INERT WALL THERMAL FEEDBACK VALIDATION STUDY

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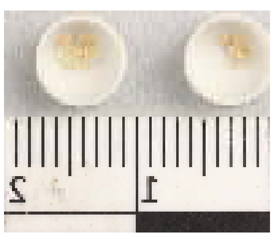
Fire development modelling of engineered wood.

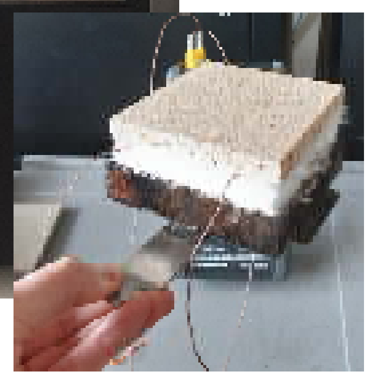
Motivation – Fire spread modeling

- **E**ngineered **W**ood **P**roducts (MDF, OSB, plywood, particleboard)
- CFD coupled to pyrolysis model
  - Thermal decomposition properties
  - Material properties
    - Thermo-physical properties
    - Optical properties
  - Model dependent parameters

Pyrolysis model input parameters

➢ Micro-scale





➢ Bench-scale

Calibration versus validation?

How to validate pyrolysis model of EWP?

Vertical flame spread experiment

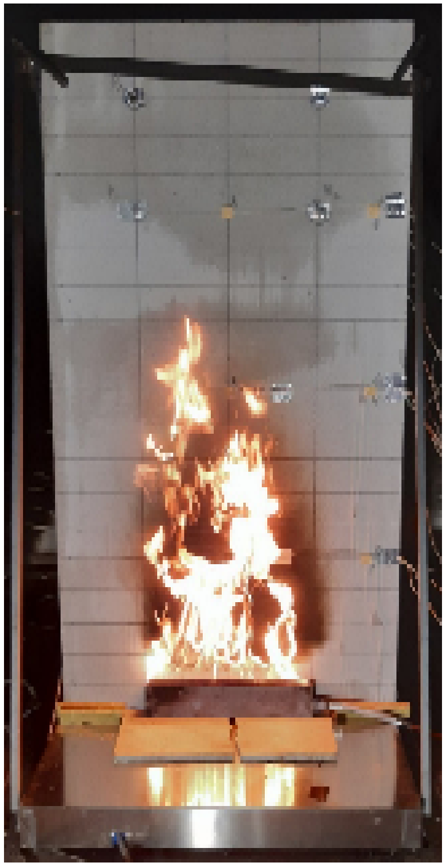
- 2 × 1 meter board
- 50 × 5 ×10 cm propane burner

Wong, William Chiu-Kit. 2012. CFD Flame Spread Model Validation: Multi-Component Data Set Framework. : Worcester Polytechnic Institute

Combustible wall fire model

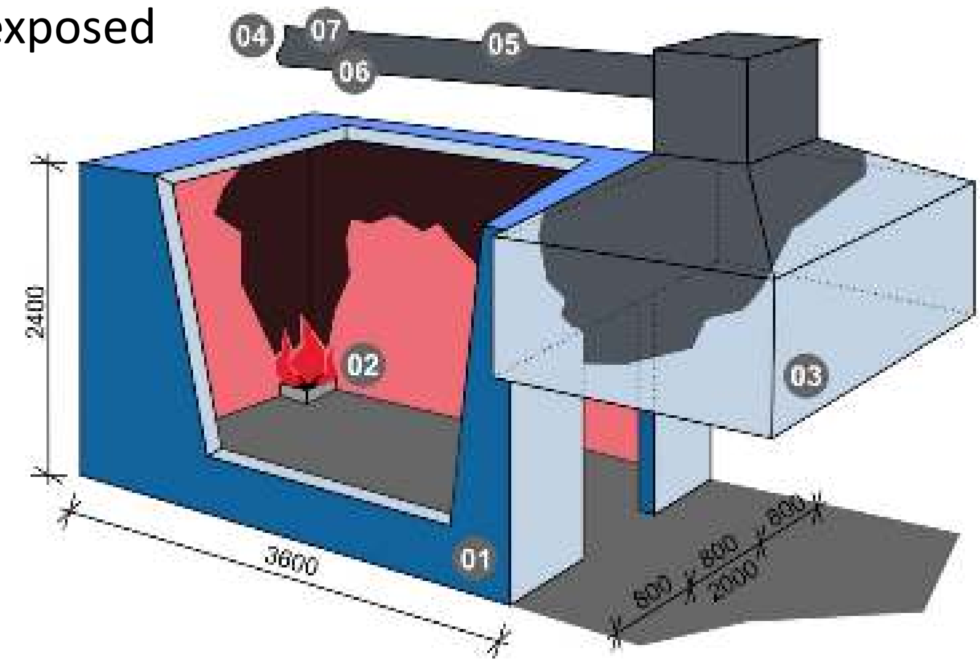
- Turbulent buoyant fluid flow
- Gas phase kinetics
- Flame heat transfer
- Pyrolysis

