A posteriori Modelling of the Dalmarnock Fire Tests

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FireGrid

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Motivation

Why do Fire Modelling ?

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- Fire Modelling has gained special interest after events of 9/11.

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- Reconstruction of fire scenarios is difficult, since not enough data are available. Generally smoke detectors and CCTV are the only "measurements".
- Unkown room-layout complicates further the recreation of fire scenarios. WTC simulations were made based largely on visual recordings of external events.

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- To what degree fire scenarios can be reproduced, if full access to all kind of measured data is available.
- Evaluate which variables have the most important impact on the course of the simulation – which variables would have to be assimilated in a super-real-time simulation → **FireGrid**.

FireGrid

Fire Models

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- CFD fire modelling of compartments has been a huge challenge for scientists. Still no "complete" CFD code for fire available.
- So far validation of CFD codes for fire based on simple enclosure fires, very few "realistic" scenarios have ever been modelled.

Dalmarnock Tests

Key differences :

- Real Building

Dalmarnock Tests

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- Real Building
- Realistic layout → real fuel load.

Dalmarnock Tests

The experimental compartment

Sofa with Bin

Dalmarnock Tests

Table of major events during the tests

Major events Observed	Time from Ignition (s)
Ignition	0
Bookcase ignites	275
Fire engulfes bookcase (flashover)	*300*
Compartment window breakage (NW Pane)	801
Extinction	1140

A posteriori Simulations

Ignition Source

- Sofa laboratory test provided HRR for same sofa as used in Dalmarnock.

A posteriori Simulations

Ignition Source

- Sofa laboratory test provided HRR for same sofa as used in Dalmarnock.
- UoE laboratory test together with other laboratory tests (NIST) → ignition source.

A posteriori Simulations

Fire Growth

Three possible approaches :

A posteriori Simulations

Fire Growth

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- prescribed :

A posteriori Simulations

Fire Growth

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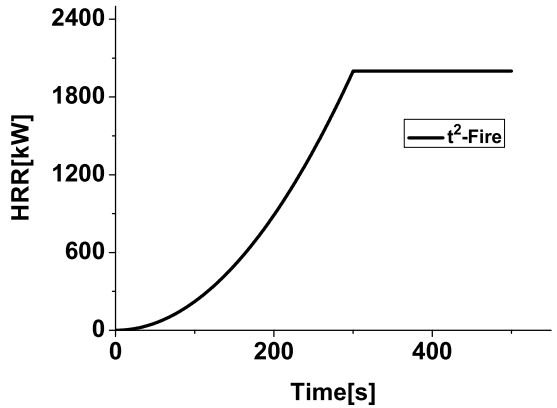
- prescribed :
  - t^2-HRR for growth phase



A posteriori Simulations

Fire Growth

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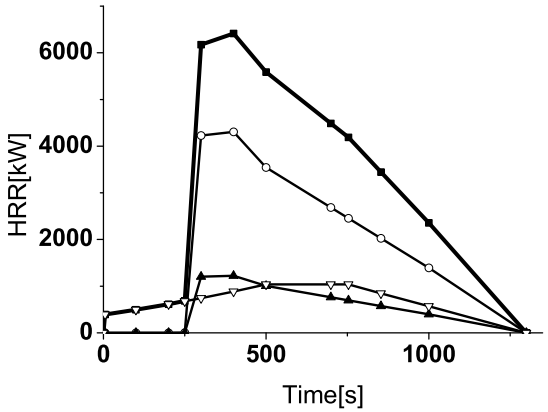
  - Imposed Overall HRR (adding individual HRR)



A posteriori Simulations

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- predicted :

A posteriori Simulations

Fire Growth

Three possible approaches :

- prescribed :
  - t^2-HRR for growth phase
  - Imposed Overall HRR (adding individual HRR)
- predicted :
  - Flame spread based on Material properties

A posteriori Simulations

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t^2-Fire during growth phase :

A posteriori Simulations

Fire Growth

t^2-Fire during growth phase :

- Many different items in the room

A posteriori Simulations

Fire Growth

t^2-Fire during growth phase :

- Many different items in the room
- Parameters of the t^2-Fire cannot be related to items in the room

A posteriori Simulations

Fire Growth

Imposed Overall HRR :

A posteriori Simulations

Fire Growth

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- Fire Dynamics Simulator (FDS) → injection of combustible gases. They burn when they meet the right fuel-oxygen mixture.

