BERGISCHE UNIVERSITÄT WUPPERTAL

Influence of Input Parameters on the Fire Simulation

C. Trettin*, P. Hagemann*, M. Werrel**, M. Meinert***, F.-W. Wittbecker*

*University of Wuppertal, Germany

**BASF, Germany

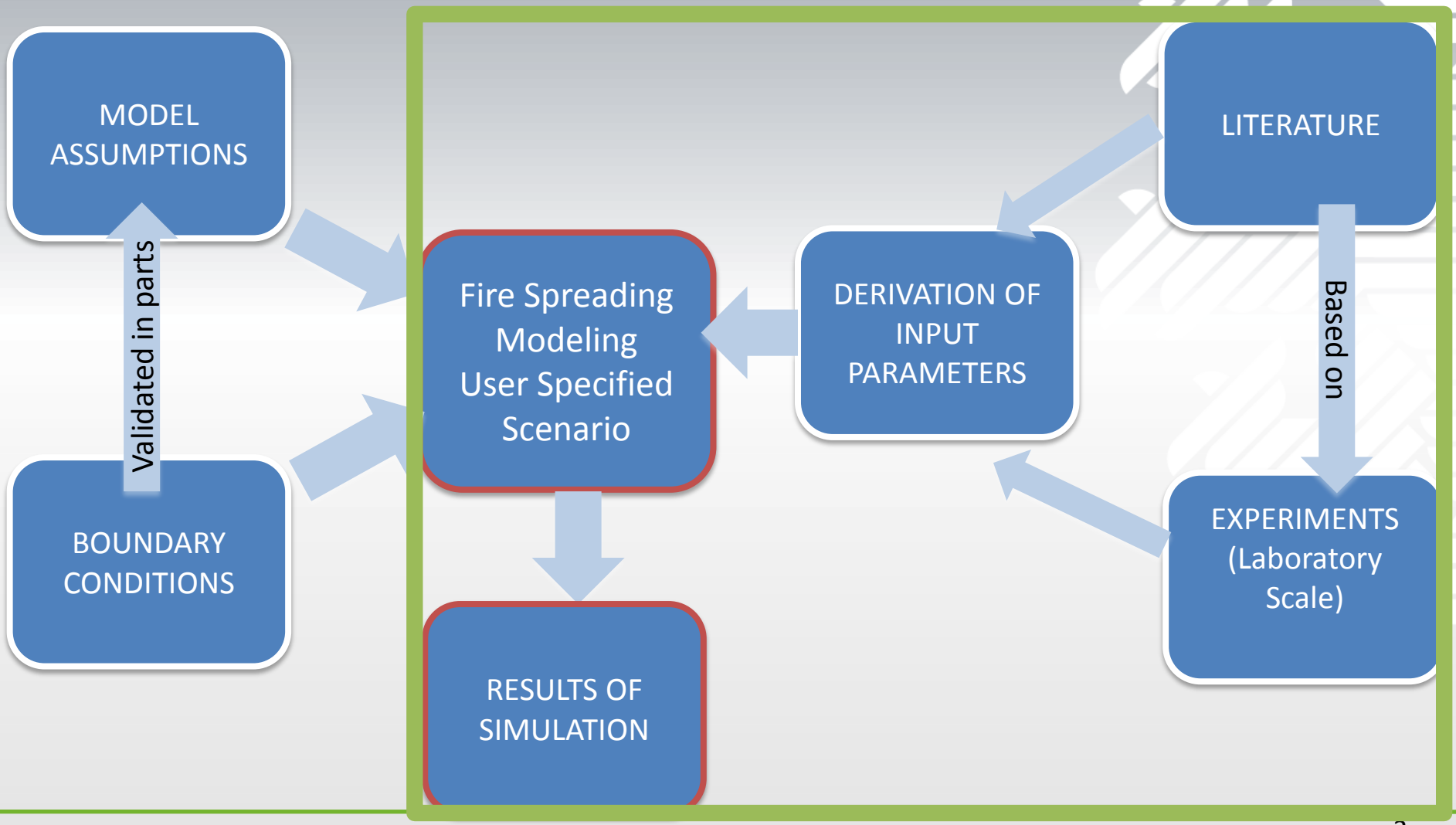
*** Muenster University of Applied Science, Germany

Content

- Introduction
- Laboratory Experiments
  - Thermogravimetric Analysis
- CFD-Simulation (FDS)
  - Laboratory Scale
  - Scaling Real Dimension
- Conclusion

Problem

- Is the simulation realistic?



Approach

Thermal Properties

ρ (kg/m³)	C (kJ/kg·°C)	k (W/m·°C)

Laboratory Experiments

Determination of Input Parameters

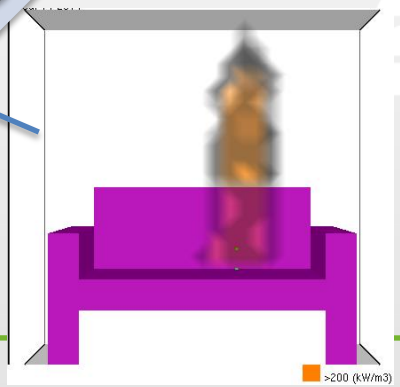
Laboratory Scale TGA & Cone

Real Scale Dimension

Analysis of Results

$$E = \frac{e r_p}{Y_0} \frac{R T_p^2}{\dot{T}} \quad ; \quad A = \frac{e r_p}{Y_0} e^{E/RT_p}$$