Inert wall fire – thermal feedback to the wall



Fiber cement panel

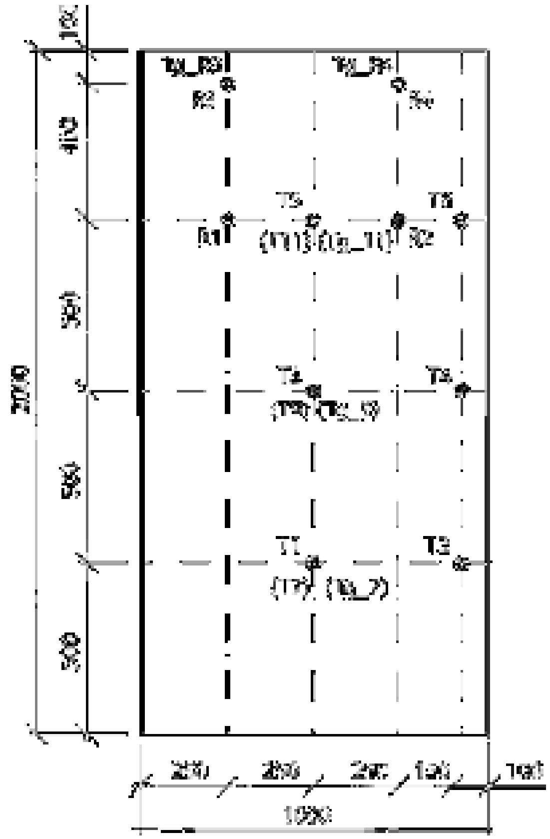
- 2 × 1 meter
- 12 mm thick
- Back side exposed



Measured quantities

Gas phase quantities

- Temperature
  - In the corner of the room
  - Close to the panel
- Net heat flux to the wall



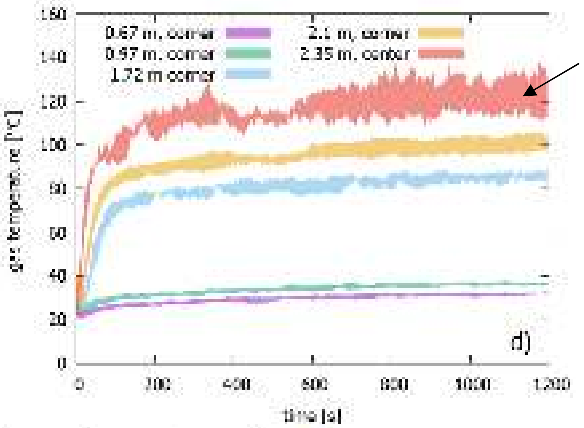
Solid phase quantities

- Surface temperature

Mineral wool fiber insulation sheet

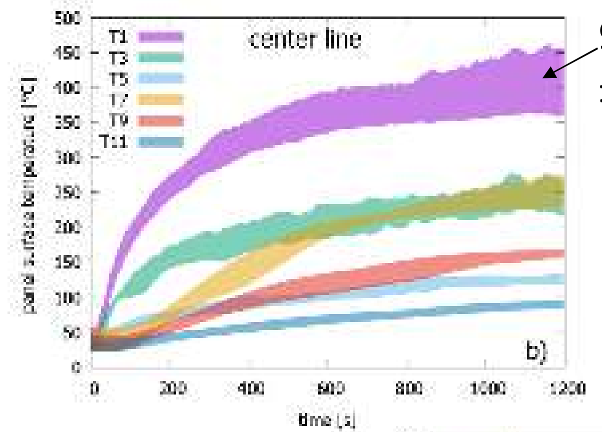
Repeatability and measurement uncertainty