A posteriori Simulations

Fire Growth

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A posteriori Simulations

Fire Growth

Imposed Overall HRR :

- Fire Dynamics Simulator (FDS) → injection of combustible gases. They burn when they meet the right fuel-oxygen mixture.
- In ventilation controlled fire, burning occurs outside (due to the lack of oxygen).
- No flames in the compartment → Flame location decoupled from pyrolyzate fuel → unphysical results.

A posteriori Simulations

Fire Growth

Results using Totally Prescribed HRR :

A posteriori Simulations

Fire Growth

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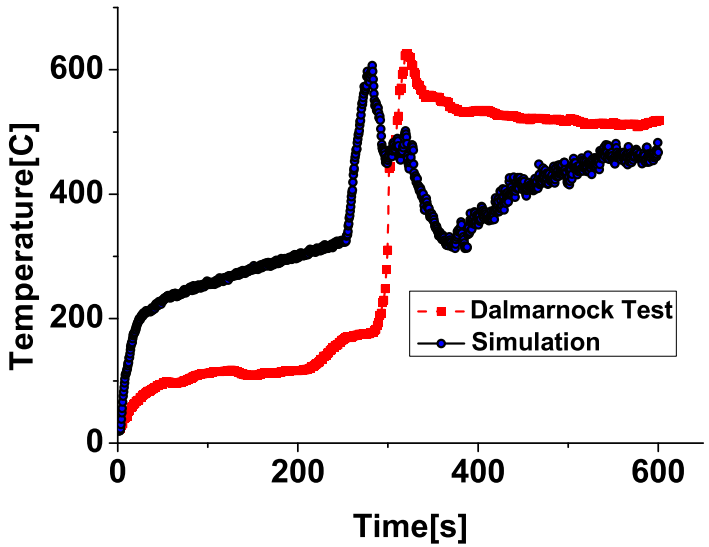

A posteriori Simulations

Fire Growth

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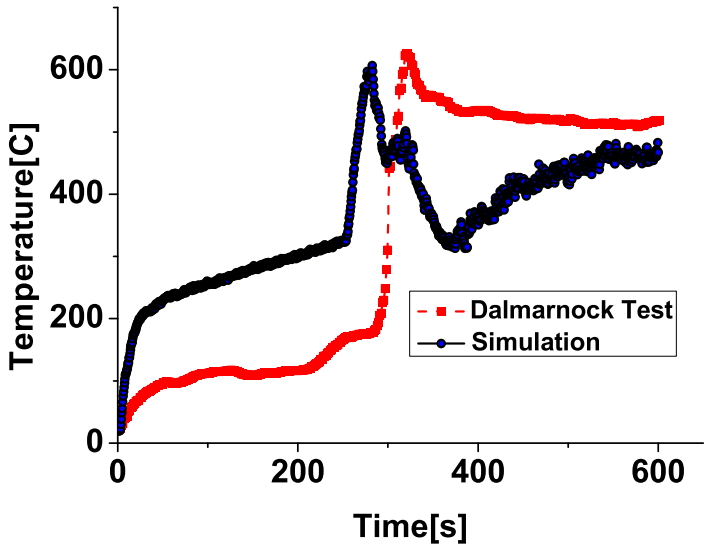

