Modeling of a fully developed natural fire in a large compartment

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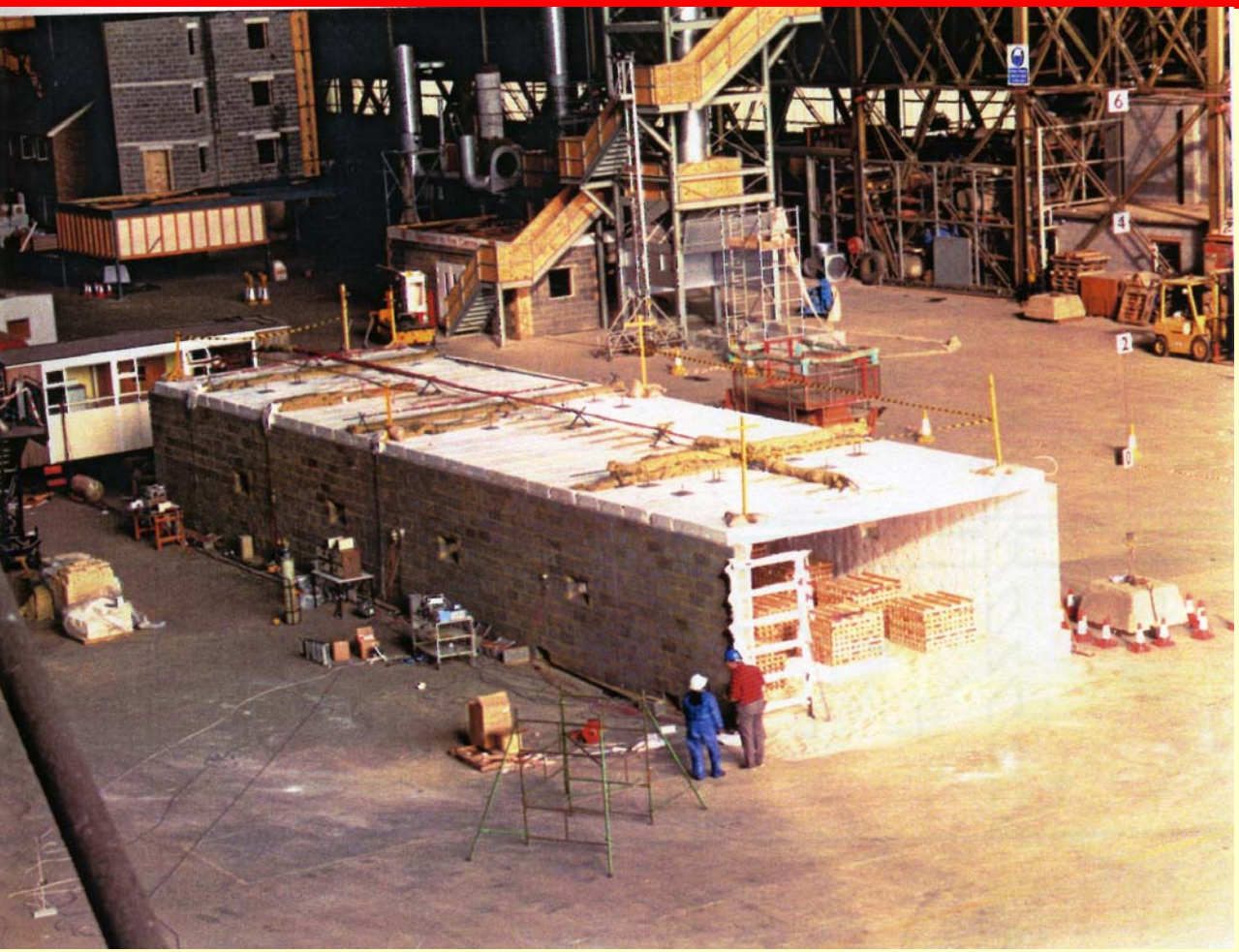
Introduction (1)