Temperature in the room



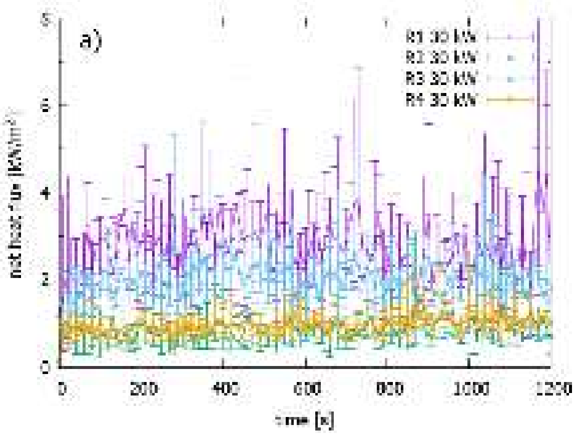
25 °C
± 2.5 °C

Panel surface temperature



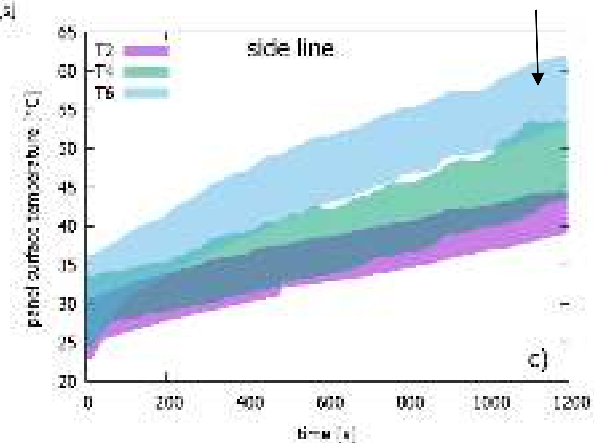
90 °C
± 3.8 °C

10 °C
± 2.5 °C

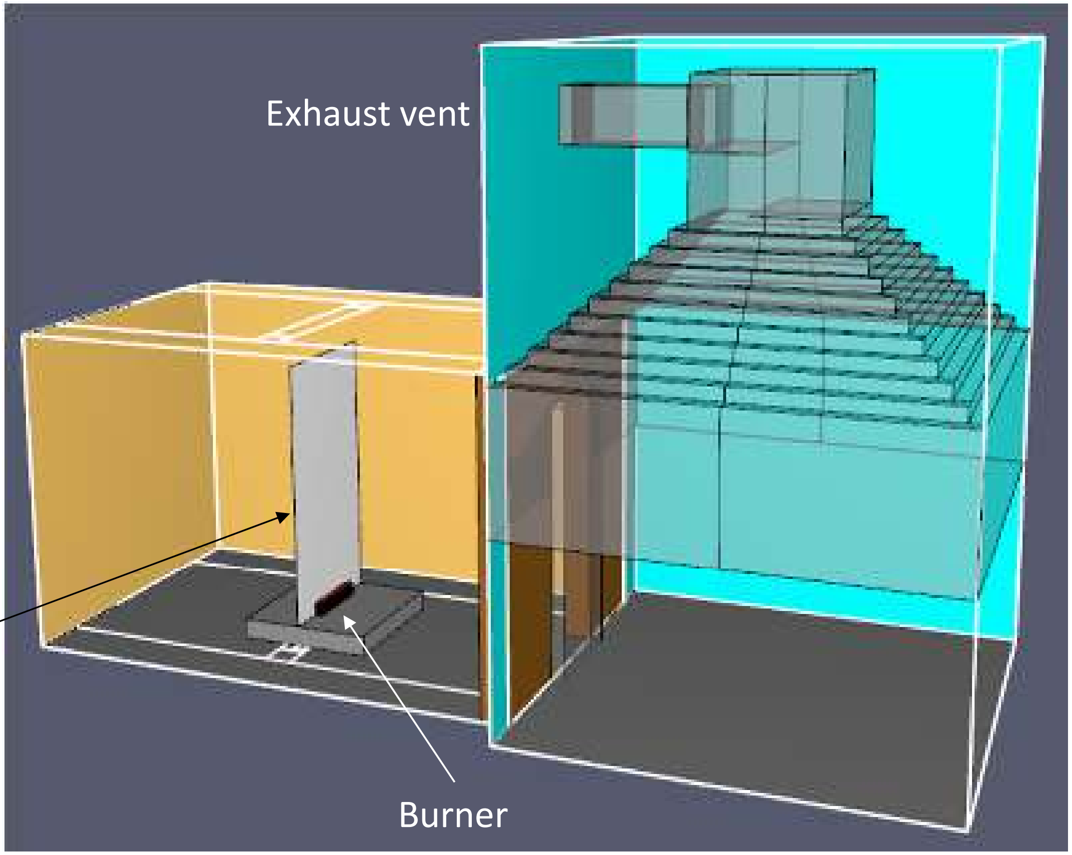


Net heat flux

- Uncertainty of the heat flux gauge?
  - Calibration accuracy is ± 3 % at full scale
  - Non-linearity error 10 to 50 %
- Net heat flux not symmetrical along the center line