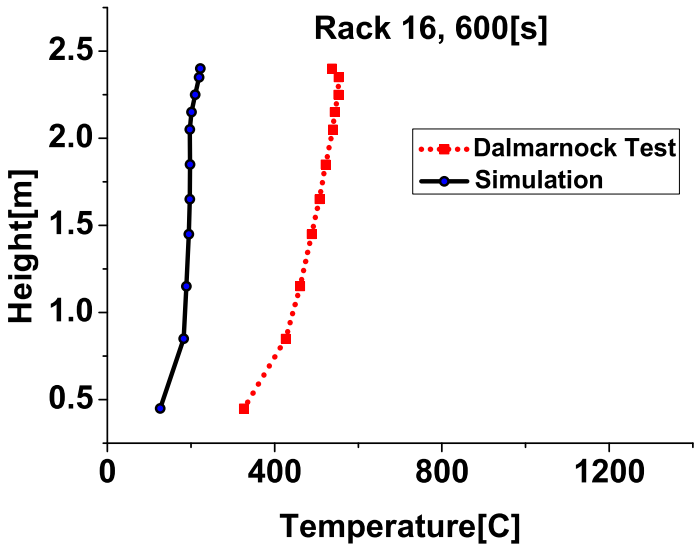

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A posteriori Simulations

Fire Growth

Predicted Flame Spread :

A posteriori Simulations

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A posteriori Simulations

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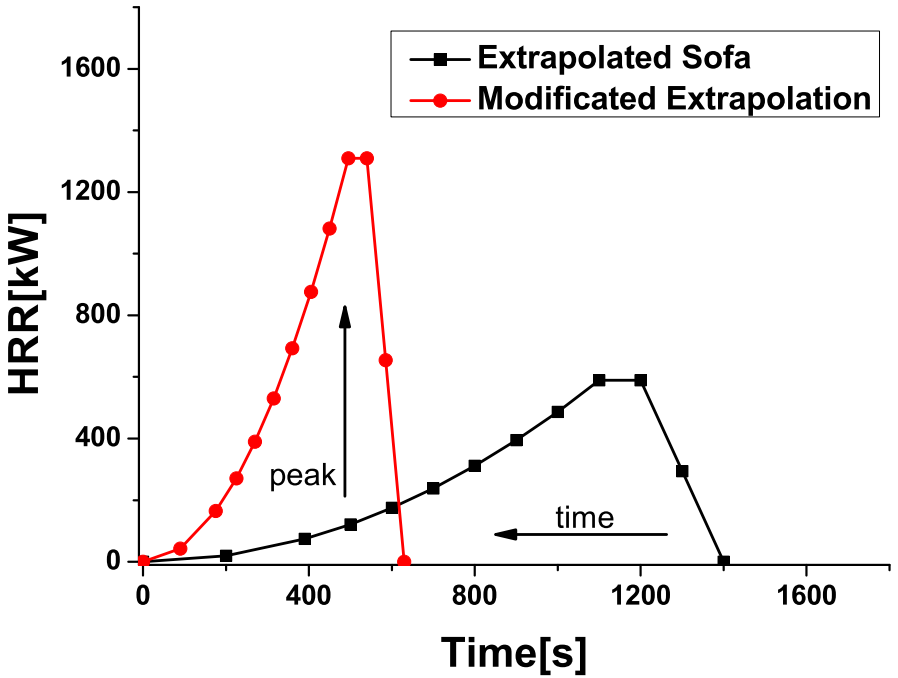
Practical way : Somewhere between fully prescribed and predicted