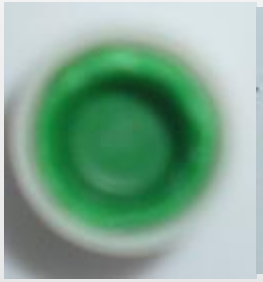
Pyrolysis Process



Thermogravimetric Analysis (TGA)

- Heating Rate: 5K/min, 60K/min
- Ambient Conditions: 10 %, 21% O_2

- Samples



ABS

PU

PMMA

Particle Board

BERGISCHE UNIVERSITÄT WUPPERTAL

Results of TGA

- Different Processes of Decomposition and Dependencies
  - Non or not Reacting Residue
  - Physical Condition
  - Heating Rate
  - Oxygen Concentration
  - Additives by Supplier
  - Thermal Inertia

PMMA

< 0.1 %

ABS

< 0.5 %

PU

6 – 8 %

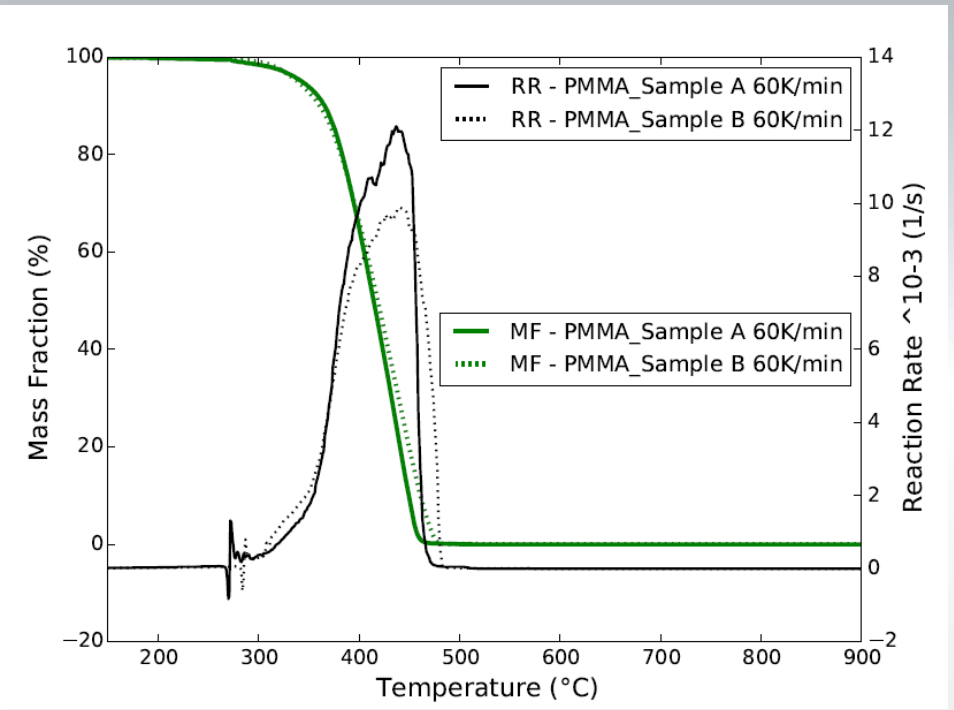
Particle Board

1 %

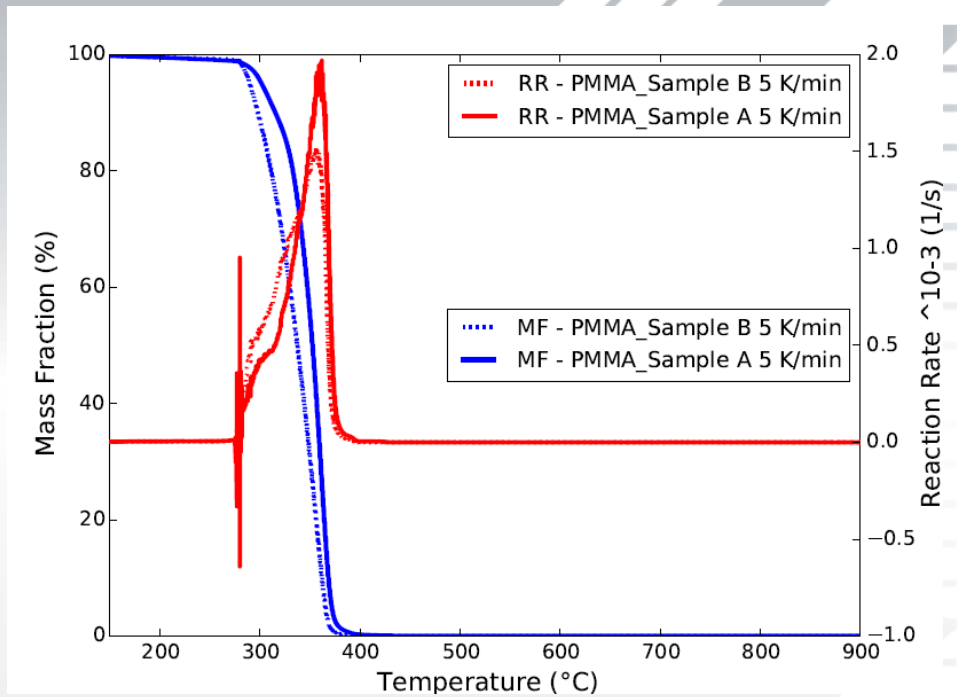
BERGISCHE UNIVERSITÄT WUPPERTAL

Results of TGA

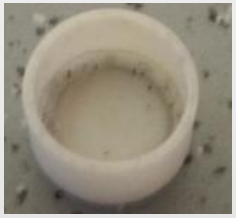
PMMA



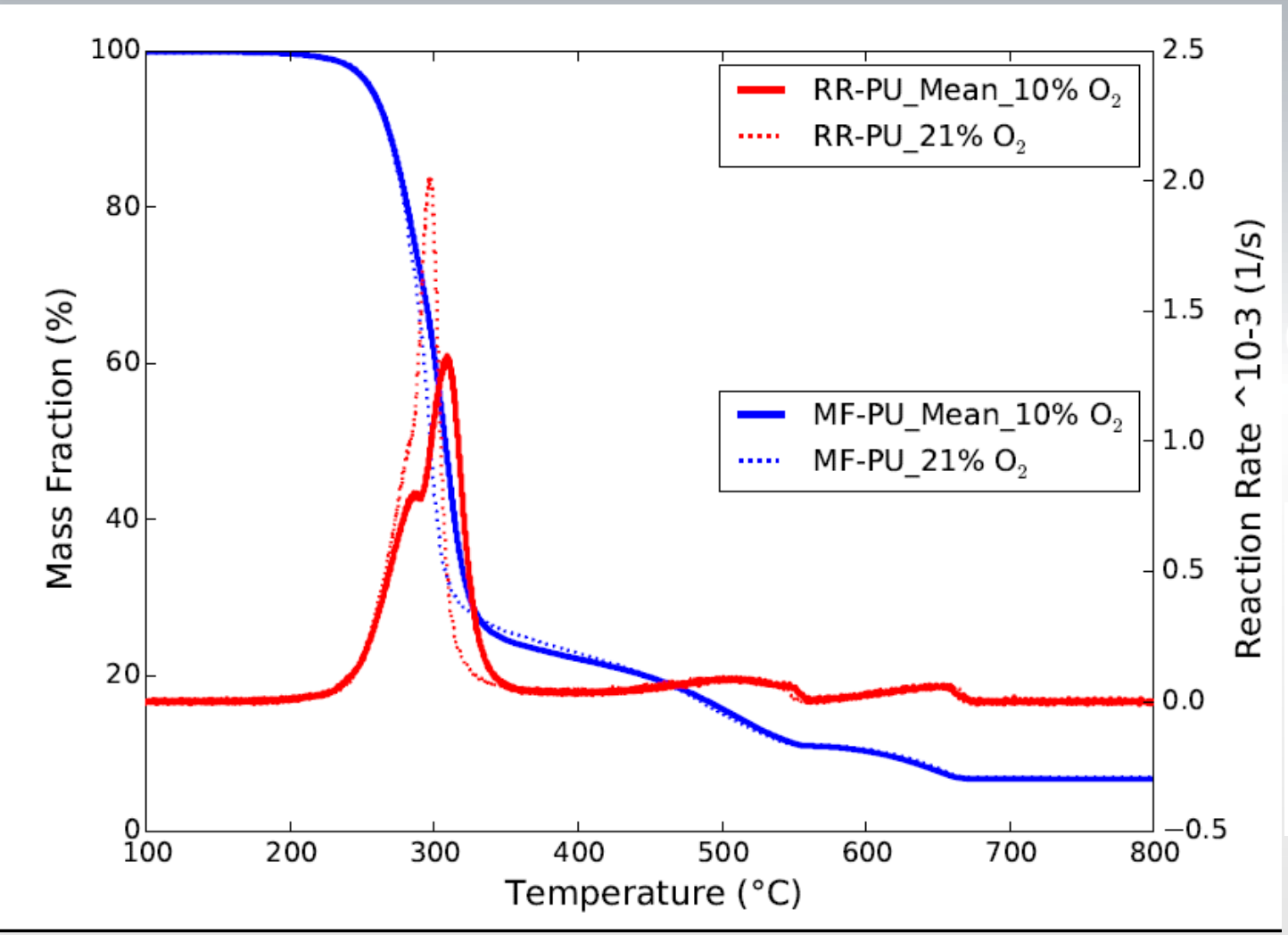
