



# Het gebruik van extractie- en stuwkrachtventilatoren bij wagenbrand in grote gesloten parkeergarages

Prof. Bart Merci

Ghent University, Belgium

Faculty of Engineering

Department of Flow, Heat and Combustion Mechanics

# Overview

- Introduction
- Fire Safety Engineering: Research – Education – Practice
- Research on smoke and heat control in case of fire in large closed car parks:
  - Research project
  - Experiments – numerical simulations
- Concluding remarks



# Fire Safety Engineering

- Relatively young engineering discipline.
- Multi-disciplinary ‘core business’:
  - Combustion
  - Fluid mechanics (turbulence)
  - Heat transfer (conduction, convection, radiation)
  - Structural stability
  - Explosions
  - Risk analysis
  - Human behaviour
  - Etc.

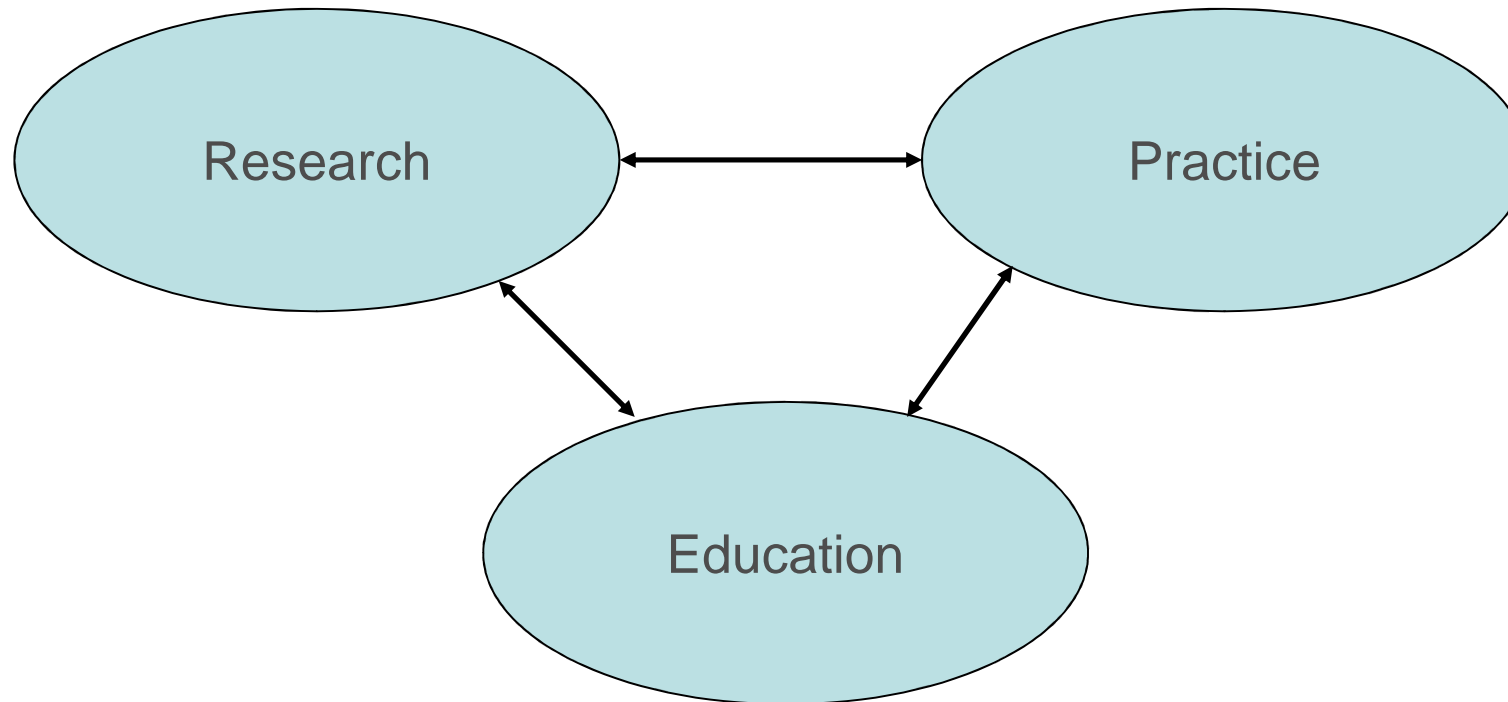


# Fire Safety Engineering

- All individual research areas are developing and there is strong interaction.
- Question: what is the most efficient way to increase general knowledge in FSE worldwide?
- Some options:
  - Improve knowledge in the ‘core business’ domains through research → certainly required long-term.
  - Improve knowledge in the community by education programs of the FSE ‘core business’ → very interesting short-term: more people → more ideas / insights.
  - Apply FSE principles (practice) → very interesting short-term: more ideas / insights.



