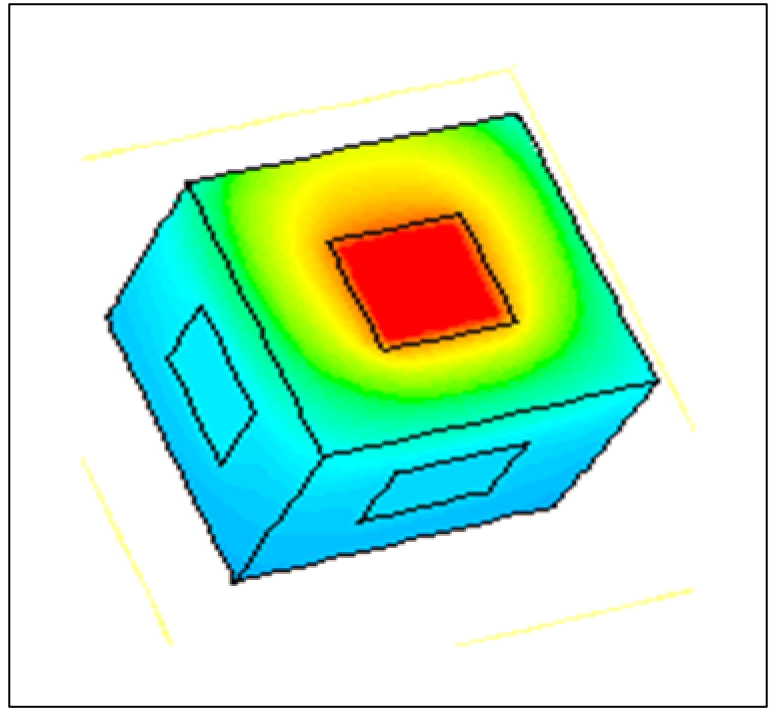


ICT
Fraunhofer Institut
Chemische Technologie

Projektträger im DLR

Temperature distribution in the box and on the parts of the measuring cube