60 K/min



5 K/min



Results of TGA



PU

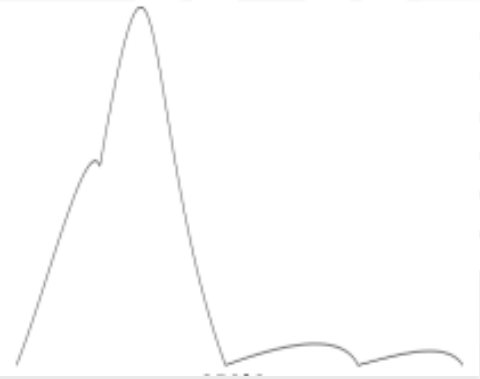
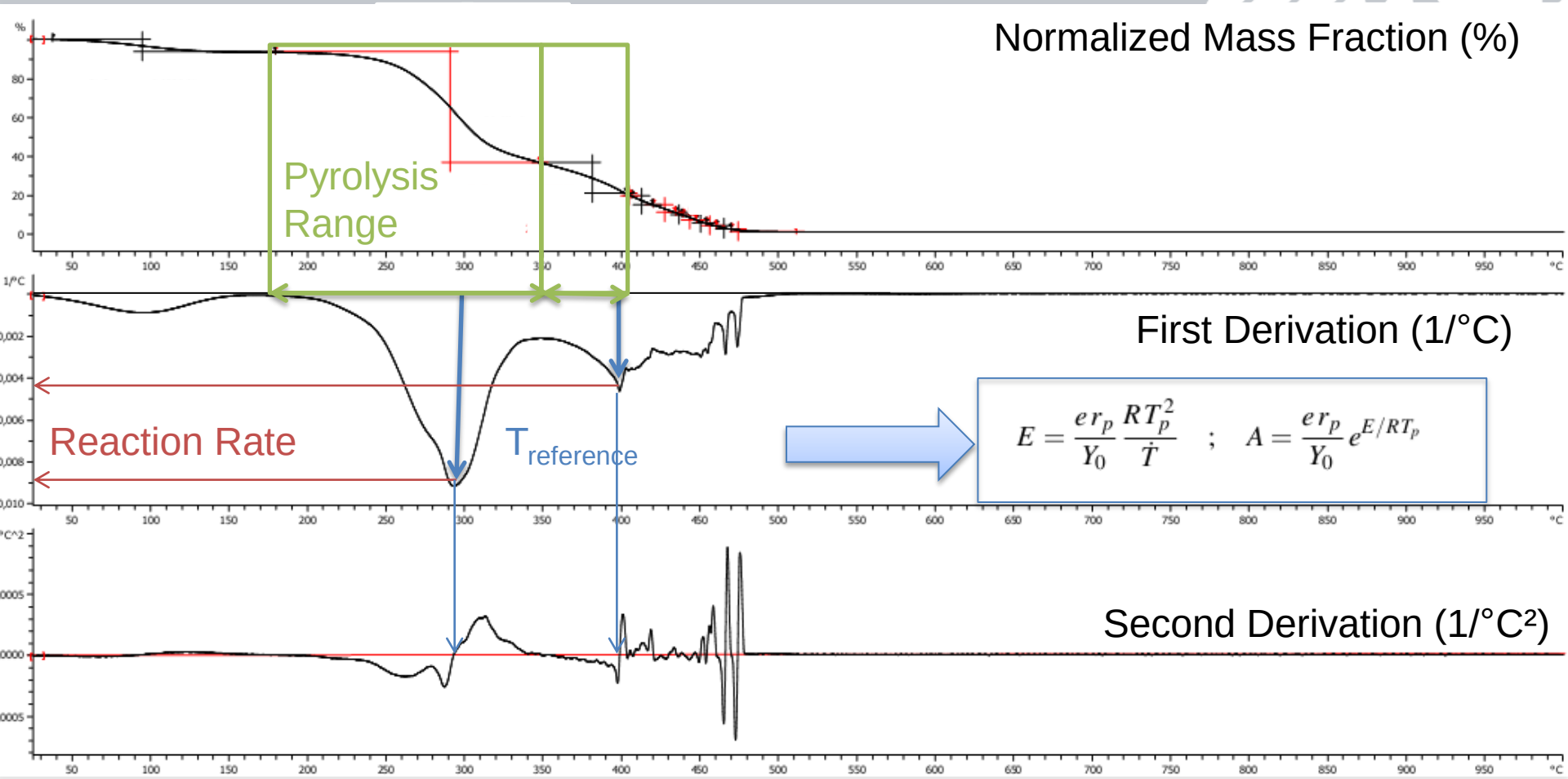


Figure by D.Bodenstein

BERGISCHE UNIVERSITÄT WUPPERTAL

Determination of Pyrolysis Parameter



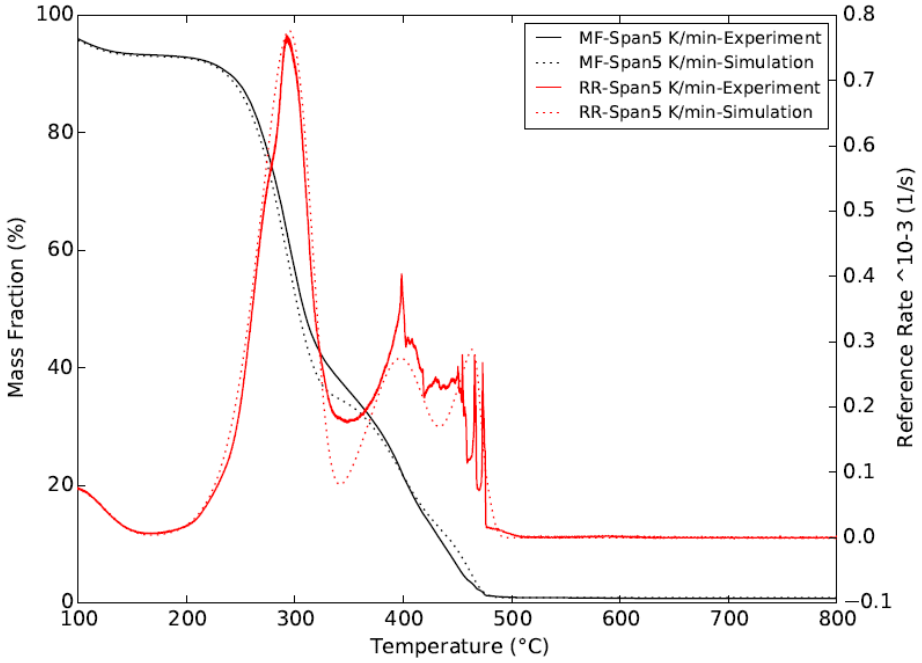
$$E = \frac{e\,r_p}{Y_0}\frac{RT_p^2}{\dot{T}} \quad ; \quad A = \frac{e\,r_p}{Y_0}e^{E/RT_p}$$