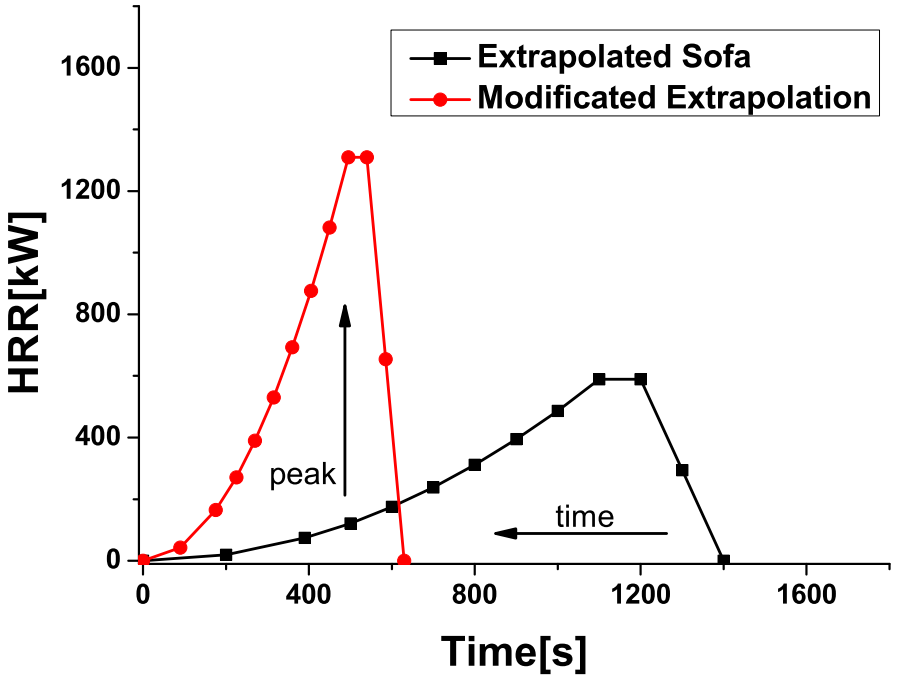
A posteriori Simulations

Fire Growth



A posteriori Simulations

Fire Growth



$$\underbrace{\int_{t_T} \mathrm{HRR}_{\mathrm{mod}}(t)\,\mathrm{d}t}_{\mathrm{TRH}_{\mathrm{mod}}} = \underbrace{\int_{t_T} \mathrm{HRR}_{\mathrm{ex}}(t)\,\mathrm{d}t}_{\mathrm{TRH}_{\mathrm{ex}}}$$

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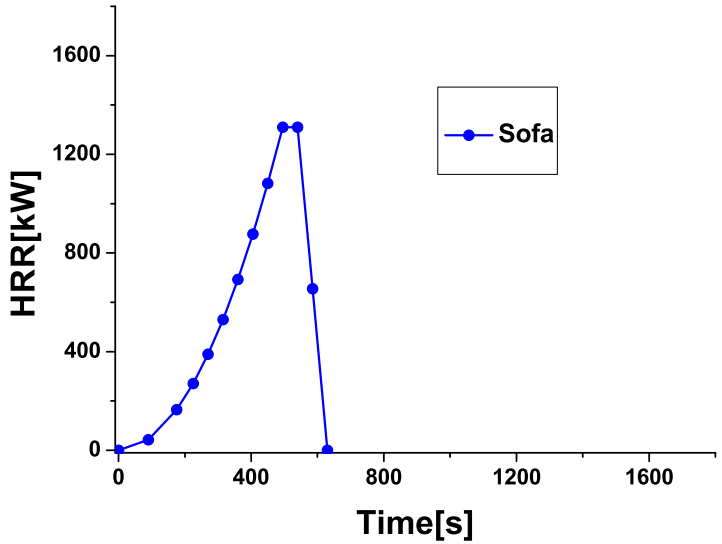
A posteriori Simulations

Fire Growth



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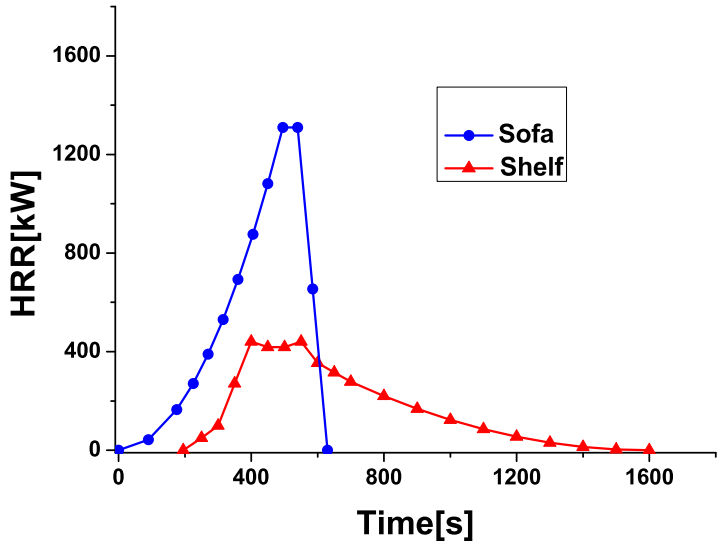