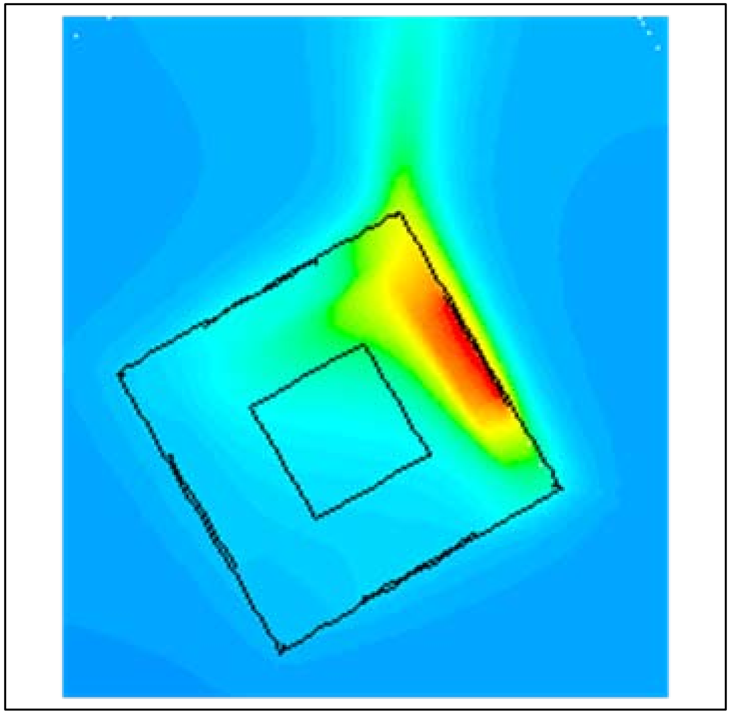


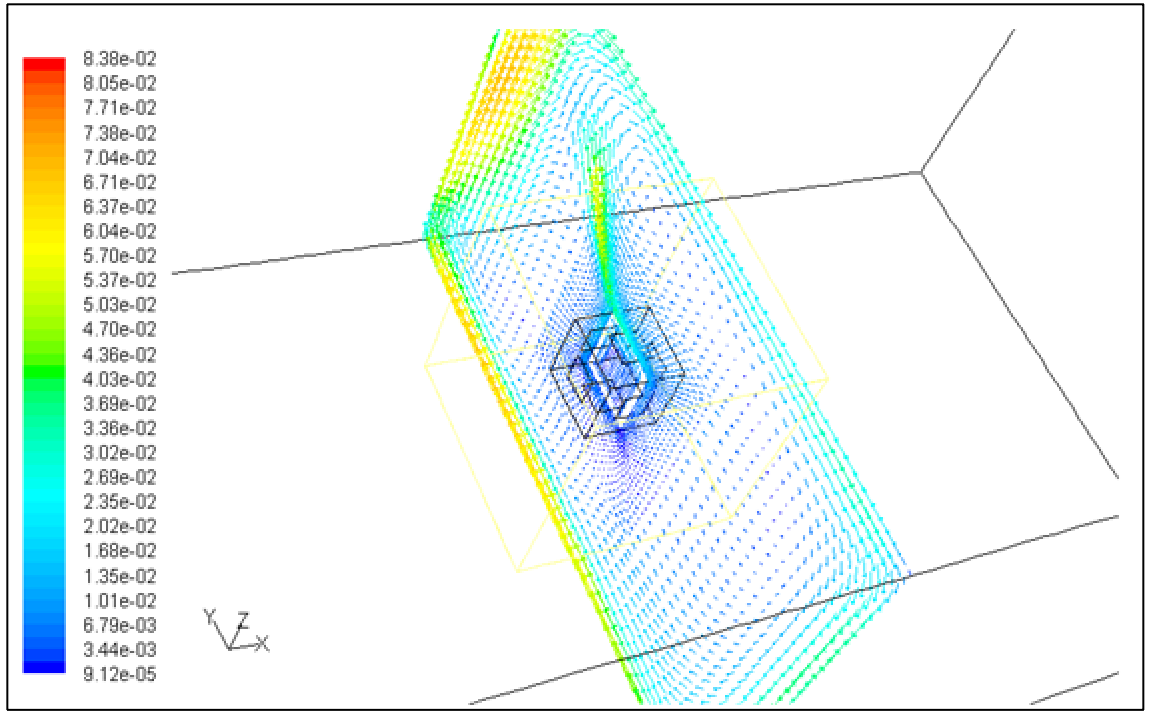


ICT
Fraunhofer Institut Chemische Technologie

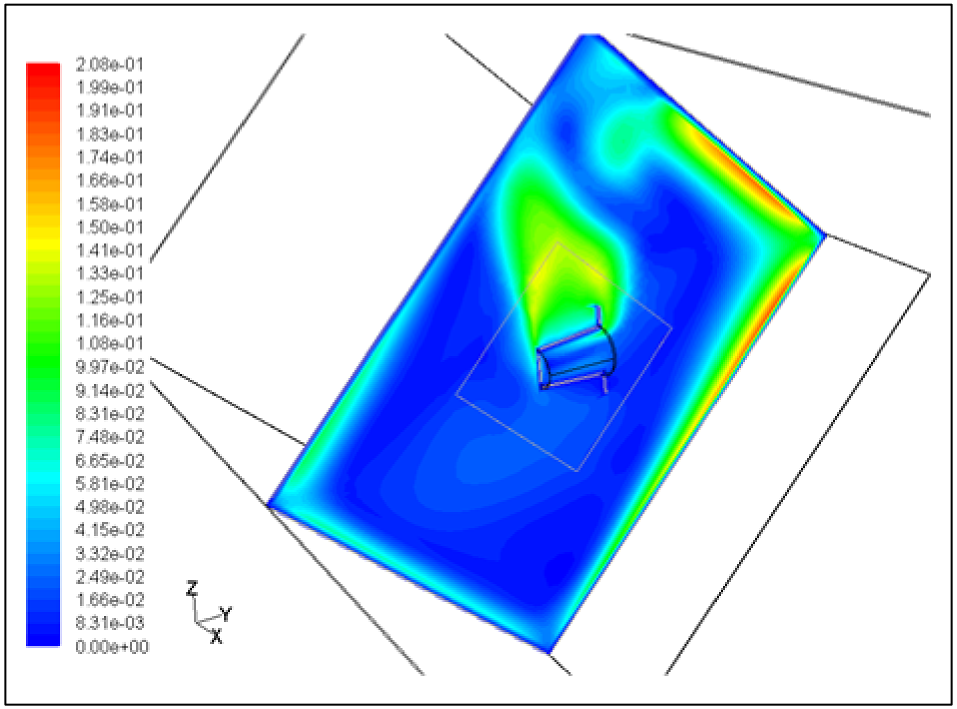
