CFD Simulation of the Water Mist Effect on Fire

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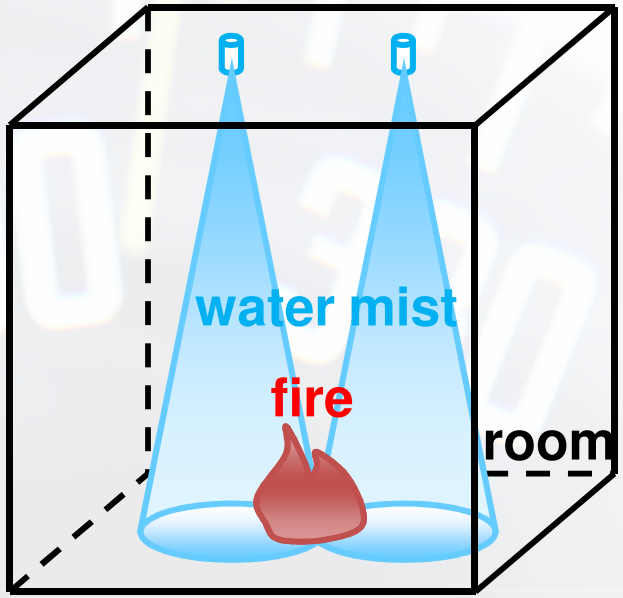
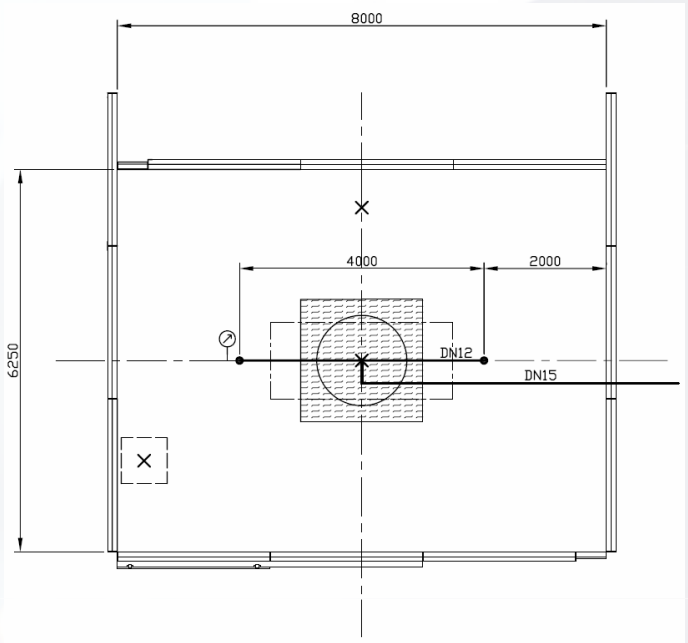
FIREPROOF, CMT

- **CMT (Center of Maritime Technologies e.V.)**
- Founded in June 2003 as a joint initiative of industry, research and the German administration
- ca. 13+ employees, ca. 1.2 Mio € turnover (2009)
- Main Fields of Expertise
  - Production and shipyard organization
  - Lightweight structures and new materials
  - Ship concepts and Life Cycle Performance assessment
  - Onboard energy management, fuel cells
  - Central Design and Tool Platform

- **Simulation: within FIREPROOF (Probabilistic Framework for Onboard Fire Safety)**
- EU project (7th framework programme)
- Main objective: to develop a **risk-based design framework** for onboard fire safety and to submit it to IMO for consideration and potential future enforcement.

Fire with mist spray system





- **Experiment: The VINNOVA water mist research project: A description of the 250 m³ machinery space tests. M. Arvidson, T. Hertzberg. SP Fire Technology, SP report 2003:29**

CFD simulation

- Simulation method
  - CFD (Computational Fluid Dynamics) (CFX)

- Simulation steps
  - Geometry and mesh generation
  - Specification of case-related input parameters (material properties, boundary conditions, thermodynamic loading, ...)
  - Solution process and obtaining initial results
  - Result evaluation and verification
  - Reporting

Model building

- **SP report - 2003:29**
- Fire:

  - Heptane pool (diameter: 790 mm)