FDS model



Test room walls - inert

Fiber cement panel
- 1 layer, 1 cell thick
- k, ρ, c_p constant
- Backing exposed

Solid phase solver
CELL_SIZE_FACTOR = 0.5
STRETCH_FACTOR = 1

Open boundary at three sides

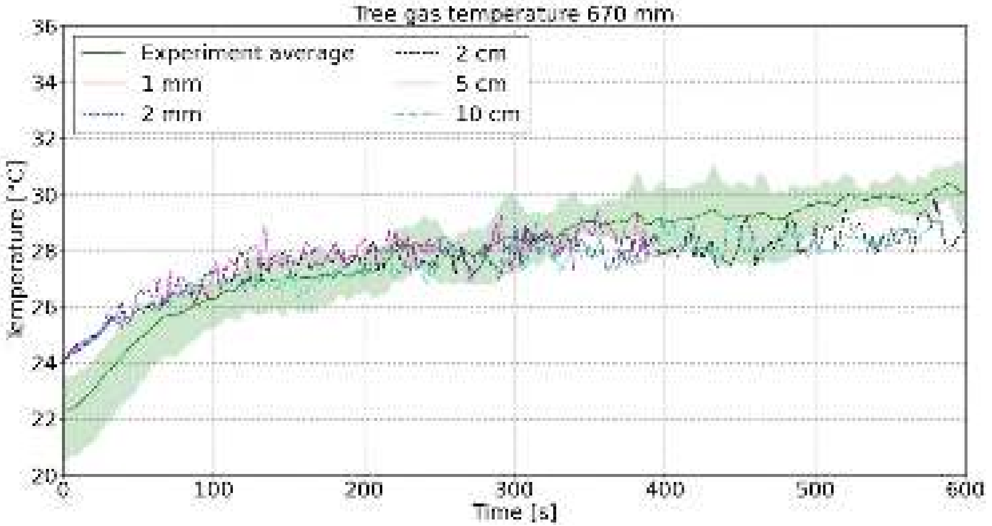
Grid resolution – 5 cases

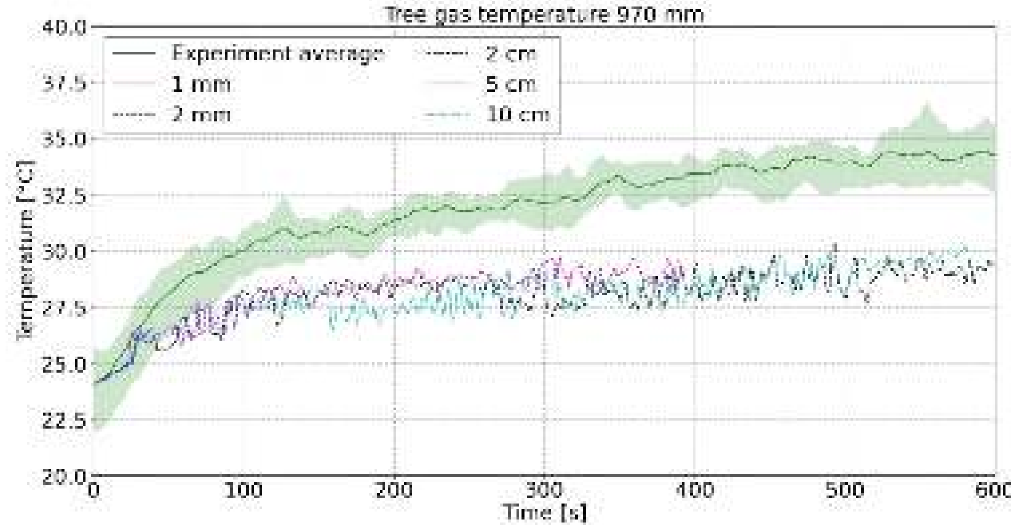
Brown, A., Bruns, M., Gollner, M., Hewson, J., Maragkos, G., Marshall, A., McDermott, R., Merci, B., Rogaume, T., Stoliarov, S., Torero, J., Trouvé, A., Wang, Y., Weckman, E. (2018). Proceedings of the First Workshop Organized by the IAFSS Working Group on Measurement and Computation of Fire Phenomena (MaCFP), *Fire Safety Journal, 101,* 1-17.