Projektträger im DLR

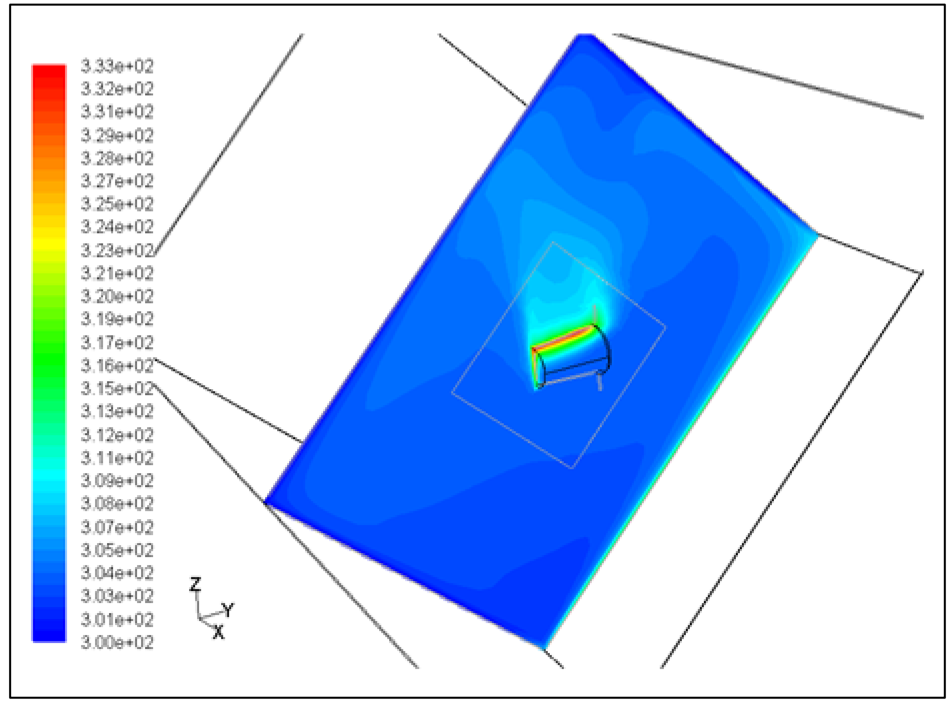
Temperature distribution in the part and induced convection current near the measuring cube