# Fire Safety Engineering



# Fire Safety Engineering

- Educational program ‘International Master of Science in Fire Safety Engineering’ (IMFSE):
  - Ghent University (Belgium)
  - Lund University (Sweden)
  - University of Edinburgh (Scotland)
- Focus is on the ‘core business’.
- Website: <http://www.imfse.ugent.be>



# Experiments – Numerical simulations

- Fire: extremely complex.
- Fire development strongly depends on ‘details’:
  - Initial conditions
  - Boundary conditions
  - Material properties
  - Geometry
- Fundamental problem: repeatability in experiments.
- Fundamental question: what scenario are we designing for?



# Experiments – Numerical simulations

- Different types of experiments required:
  - ‘Realistic’ (or ‘heroic’?) large-scale experiments, with as recent examples the Dalmarnock experiments and the BRE car park fire experiments.
  - Repetitive experiments, for model validation.
- It needs to be accepted that there will always be spreading in the measurements and it is important to have an estimate on this spreading.
- Deterministic models can, at their best, only reproduce the ‘average’ scenario.



# Experiments – Numerical simulations

- Numerical simulations: are we happy with the state-of-the-art?
- Reliability of numerical simulations:
  - Numerical issues (computational mesh, solver, convergence checks)
  - Modelling issues
- Sensitivity of numerical simulations:
  - Initial conditions
  - Boundary conditions
  - Material properties
  - Geometry



# Car Park Fire and Explosion Safety

- Large research project (<http://www.carparkfiresafety.be>), financed by IWT-Vlaanderen through SBO (Strategisch Basisonderzoek) channel.
- Partners:
  - Ghent University (coordinator)
  - Von Karman Institute
  - KU Leuven
  - Royal Military Academy
  - WFRGent NV



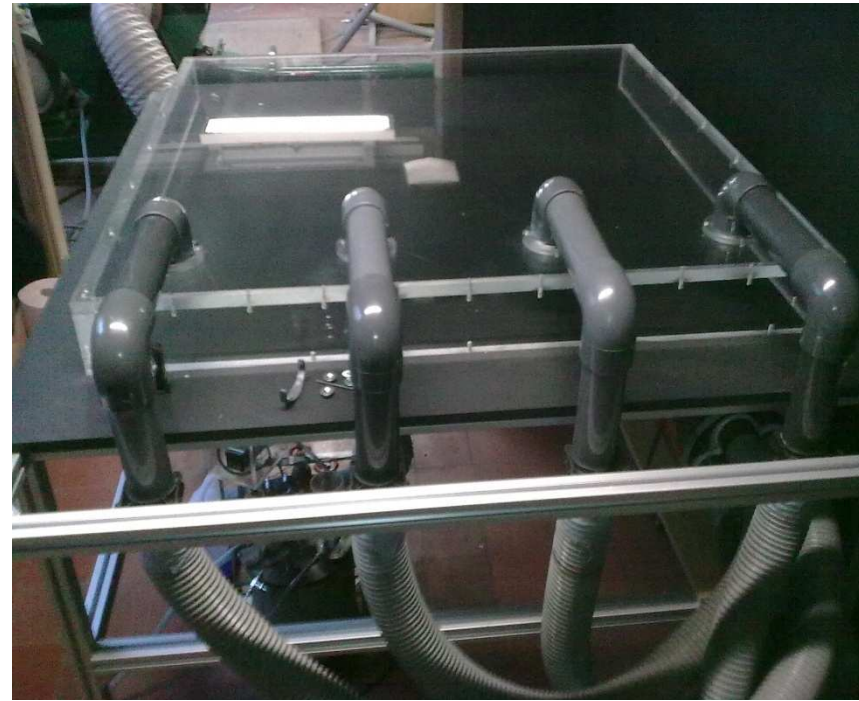
# Car Park Fire and Explosion Safety

- Different aspects:
  - Smoke and heat control
  - Structural stability
  - Explosion risk
  - Impact of explosions
  - Full-scale vs. reduced scale