BERGISCHE UNIVERSITÄT WUPPERTAL

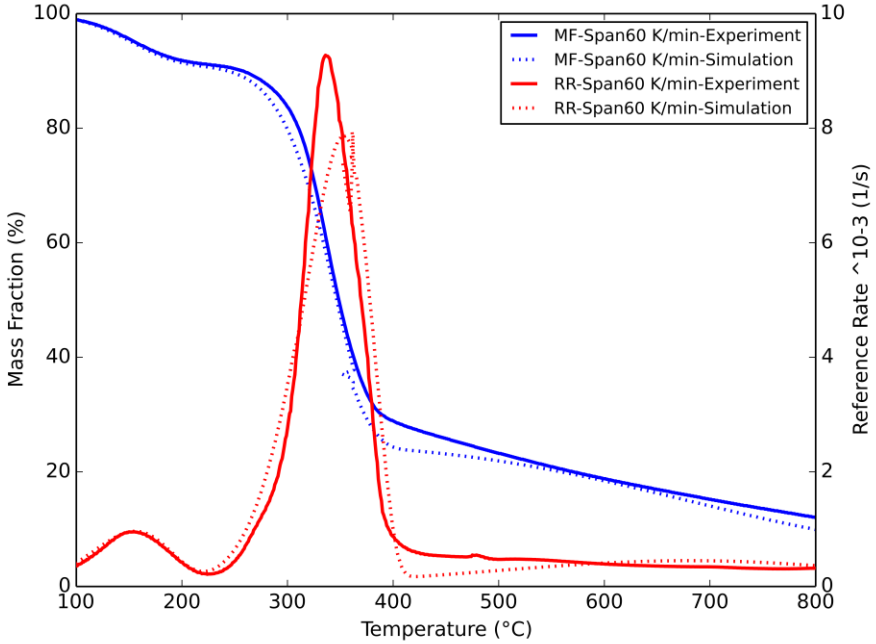
Comparison of Simulated TGA

Particle Board

5 K/min



60 K/min



Arrhenius parameters

$$E = \frac{e r_p}{Y_0} \frac{R T_p^2}{\dot{T}} \quad ; \quad A = \frac{e r_p}{Y_0} e^{E/RT_p}$$