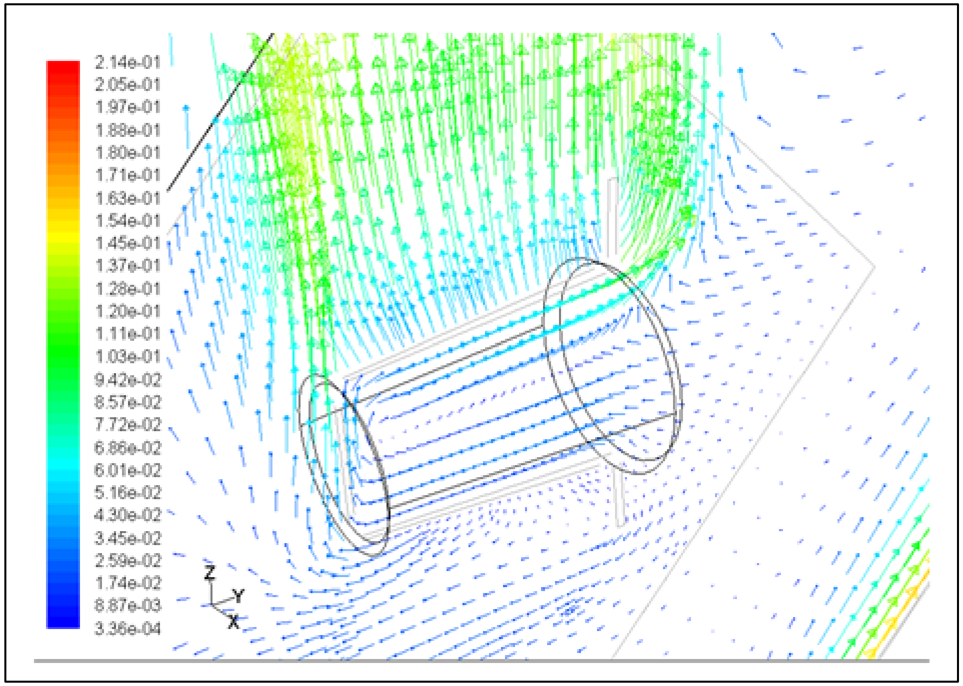


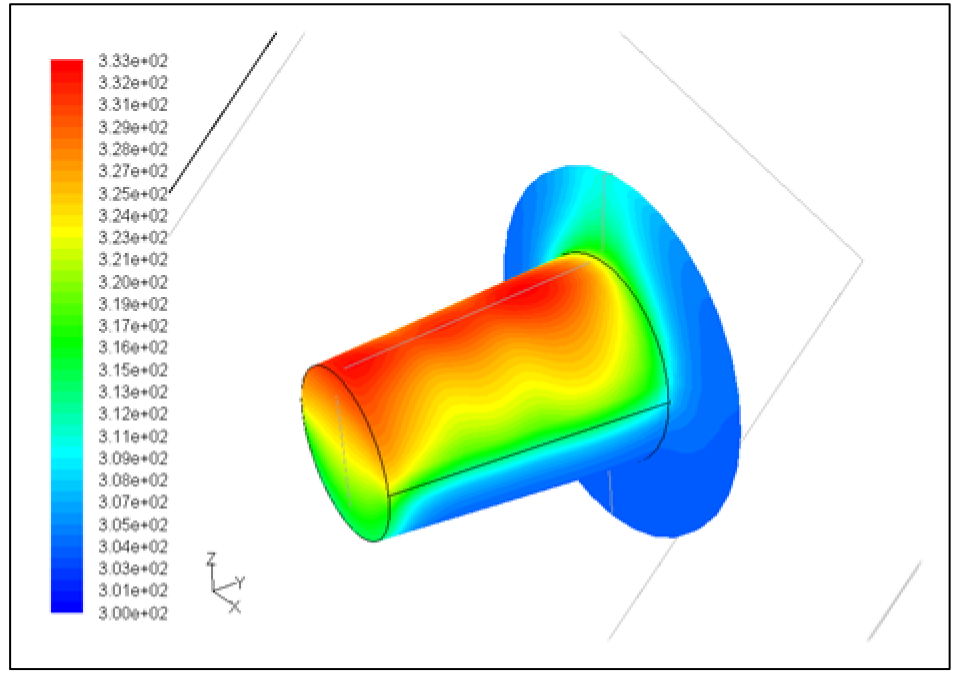
Air velocity- and temperature distribution in the box and on the part