# Car Park Fire and Explosion Safety

- E.g. full-scale vs. reduced scale:



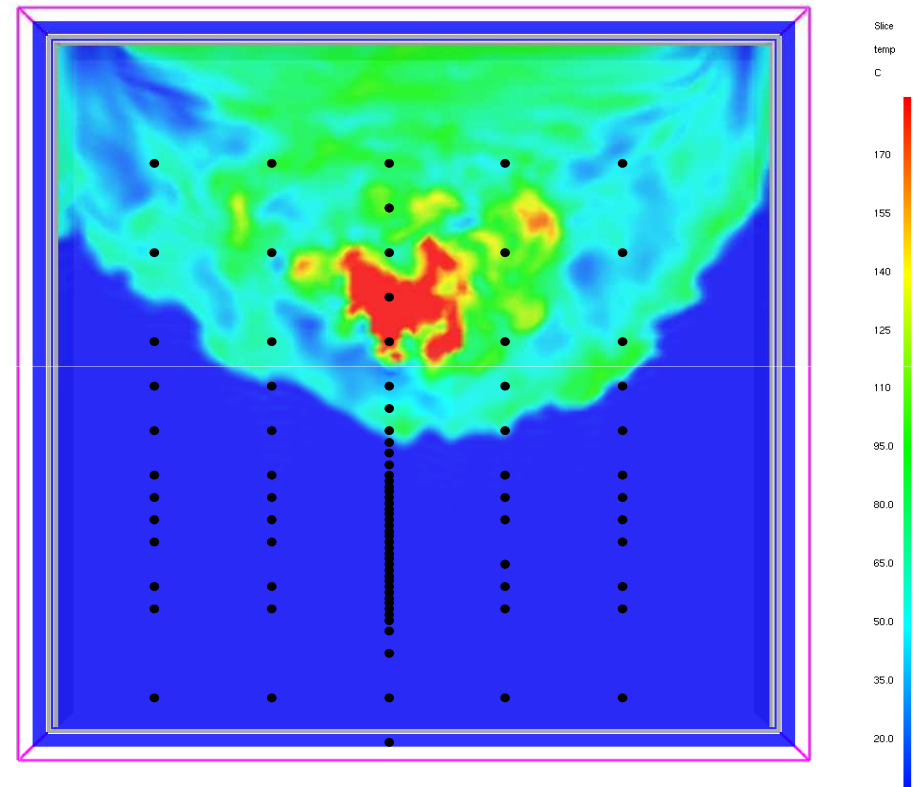
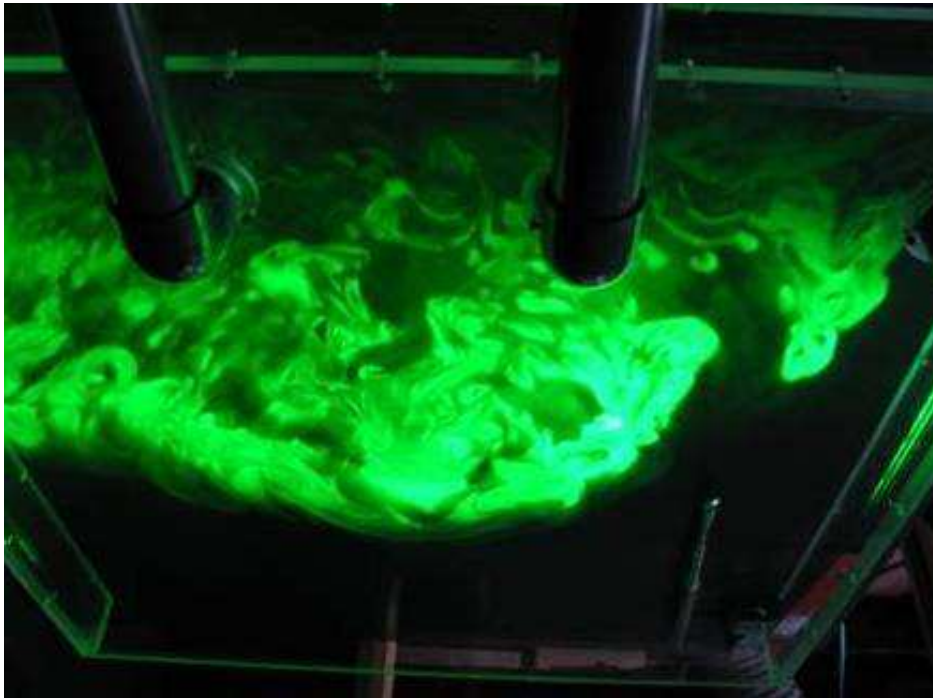
# Car Park Fire and Explosion Safety