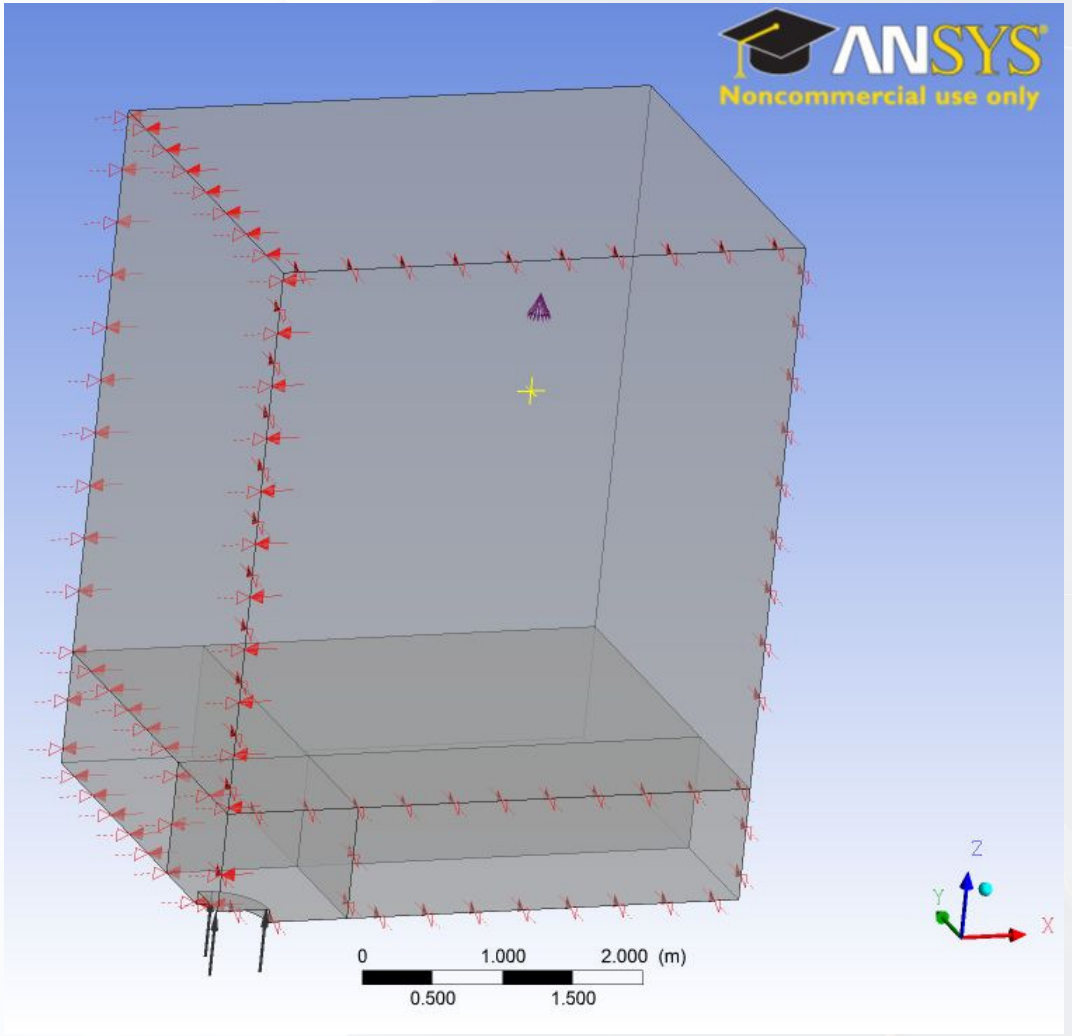
  - Heat release rate (HRR): 1 MW
- High-pressure water mist system (Marioff Corporation Oy):
- - 2x15 L/min at 70 bar
- Fire test procedure:

  - 00:00 Start of the measurement

  - 01:00 Ignition of the fire

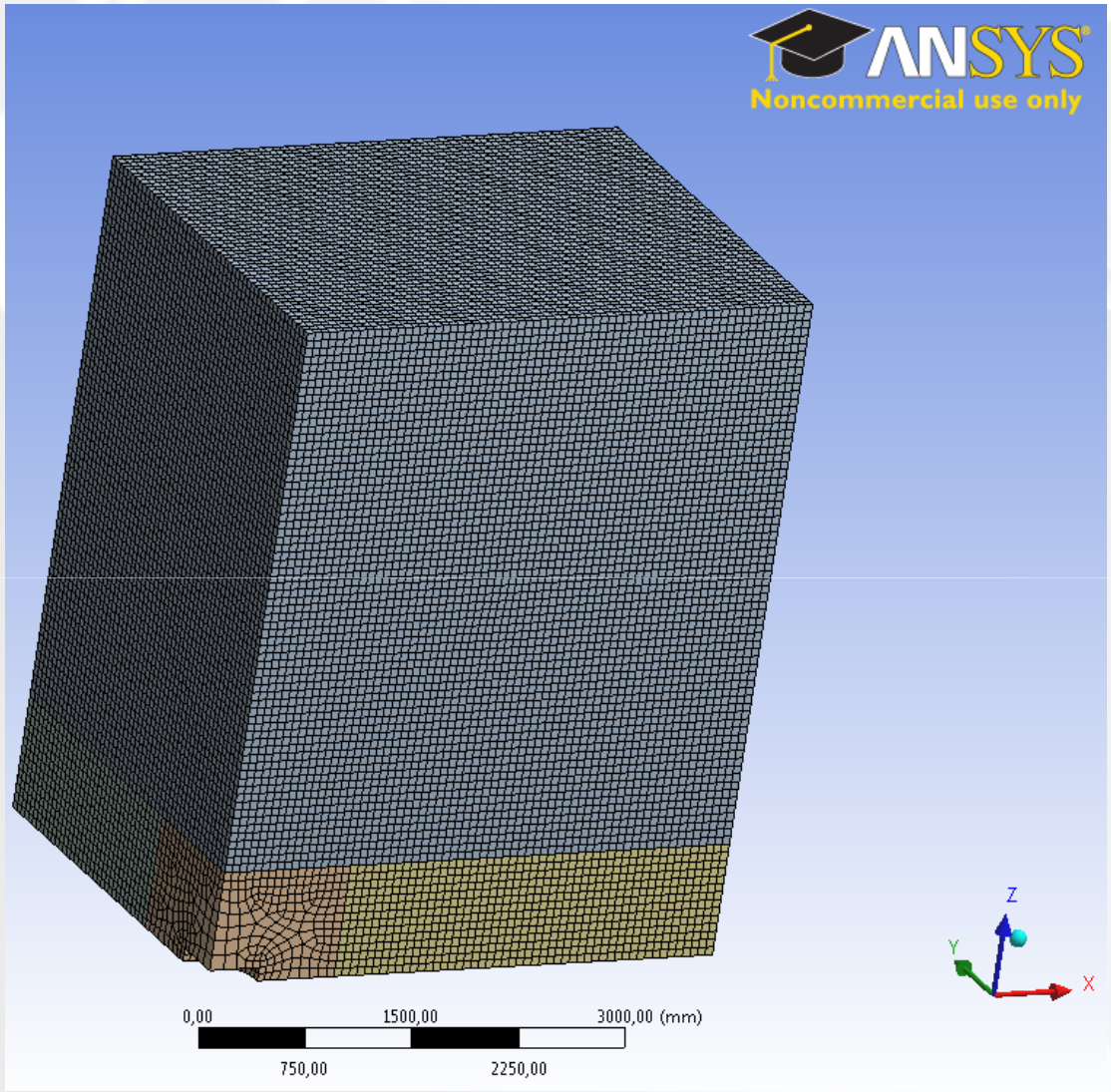
  - 01:05 Closure of the steel door to the test compartment

