Modeling of a fully developed natural fire in a large compartment

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Introduction (1)

• Speeding up the development of quality new building systems is of primary importance for Corus and CFD modeling is an important part of this process.
• Subjecting whole compartments to virtual natural fires helps us to improve the fire performance of our products.
• An ongoing project assesses the performance of ANSYS CFX in modeling natural fires in large compartments by comparing with data from past experiments.
During 1993 the FRS, BRE & BST (Swinden Laboratories) conducted nine fully developed fire tests in a purpose built large compartment in the BRE Cardington Laboratory.

Note: Nowadays BS forms a part of Corus.
• The compartment’s dimensions are: 23m X 6m X 3m
• The fire load consists of 33 dry wooden cribs (3 rows of 11 cribs)
• The concrete walls are insulated
• Temperature, velocity, radiation intensities and major species concentrations are measured at selected locations.
• Crib weight is also monitored
• Temperature readings are taken at various steel members (protected and unprotected)
• Test 9 from the test series was selected for simulation
• The ventilation opening is only obstructed by a column
• In this test all cribs are set in fire simultaneously

• The duration of the experiment is 3h
• The fire load is 20 kg/m² of dry timber
• The entire fire load has burnt by the end of the test
• Cribs closer to the opening burn first
• Temperature, radiation, major gas species concentration and velocities were measured during the test
• In this presentation temperatures only in the indicated locations are considered
• The column in front of the compartment supports thermocouples
Numerical model (1)

- ANSYS Design modeler, CFX Mesh, ICEM Hexa, CFX 10 were used to build the geometry, fluid and solid mesh and model, respectively.
- Simplifications & Assumptions:
  - computational domain extended to minimize the effects of the BCs
  - the heat release rate of each crib was estimated via averaging (the mass loss rate has been measured only for each second crib in the middle row)
  - crib mass loss extrapolated after the times indicated
Numerical model (2)

- Turbulence model: SST
- Combustion Model: Eddy Dissipation
- Radiation model: Monte Carlo, grey, gas emissivity depends on composition
- The cribs are modelled as volumetric sources of fuel (methane) and resistance to flow
- CHT through solid walls, floor and ceiling
- Structured grid used to mesh the solids and unstructured for the fluid domain

- Inflated mesh has been used in the near-wall region and a finer mesh close to the cribs, 150 000 nodes for the fluid domain, 280 000 for the solid domains
- time step 0.25s at the beginning of the simulation, 0.5s and 1s at later stages
- simulated time 105 min
Results (1)

Main flow features

Surface temperatures

Temperature in a vertical plane

Velocity vectors in a vertical plane

at 20min

at 40min
Temperature – time curve comparison for probes in groups A, B, C
Temperature – time curve comparison for probes in group D
Conclusions & planned improvements

• A 25% agreement in space and time has been achieved with the experimental data for the temperature
• Correcting temperatures for radiation (where applicable)
• Comparing with other quantities available from the experimental data
• Mesh refinements