- Grid resolution required to resolve boundary layer and wall gradients is in an order of 1 mm
- High resolution grid reduce numerical errors - the discrepancies between experimental data and computational results may be attributed to modeling errors

Mesh ID	Grid cell size in direction perpendicular to the panel (number of cells in this direction)	Total number of cells	Number of meshes	Simulation time (s)
1 mm	1mm (12) - 2mm (26) - 4mm (9) - 2cm (95)	65 902 500	80	10
2 mm	2 mm (20) - 4 mm (10) - 8 mm (10) - 4cm (46)	22 222 800	36	40
2 cm	1cm (20) - 2cm (10) - 10 cm (17)	804 084	11	600
5 cm	1 cm (20) - 5 cm (38)	1 070 496	6	394
10 cm	1 cm (20) - 10 cm (19)	637 812	6	585

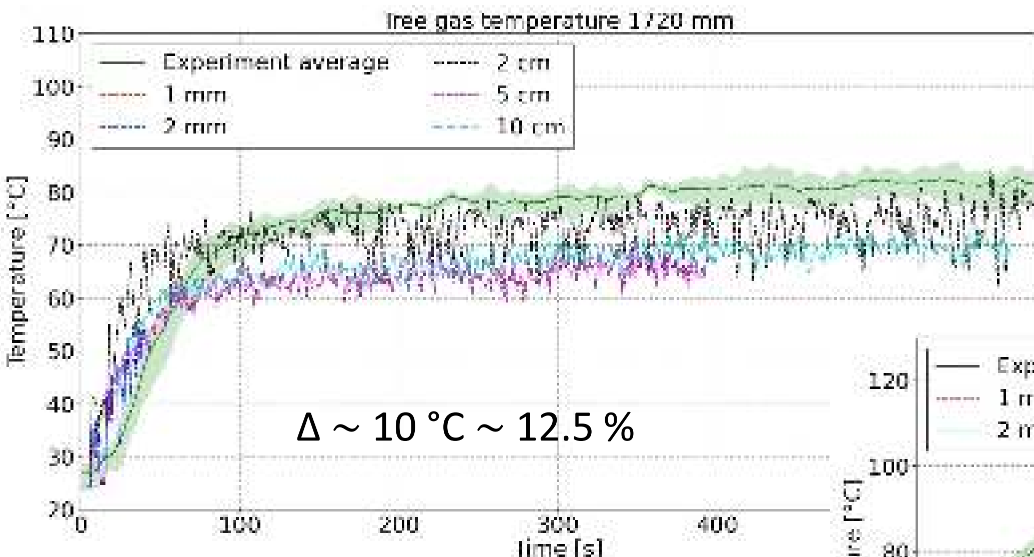
Cold layer temperature



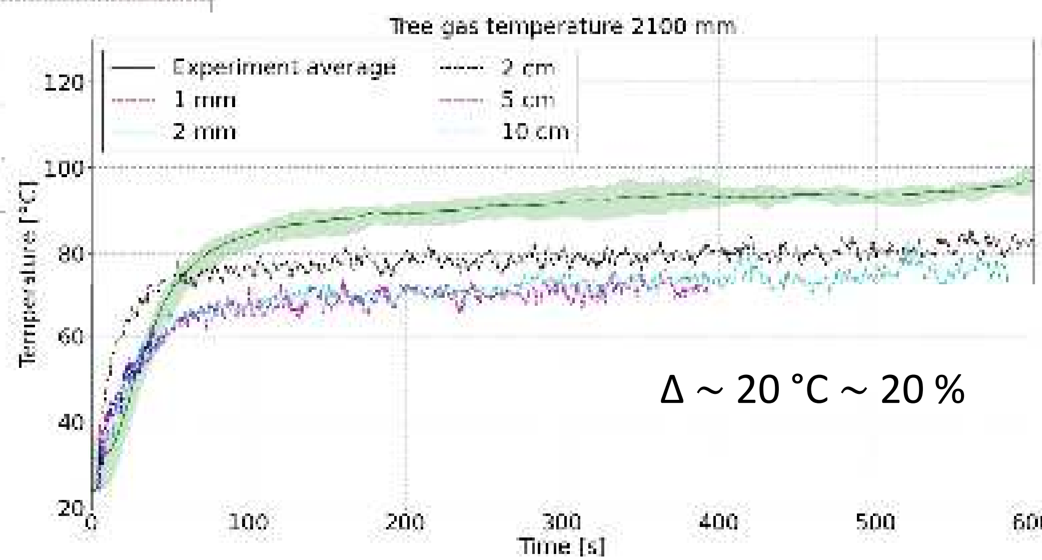


Δ ~ 5 °C ~ 15 %

Hot layer temperature

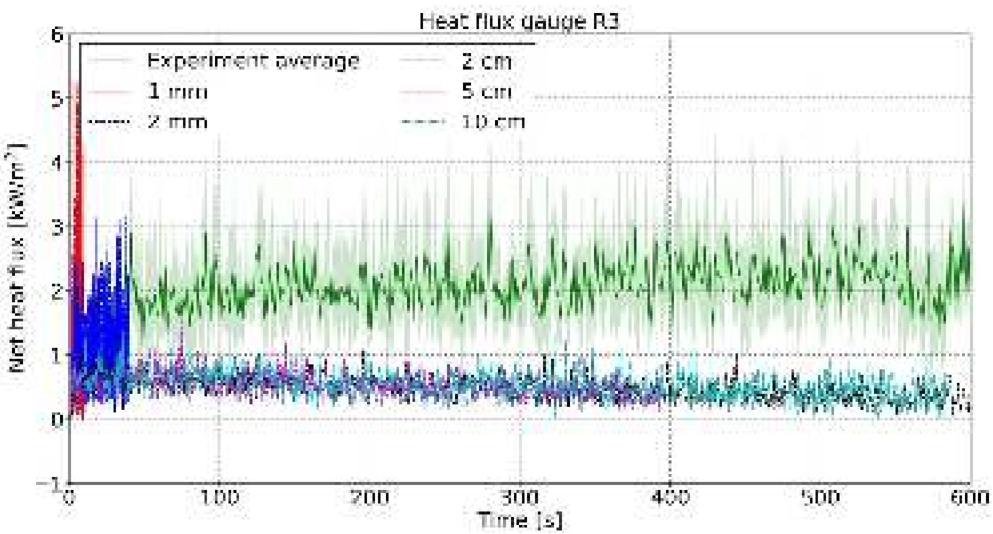