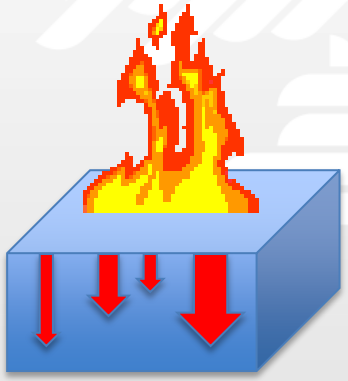
Condition of Simulation

- TGA
  - Neglecting of Thermal Influence
  - Focus: Pyrolysis

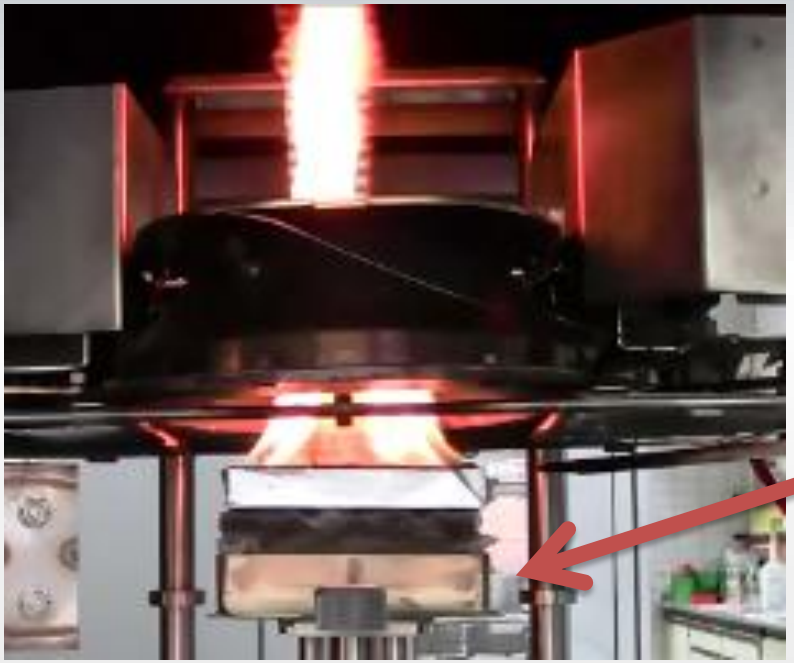
$O_2 = 0.01$

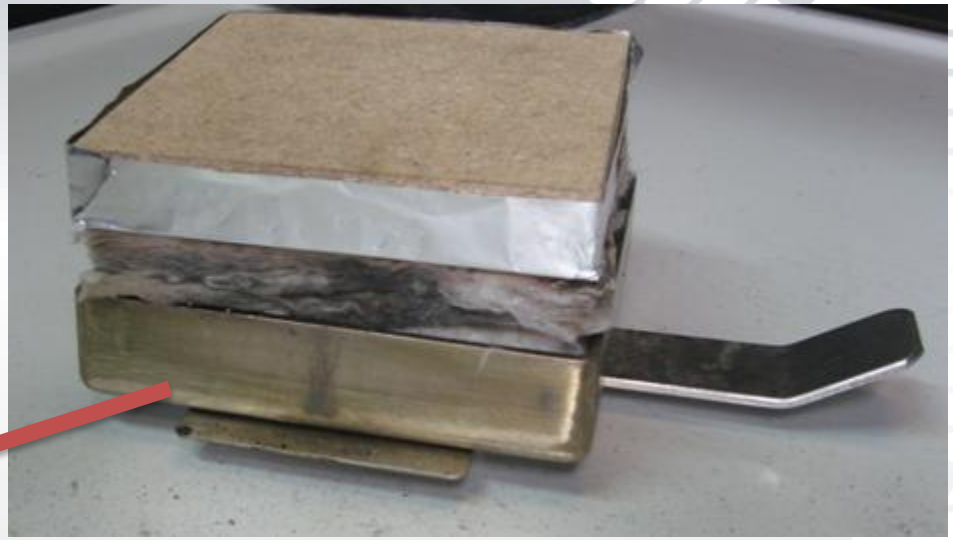
- Cone
  - Definition of Thermal Depth
  - Oxygen Concentration
  - Focus: Mass Lose Rate and Heat Release Rate

$O_2 = 0.23$



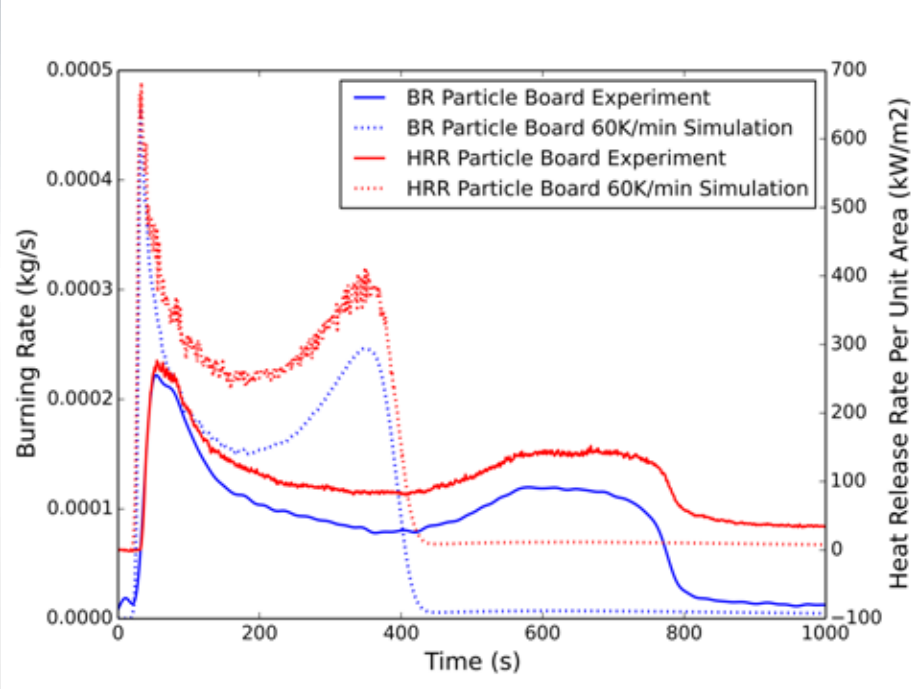
Simulated Cone Calorimeter of Particle Board