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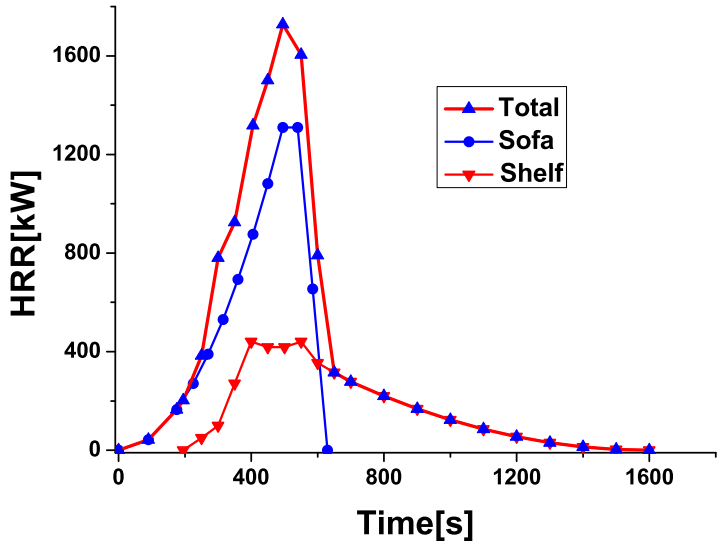

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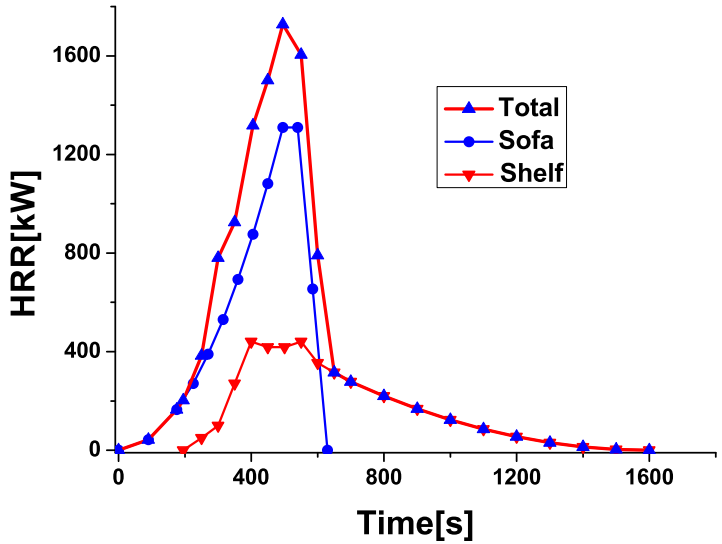

Rest of the furniture burns according to material properties

A posteriori Simulations

Other Parameters

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- Boundary conditions → Wind.
- Ventilation conditions (window breakage).
- Ignition temperature for other items in the room.

Results – Averaged Quantities

Best input found – Partially Prescribed HRR

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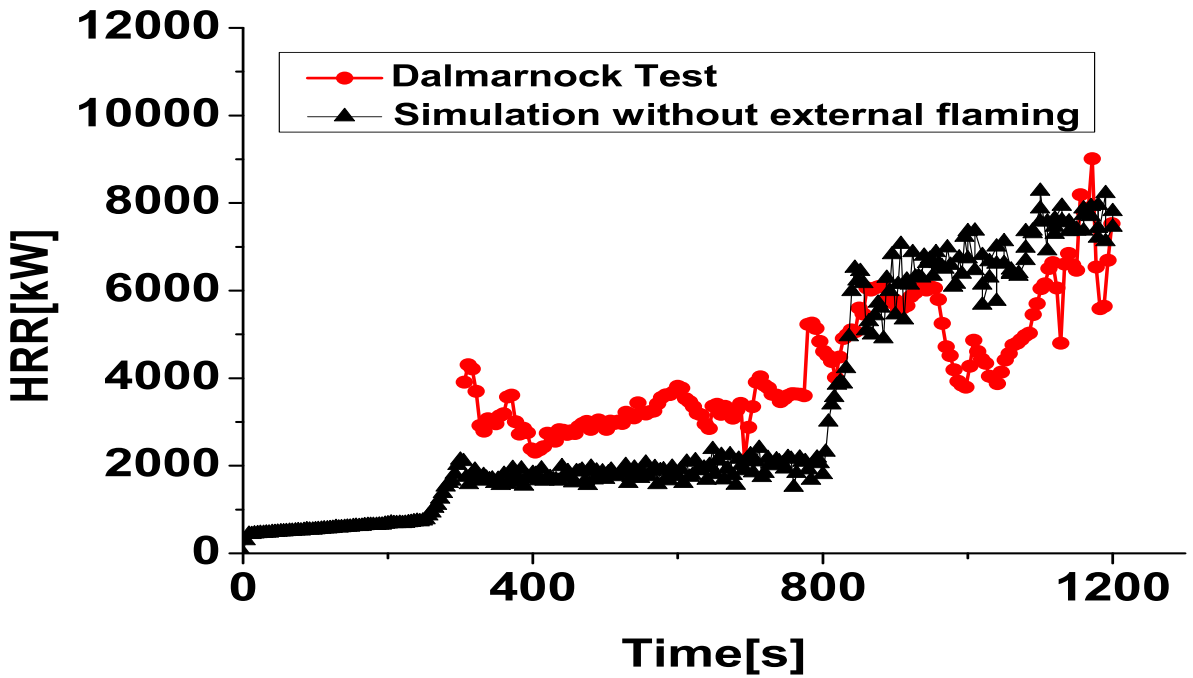