- E.g. full-scale vs. reduced scale:



# Car Park Fire and Explosion Safety

- E.g. full-scale vs. reduced scale:



# Car Park Fire and Explosion Safety

- Focus on smoke and heat control:
  - **Full-scale experiments**
  - CFD simulations
  - Reduced scale experiments

# Car Park Fire and Explosion Safety

- Location: WFRGent NV
- Car park dimensions: 30 m x 29m x 2.7m (=2350m<sup>3</sup>).
- Installed extraction rate system:
  - 4 extraction fans of 50000m<sup>3</sup>/h each.  
Note: about 85 air changes per hour!
  - Vertical extraction.
  - 2 Induction type fans (50N each).

# Car Park Fire and Explosion Safety

- Joint installation:
  - Somati NV
  - Colt International
  - Brakel Aero

# Car Park Fire and Explosion Safety



# Car Park Fire and Explosion Safety

Hexane pool fire (up to 4MW)



# Car Park Fire and Explosion Safety

- Insulation:
  - Square area (6 m by 6 m) above burner: 2 layers of 25 mm (Promaglaf HTK blanket), for temperatures up to 1200 °C.
  - Further away: 1 layer of 50 mm stone-wool type material (Rockwool ProRox WM 80), for temperatures up to 650 °C maximum.
  - Chicken wire to avoid falling objects.



# Car Park Fire and Explosion Safety



# Car Park Fire and Explosion Safety

- Extraction fans:

<b>Diameter</b>	1000 mm
<b>Blades</b>	9 @ 24°
<b>Capacity</b>	18 kW, 34.8 A
<b>Velocity</b>	1470 rpm, 17.9 m/s (192 Pa dynamic)
<b>Motor</b>	18 kW, 34.8 A
<b>Smoke venting</b>	300 °C for 2 hours
<b>Extraction flow rate per fan</b>	50 000 m <sup>3</sup> /h

- Frequency control (careful: flaps!)