  - 01:30 Initiation of water

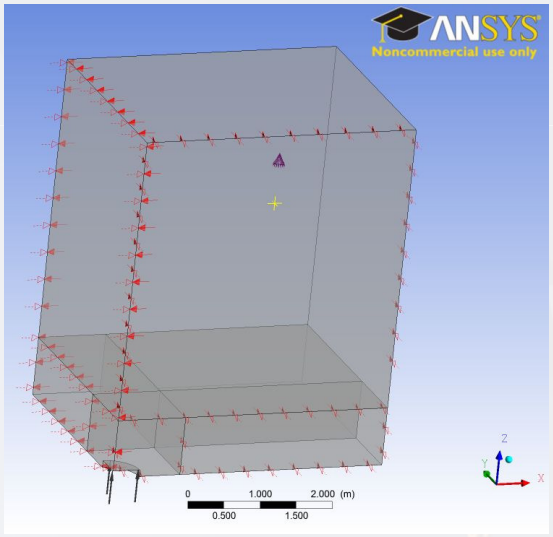


- Burning for 30 sec before initiation of water mist

Fire with mist spray system



- Element: 289,888
- Node: 302,186



Fire with mist spray system

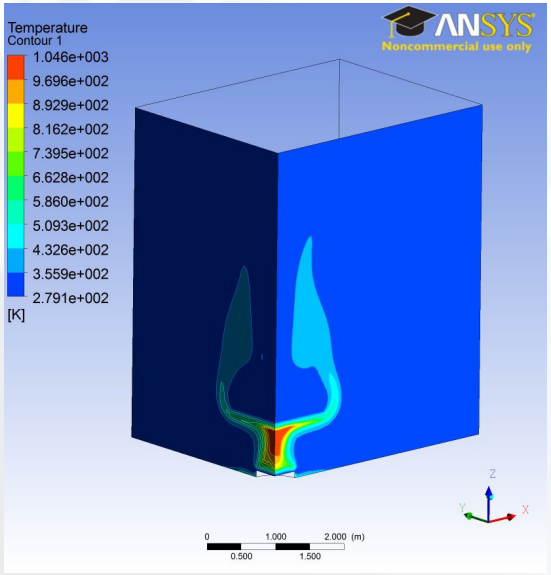
Very small time steps due to high speed of mist	very long calculation time
Big mass flow rate, small diameter of the mist	very long calculation time
A large number of elements for accurate results	very long calculation time
Air-water mist	multi-phase simulation
Air-water-burning	complex modelling

Long calculation, difficulties in getting good results

Case-related input parameters

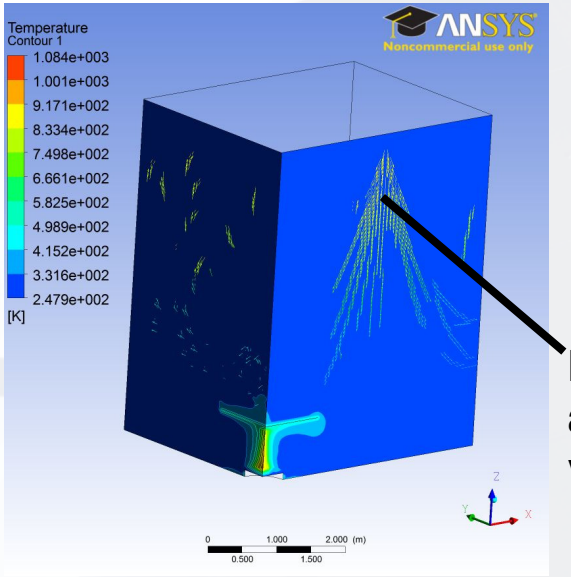
- Fire:
  - Heptane-air
  - Heat release rate (HRR): 1 MW
- High-pressure water mist system:
  - Flow rate per nozzle: 15 L/min
  - Collision of water droplets considered
  - Water mist - vapor conversion not considered
- Steel plate (4 mm in exp.): a plane at 240 ℃ in simulation
- Floor: adiabatic
- Wall and ceiling: RT, heat transfer coefficient 0.1 W/(m²·K)
- No outlet in simulation
- Burning for 30 sec before initiation of water mist
- Simulation time: 108.25 S