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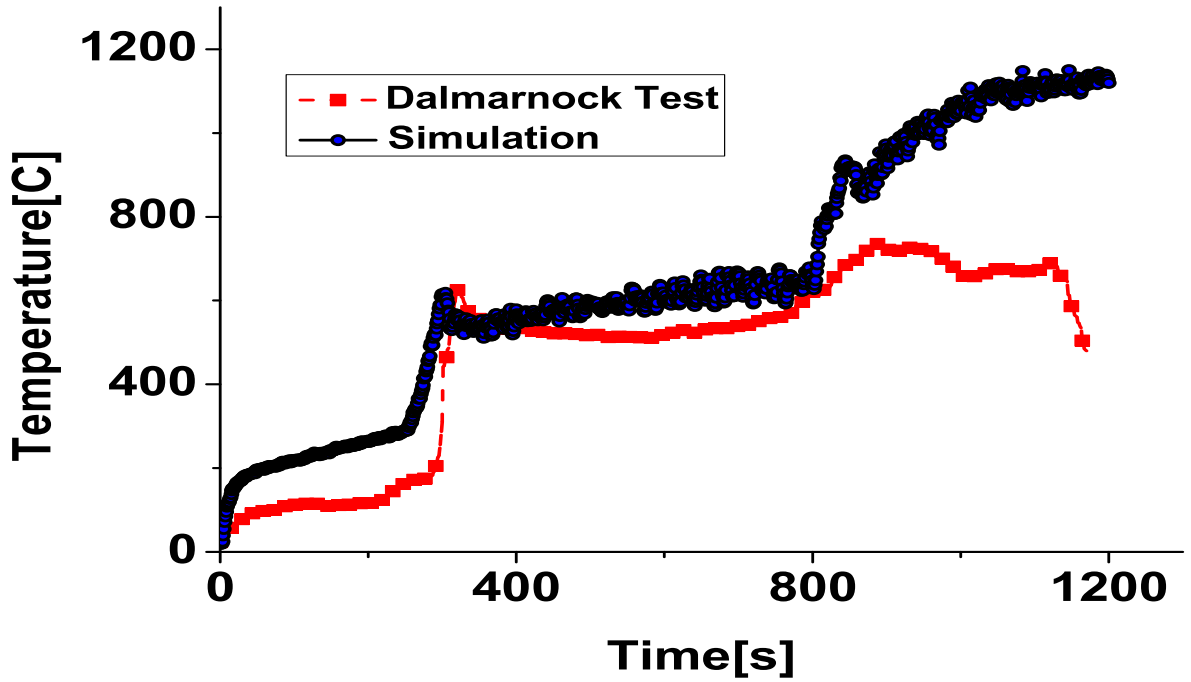