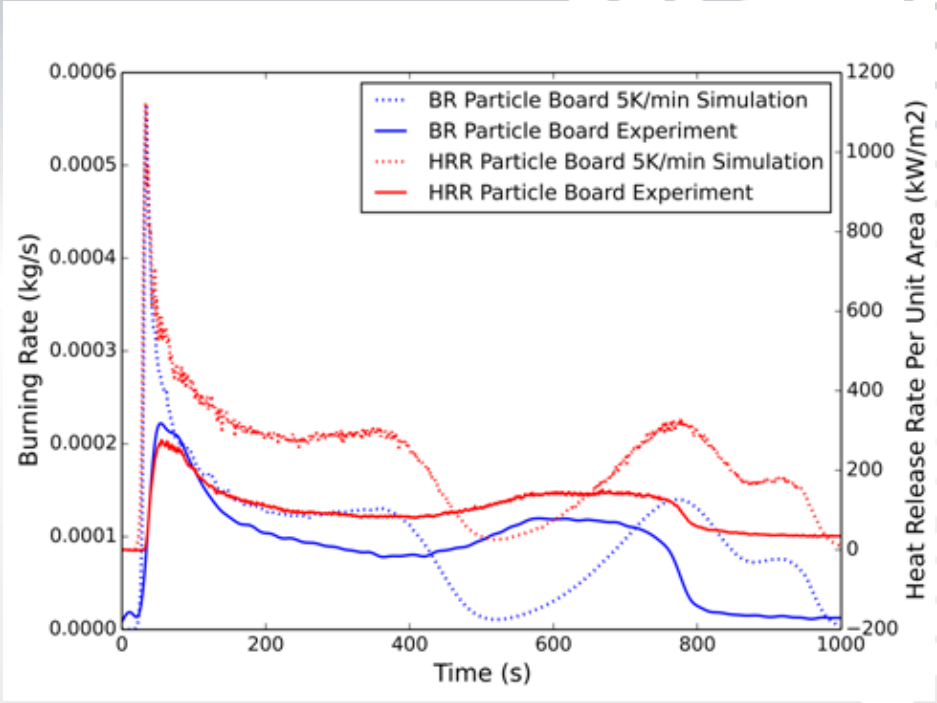


BERGISCHE UNIVERSITÄT WUPPERTAL

Simulated Cone Calorimeter of Particle Board



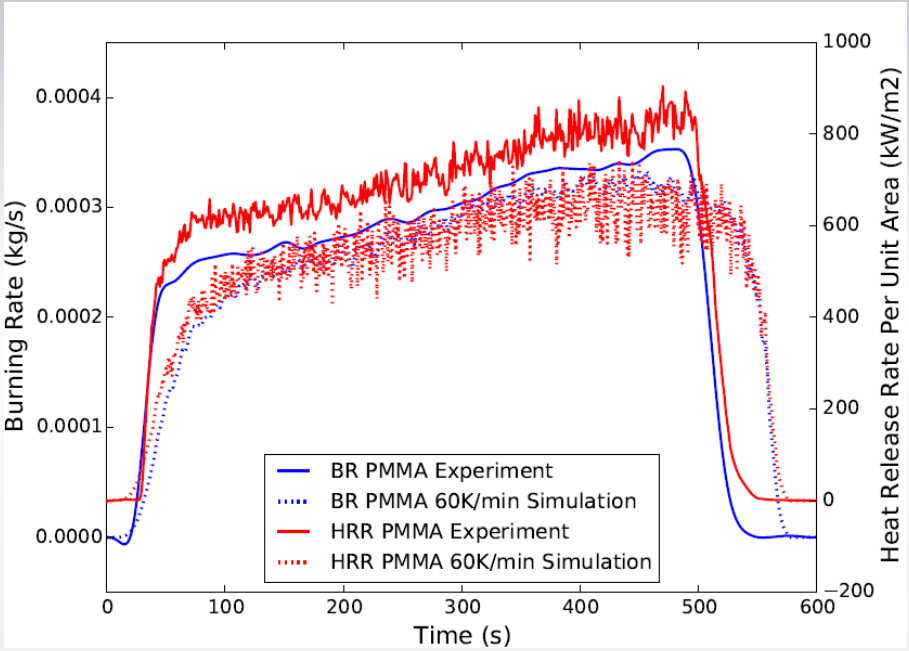
60 K/min



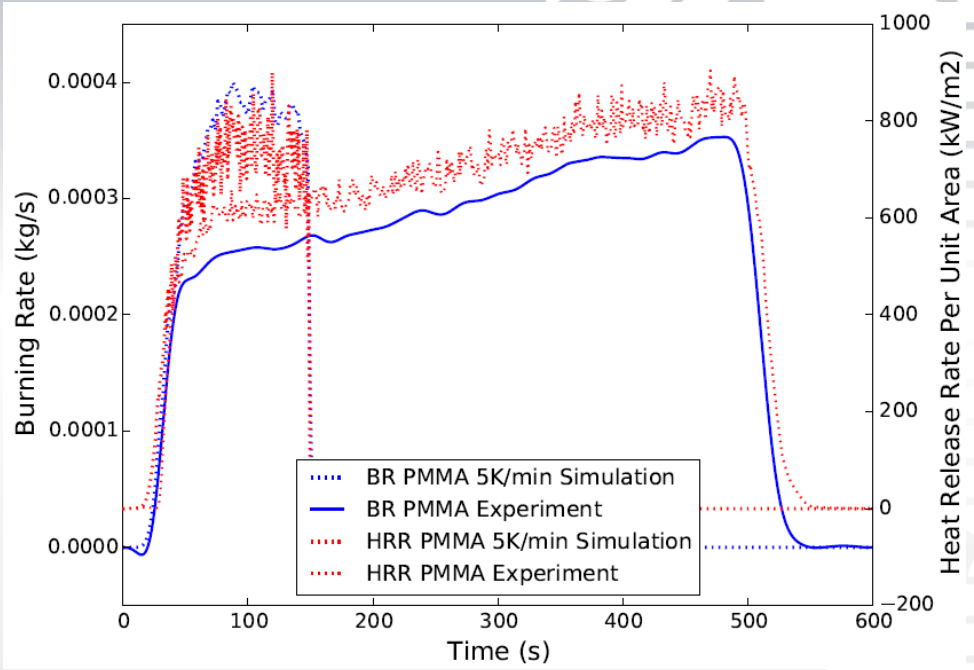
5 K/min

BERGISCHE UNIVERSITÄT WUPPERTAL

Simulated Cone Calorimeter of PMMA



60 K/min



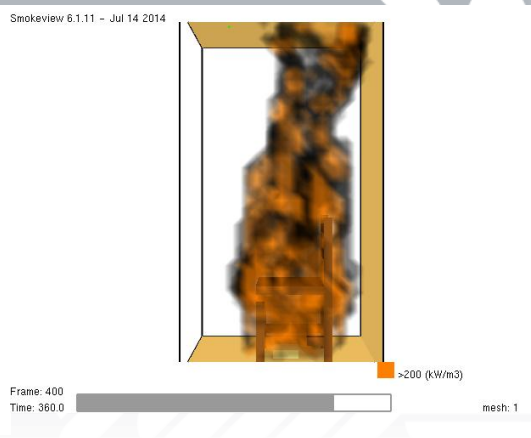
5 K/min

BERGISCHE UNIVERSITÄT WUPPERTAL

Real Scale Dimension

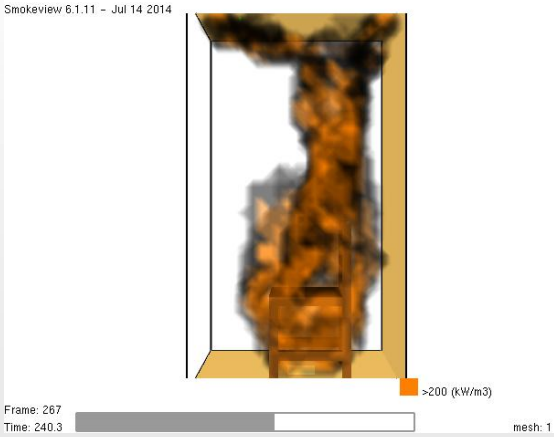
- Particle Board
  - 5 K/min
  - Max. Heat Release Rate 500 kW