Initial results

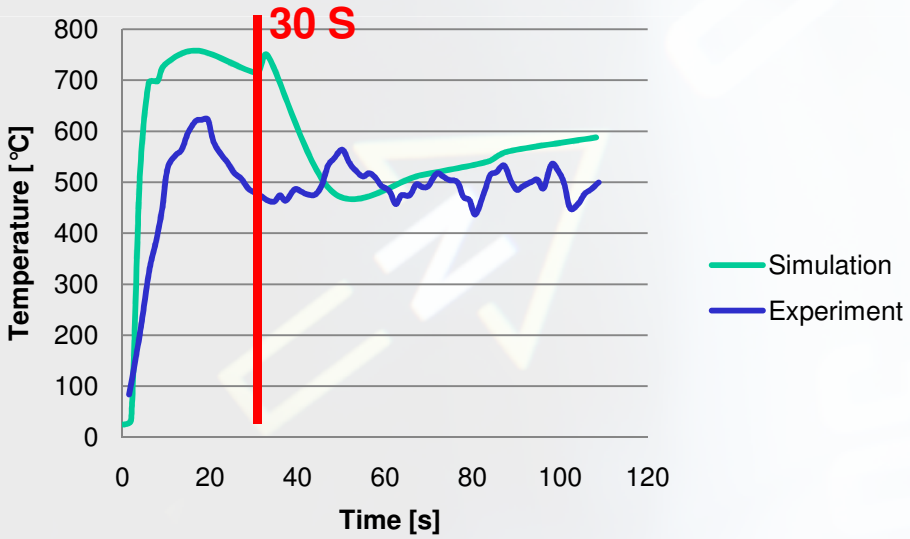


12 S

78 S



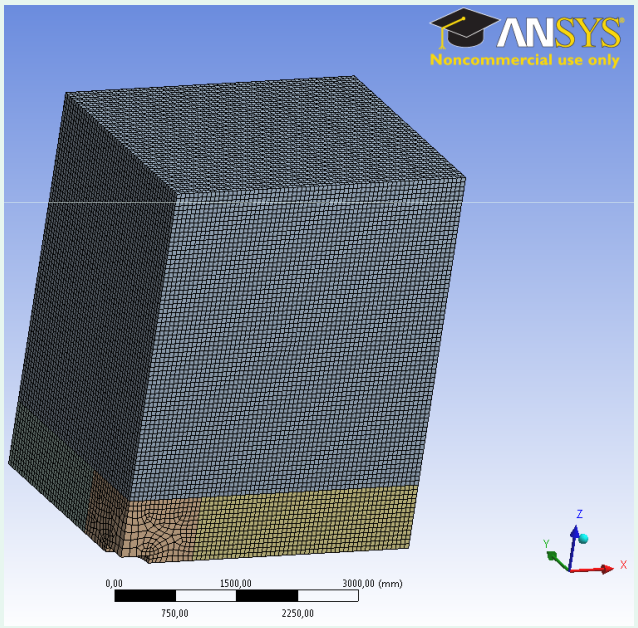
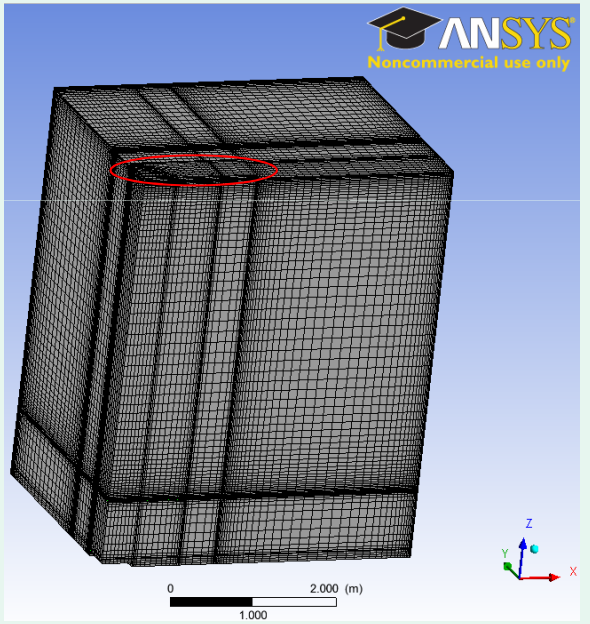
Mist averaged velocity



- Flame temperature
  - Too coarse mesh
  - Heat from steel plate
  - Mist - vapor conversion not considered
  - Completely sealed room in simulation - no outlet

- Effect of the water mist on fire can be simulated with CFD and good results can be expected.