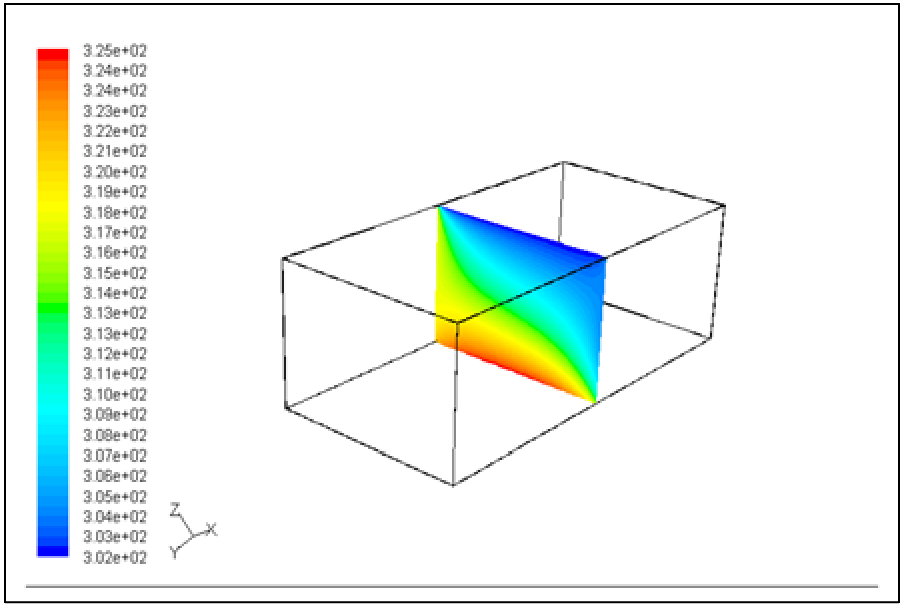


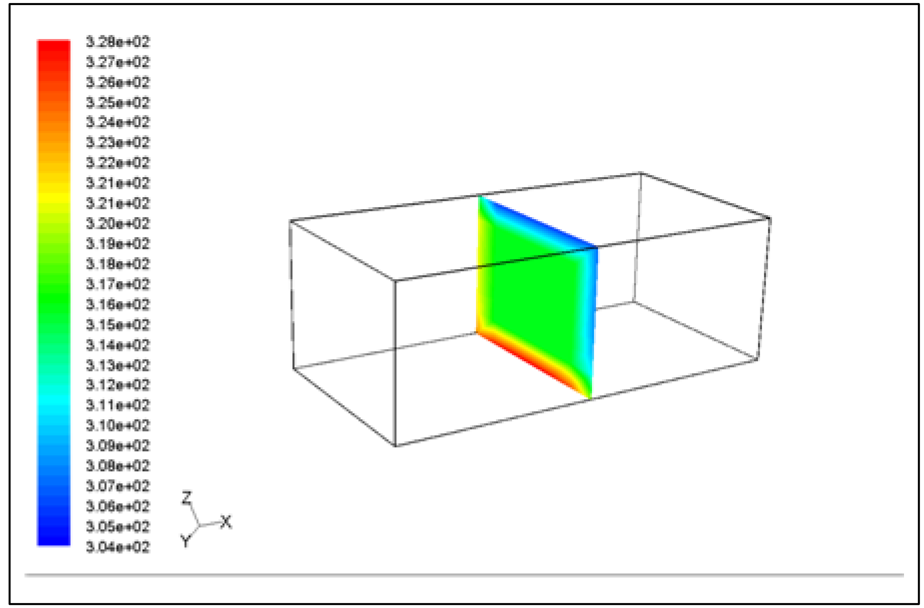
Induced convection in the hat and temperature distribution on the surface





Temperature distribution in the test box without (left) and with convection





Shadow creation at 7:00 h and 8:45 h local time Phoenix/Arizona, 13th of June 2008