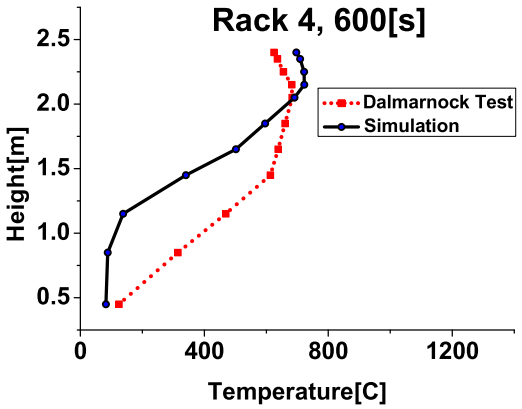
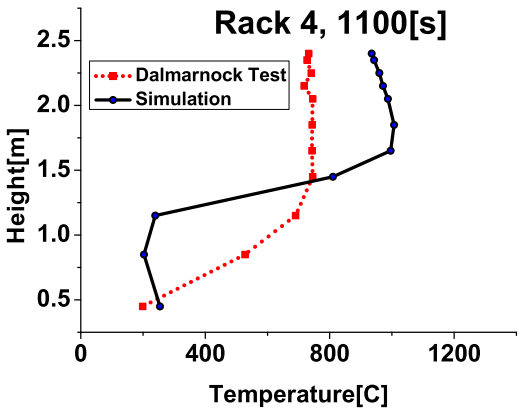
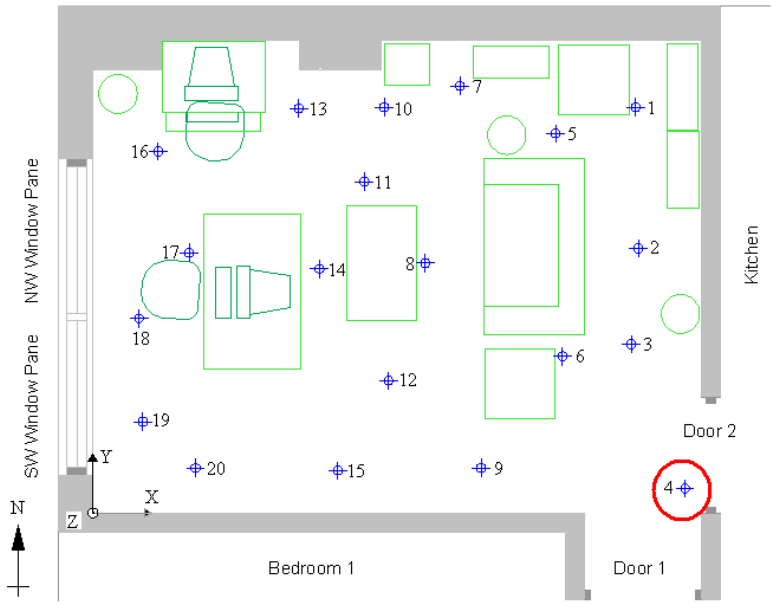