Model improvements

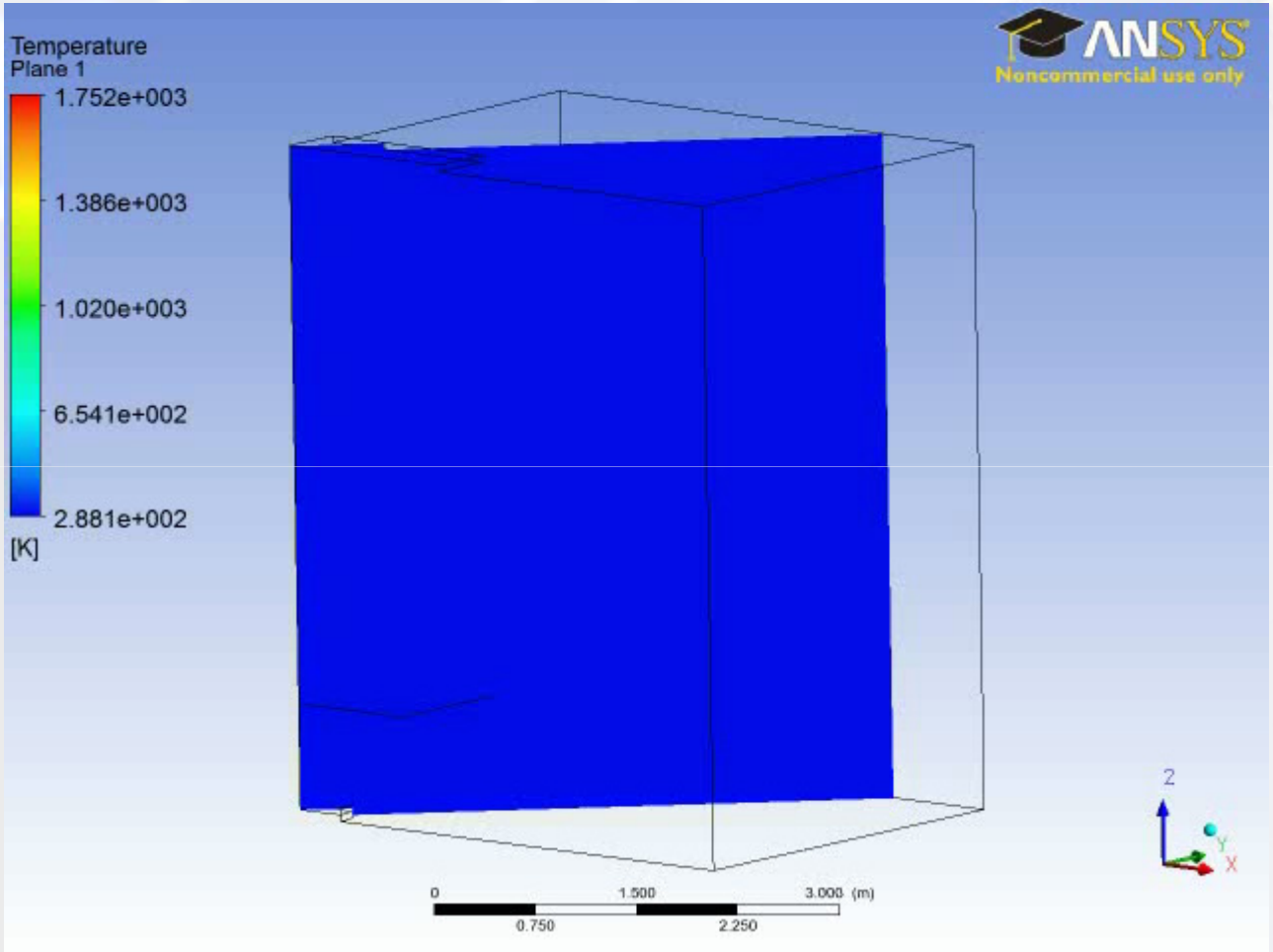
	Original model	Updated model
Opening/outlet	No	A ventilation on the ceiling
Improved mesh quality		

Model improvements

	Original model	Updated model
Steel plate	240 ℃	Adiabatic
Water mist - water vapor conversion considered	No	Yes
Fire	HRR: 1 MW	**Heptane reactions - effect of exhausting O_2 on burning** $2C_7H_{16} + 15O_2 \rightarrow 14CO + 16H_2O$ $2CO + O2 \rightarrow 2CO_2$
Optimized case-related input parameters		e.g. smaller timestep - 0.01 s/step

Model improvements

- Updated model



Conclusions

- **Fire and water mist can be simulated with CFD.**
- **Complex model, long calculation time needed for accurate results.**

Acknowledgements

- The simulation was carried out as a part of the work for the EU project FIREPROOF.

- SP Technical Research Institute of Sweden is thanked for providing experimental data for the modelling.

Thank you for your attention!

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