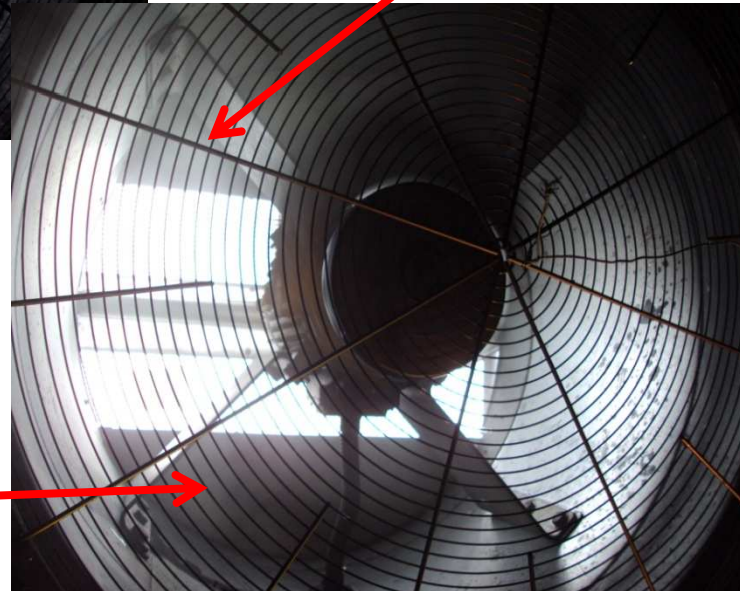
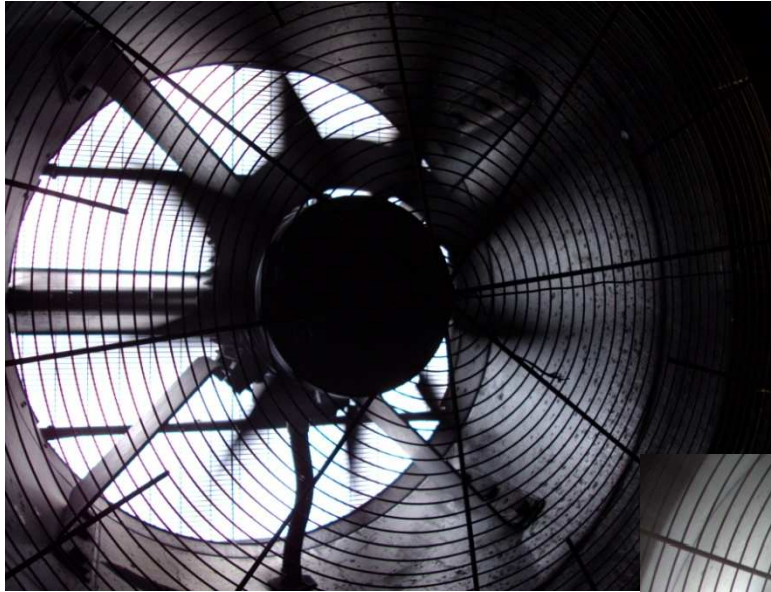
# Car Park Fire and Explosion Safety



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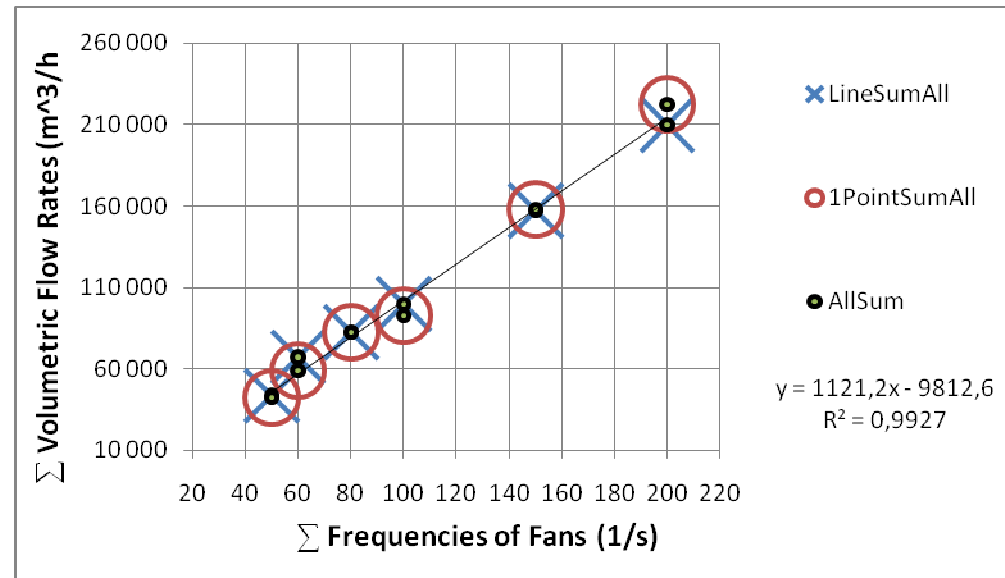
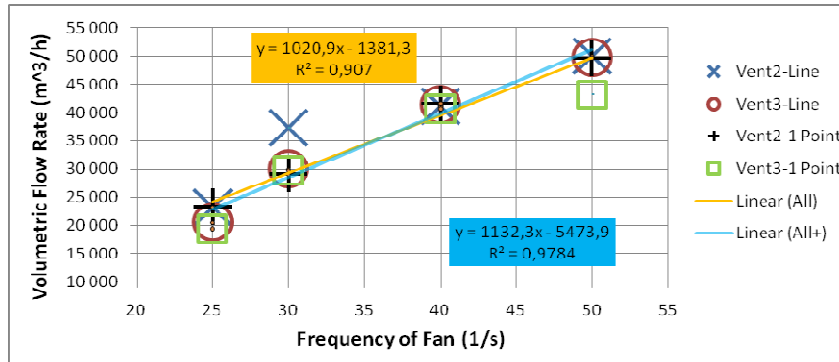