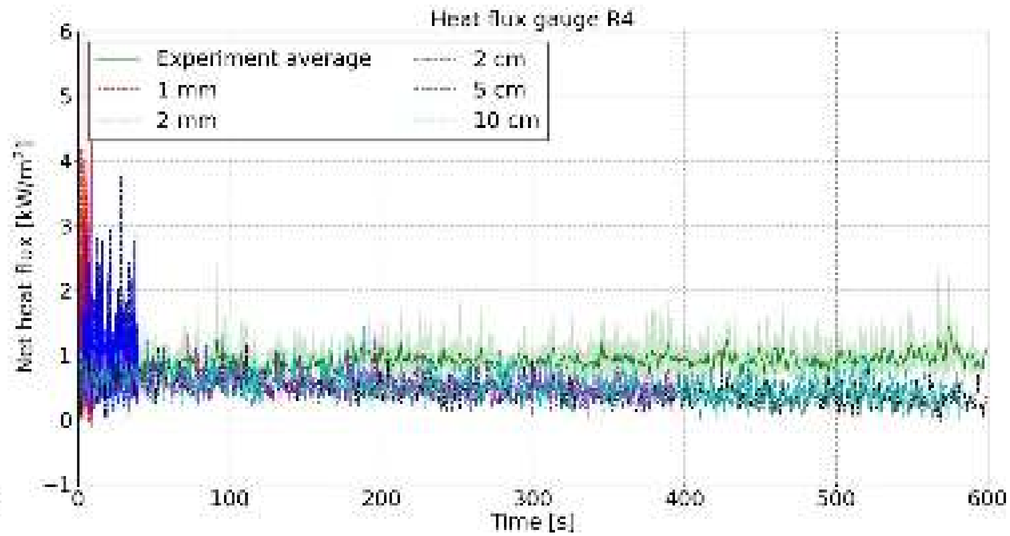
Δ ~ 10 °C ~ 12.5 %



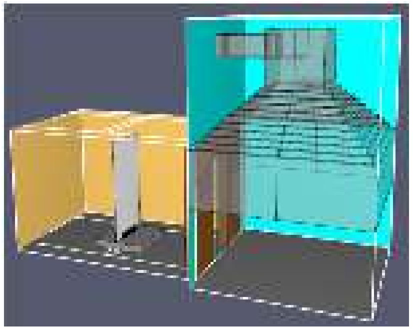
Δ ~ 20 °C ~ 20 %

Net heat flux to the wall

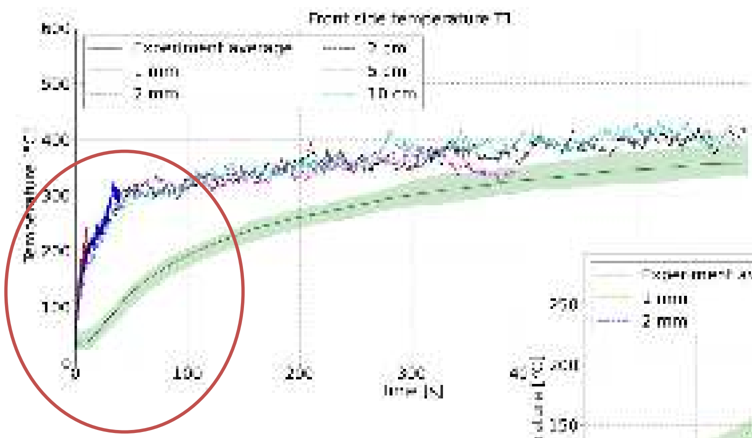


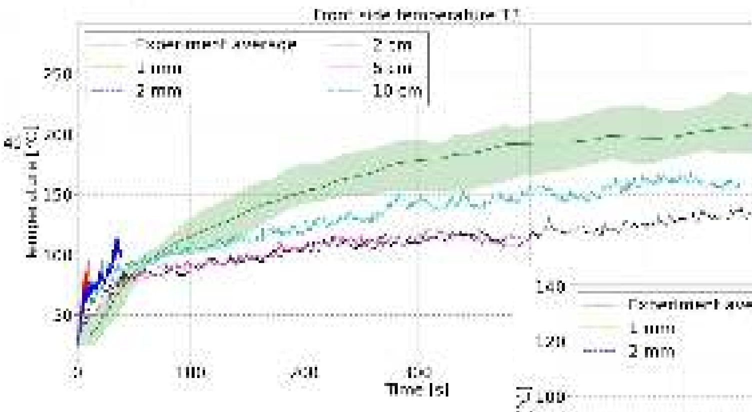


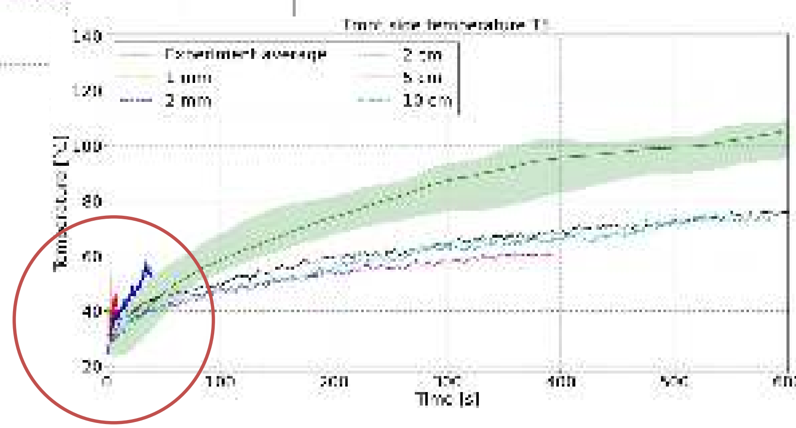
- Heat flux in the model is symmetrical along the panel center line
- Wrong boundary condition in the hood area
- Net heat flux to the cold versus hot wall