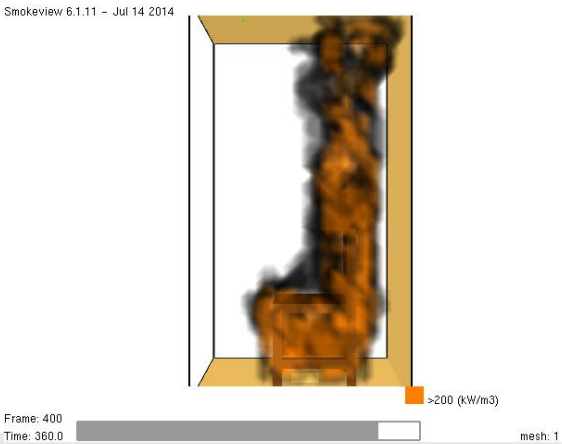
240 s



360 s

  - 60 K/min
  - Max. Heat Release Rate 700 kW

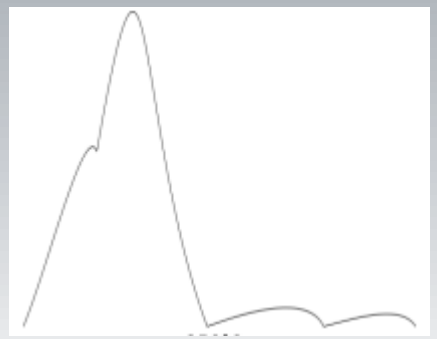


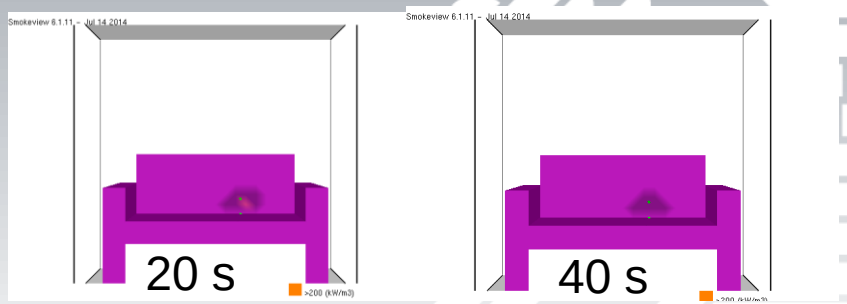


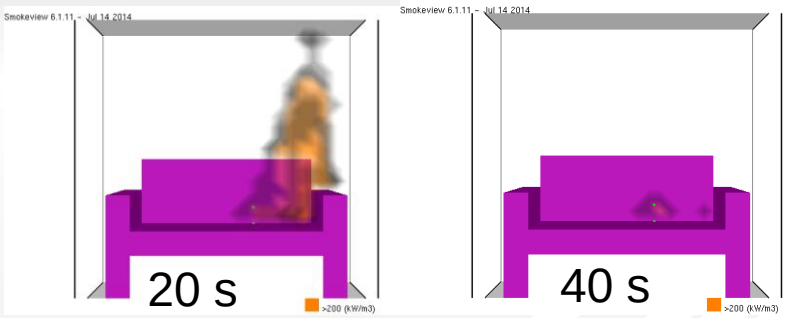
BERGISCHE UNIVERSITÄT WUPPERTAL

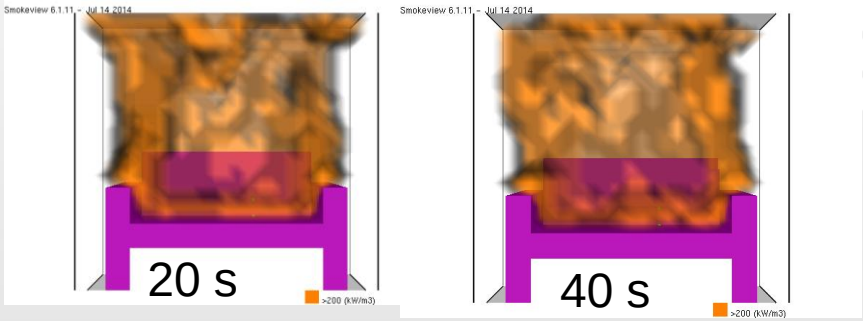
Real Scale Dimension

- PU
  - 3 pyrolysis processes
  - 2 pyrolysis processes
  - 1 pyrolysis process









Results

- Transfer of material properties is limited
- Modeling the same fire scenario by adjusting parameters
- One changing configuration (e.g. heating rate) lead to a complete change in fire behavior

Conclusion

- Specific fire scenario
- Sensitivity
- Modeling procedure
- Definition of material properties
- Classification
- Experience

BERGISCHE UNIVERSITÄT WUPPERTAL

Thank you.

trettin@uni-wuppertal.de