# Car Park Fire and Explosion Safety

- Extraction fan flow rate = nominal flow rate?
- Interaction between fans?
- Frequency control: influence?
- Detailed measurements: courtesy Istvan Horvath (von Karman Institute).



# Car Park Fire and Explosion Safety



# Car Park Fire and Explosion Safety

- Extraction fan flow rate = nominal flow rate? **YES.**
- Interaction between fans? **YES.**
- Frequency control: influence? **ALMOST LINEAR.**
- Detailed measurements: courtesy Istvan Horvath (von Karman Institute).



# Car Park Fire and Explosion Safety

- Induction type jet fans (50 N).

Air exit area	0.6 m x 0.15 m
Thrust	50 N
Outgoing air velocity (derived value based on $\rho_{\text{air}} = 1.2$ )	21.5 m/s



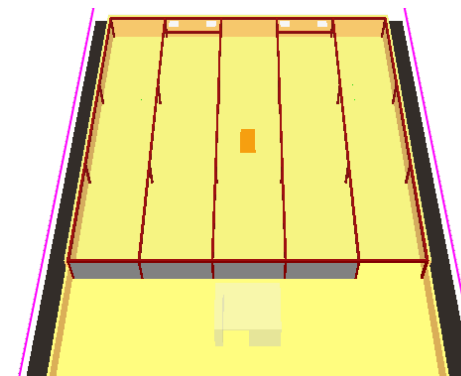
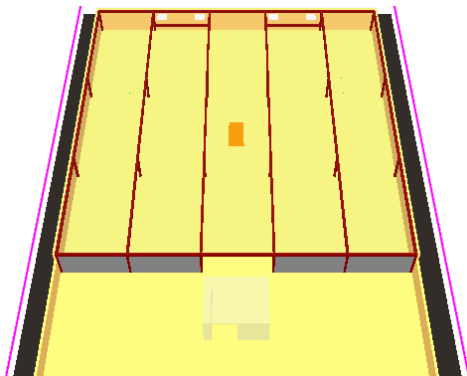
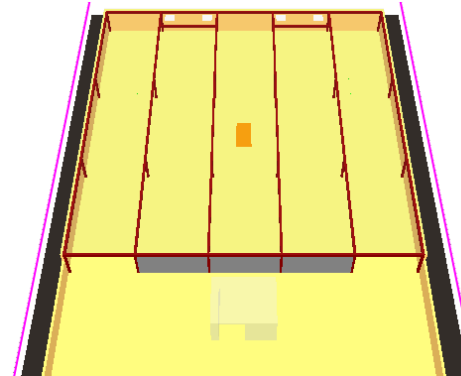
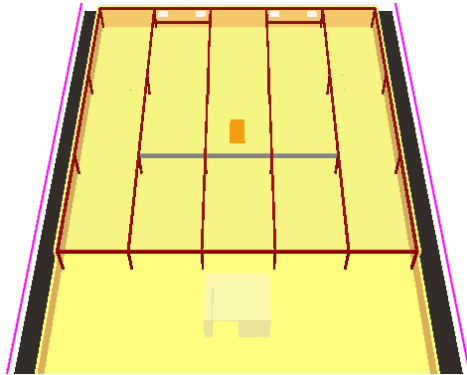
# Car Park Fire and Explosion Safety

- Induction type jet fans (50 N). Observations:
  - Velocity in exit plane not uniform.
  - Quite strong downward angle (Coanda effect) → under-shoot smoke?
  - Careful in CFD simulations.

# Car Park Fire and Explosion Safety

- Observations:
- Main extraction system:
  - In principle: higher extraction rate  
→ less smoke back-layering.
  - Only true if flow pattern is simple  
(uni-directional)!