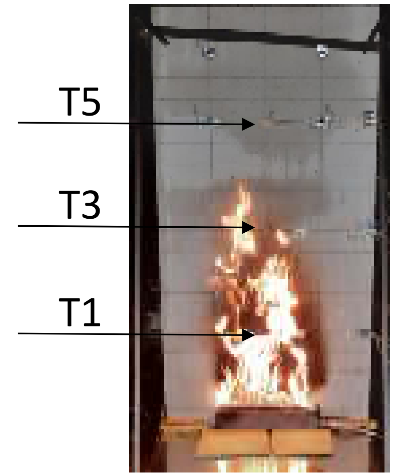


Panel surface temperature – center line



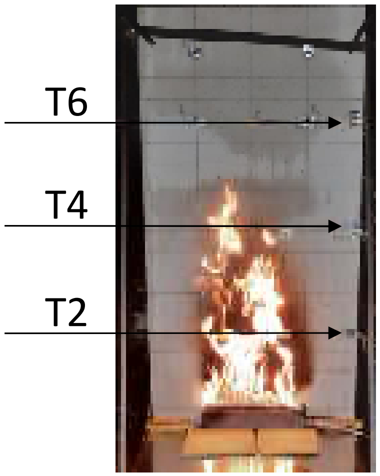


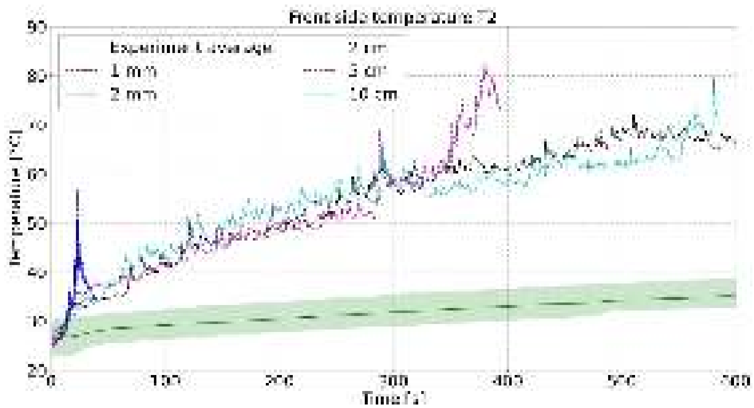


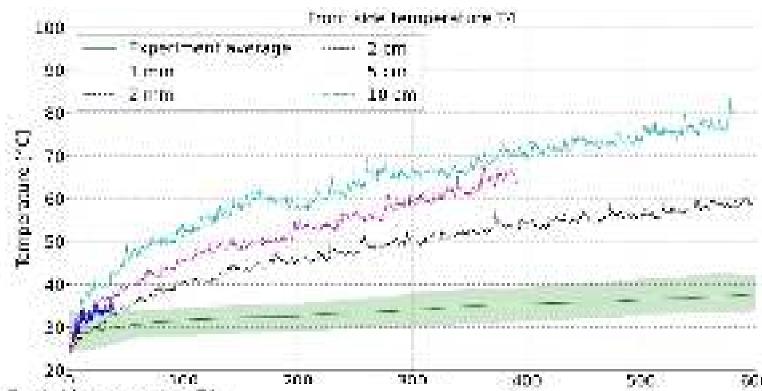


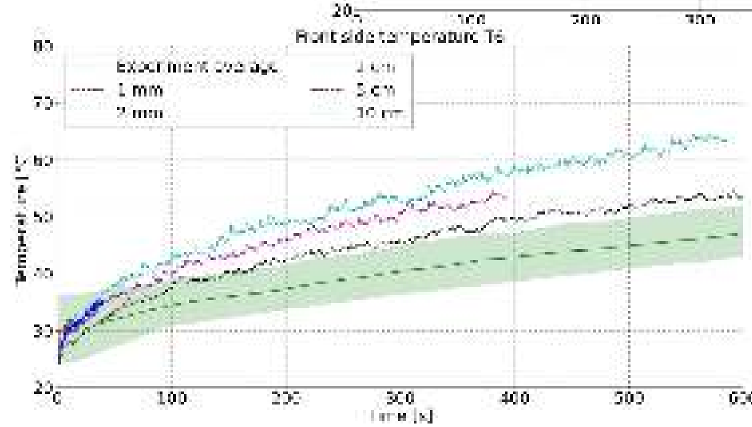
- Grid resolution
- Presence of moisture
- *k*, c_p are temperature dependent
- 1D heat transfer

Panel surface temperature - side line









- Unsymmetrical flow conditions
- Presence of moisture
- k, c_p are temperature dependent
- 1D heat transfer

Conclusions

Experiments

- Evaluate the HFG uncertainty
- Measure velocity profile in the doors to the room

Model

- Change boundary condition in the hood area
- Add temperature dependent k, c_p
- Evaluate the „conductive losses" upwards and to the side of the panel - 3D heat transfer.
- Get at least 200 seconds of the very fine grid resolution simulation