Results – Field Temperatures







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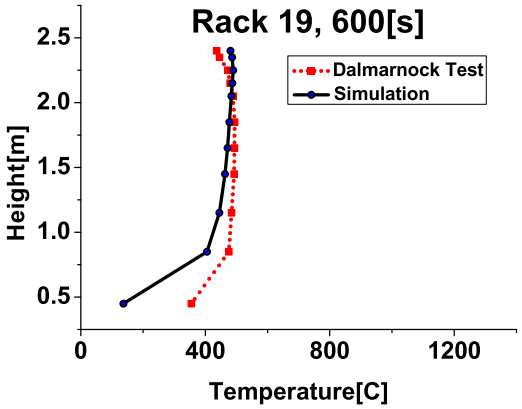

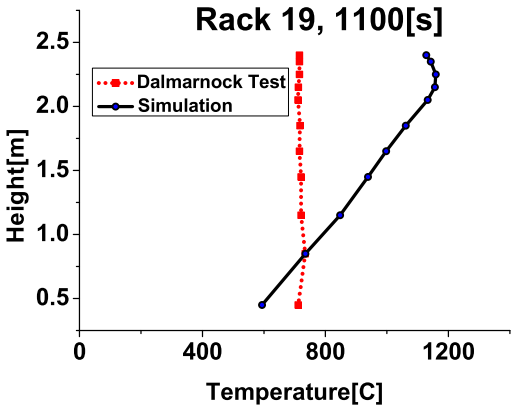

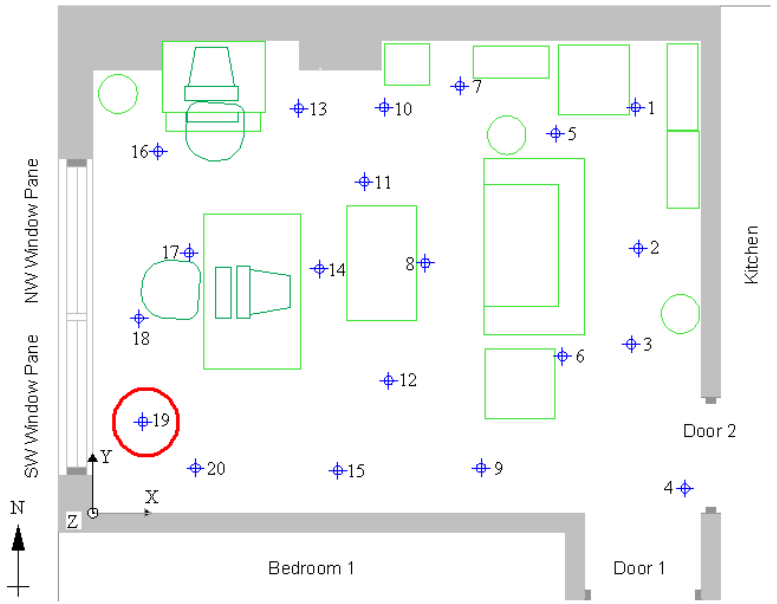

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- *A posteriori* simulations aided by measurements can reach reasonable agreement with observed fire dynamics.
- Sensor data is crucial to capture critical events during the fire (secondary ignition, flashover time etc...) and to estimate proper boundary conditions (wind, ventilation conditions).

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- This work is a validation of the input file, not of the model → for a different scenario the entire work has to be repeated.
- It is a very difficult process, many simulations had to be run in order to set up the input file → time consuming and never-ending.

Thank you !

Any Questions ?

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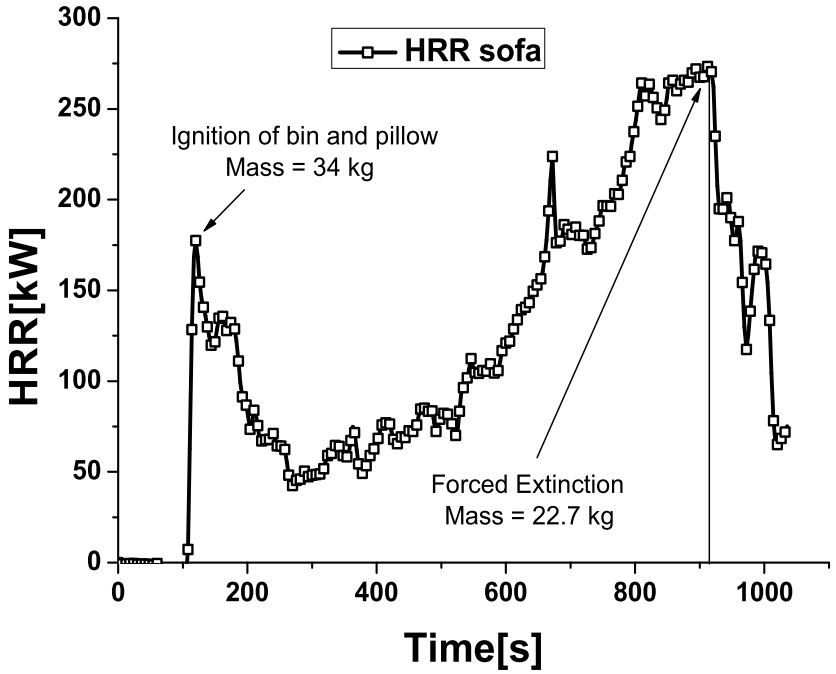
A posteriori Simulations



A posteriori Simulations