# Car Park Fire and Explosion Safety

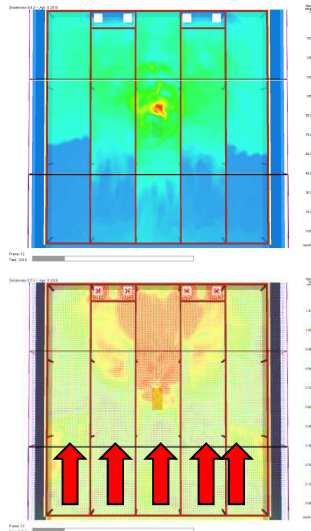


## Effect of configuration air inlet

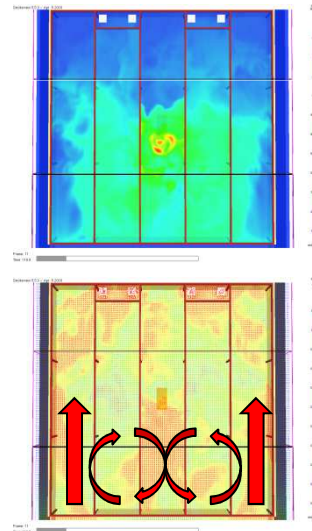
different forces in different cases:  
flow pattern!

- HRR=500 kW
- Extraction = 200.000 m<sup>3</sup>/h
- Temperature: 0 – 150 °C
- Velocity vectors: 0 – 1.2 m/s

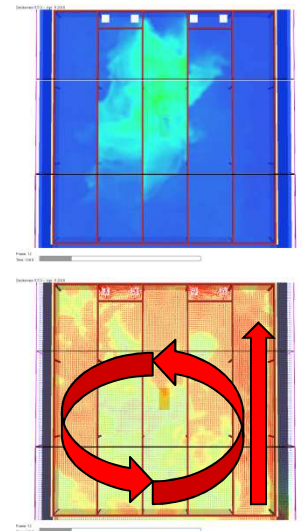
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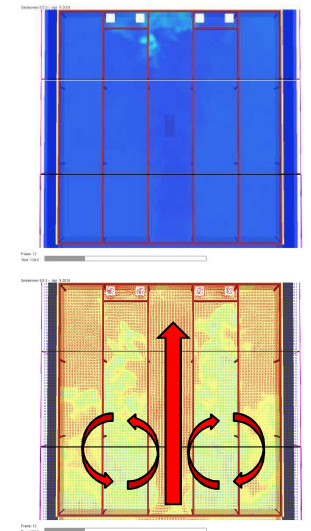
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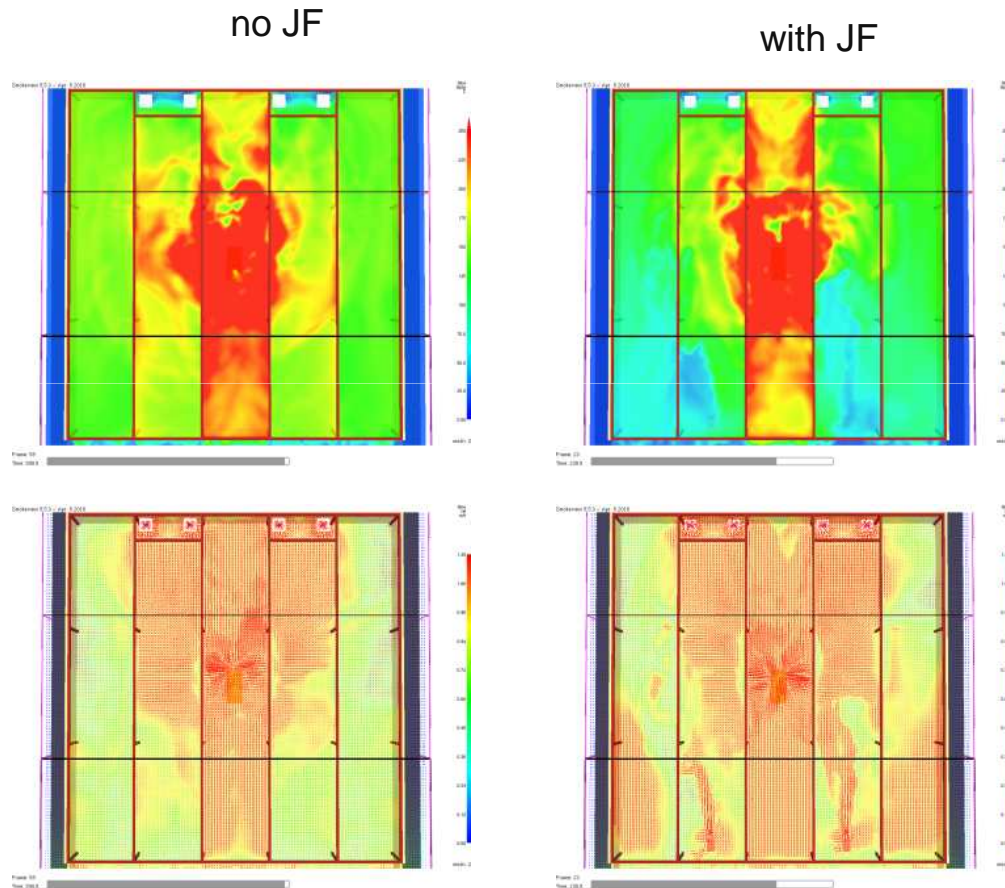
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# Car Park Fire and Explosion Safety

- Observations:
- Jet fans:
  - Local (strong) effect (mixing, thrust, temperature decrease).
  - Global effect not very strongly pronounced for cases studied.
  - Good to ‘wash out’ difficult zones.

# Effect of jet fans (CFD)



In the experiments the jet fans:

- suck in fresh air
- local mixing → local cooling
- no straight jet
- no uniform velocity
- strong downward angle

- HRR=4 MW
- Extraction = 200.000 m3/h

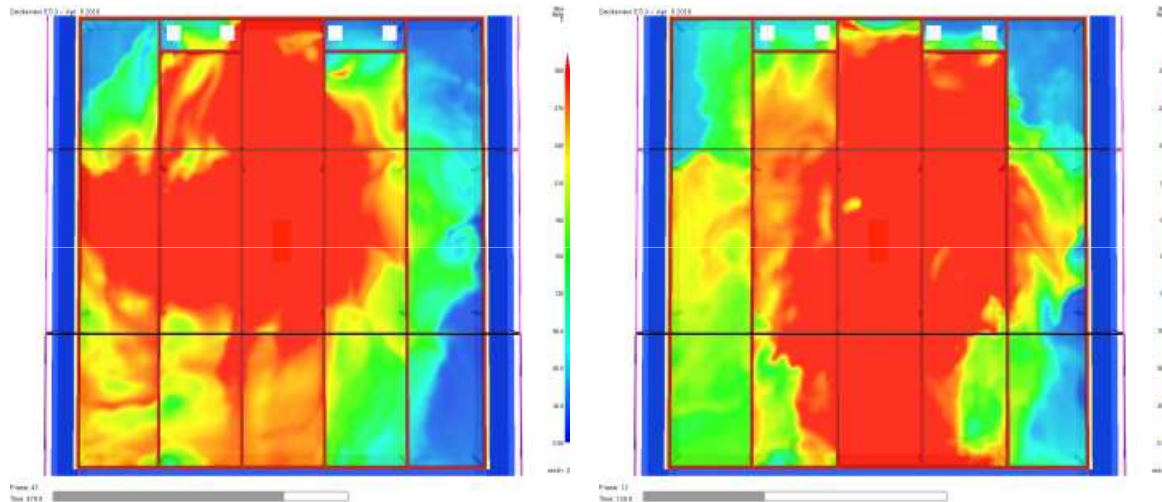
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# Effect of jet fans (CFD)

no JF

with JF

XXXXO: recirculation pattern:  
jet fans can break this pattern



- HRR=4 MW
- Extraction = 200.000 m3/h

XXXXO

# Movie: single burning car

# Concluding remarks

- CFD and experiments complementary.
- 10 air changes per hour is way too little for extraction.
- Flow pattern very important: in case of smoke in recirculation regions, increasing extraction rate does not help to remove smoke.
- Jet fans are useful to ‘wash out’ difficult zones.