- 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

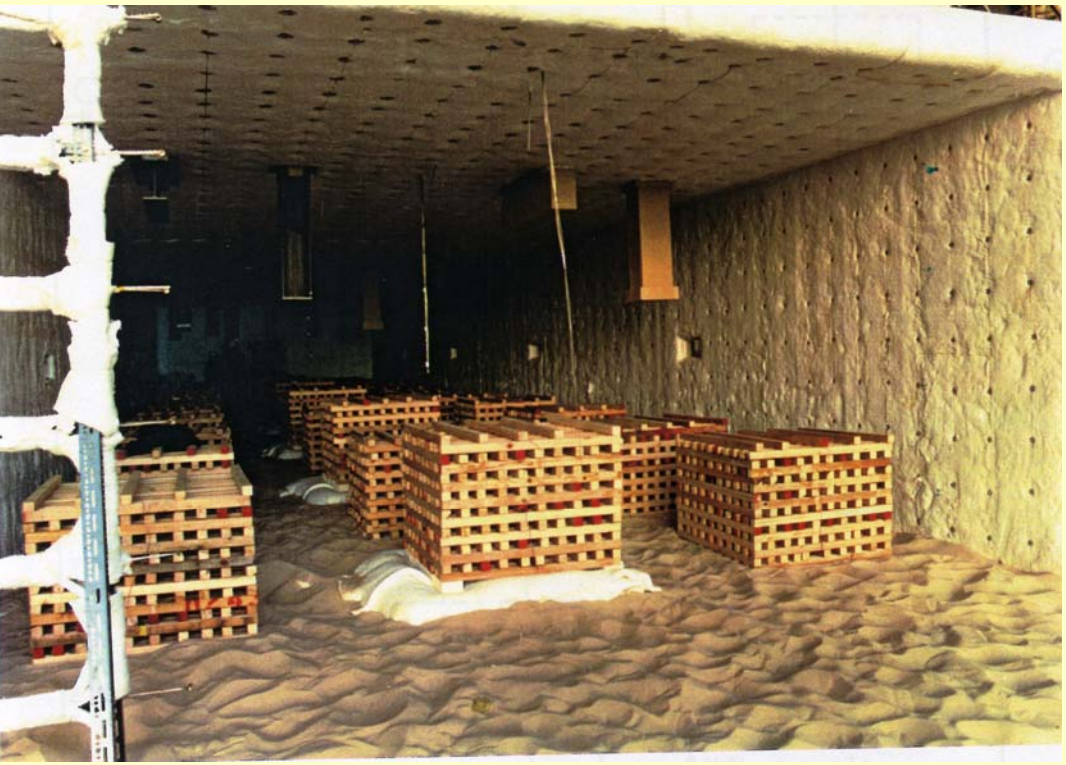
Introduction (2)



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

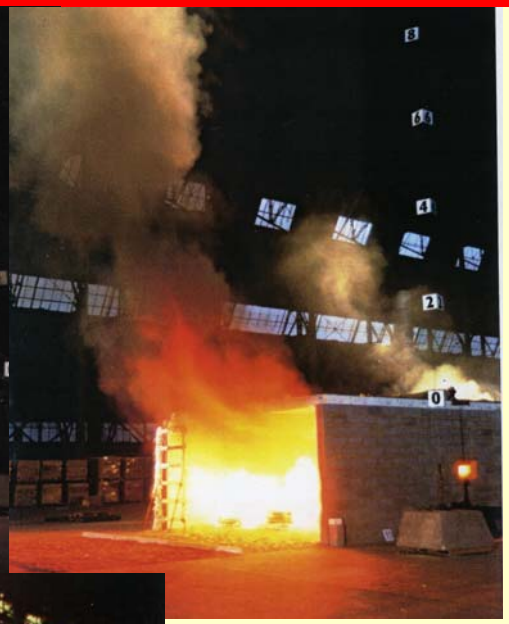
Note: Nowadays BS forms a part of Corus

Introduction (3)



- 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)

Introduction (4)

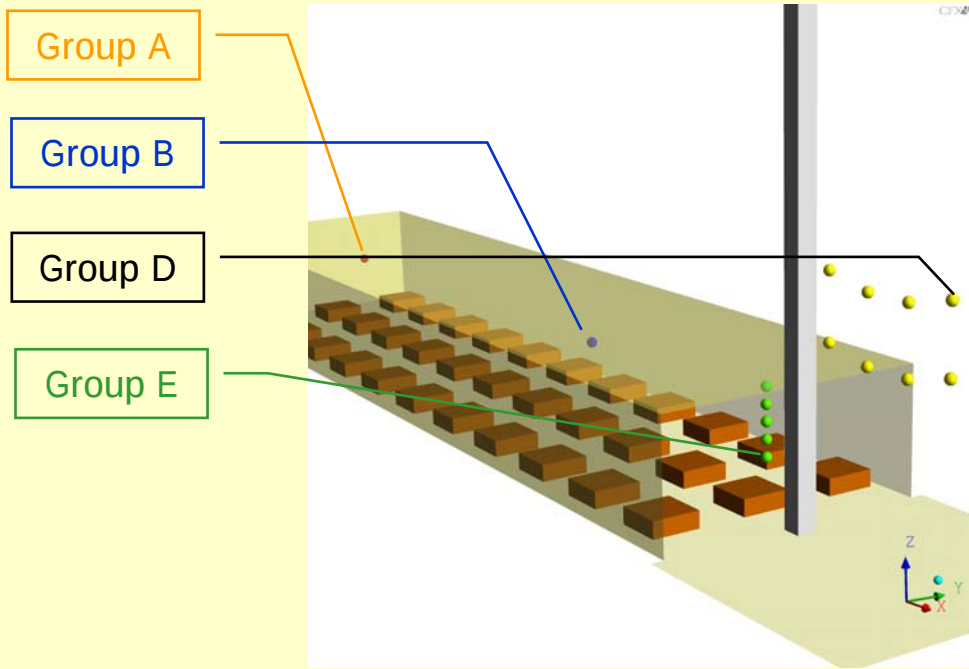


- Test 9 from the test series was selected for simulation
- The ventilation opening is only obstructed by a column
- In this test all cribs are set in fire simultaneously

- The duration of the experiment is 3h
- The fire load is 20 kg/m^2 of dry timber
- The entire fire load has burnt by the end of the test
- Cribs closer to the opening burn first

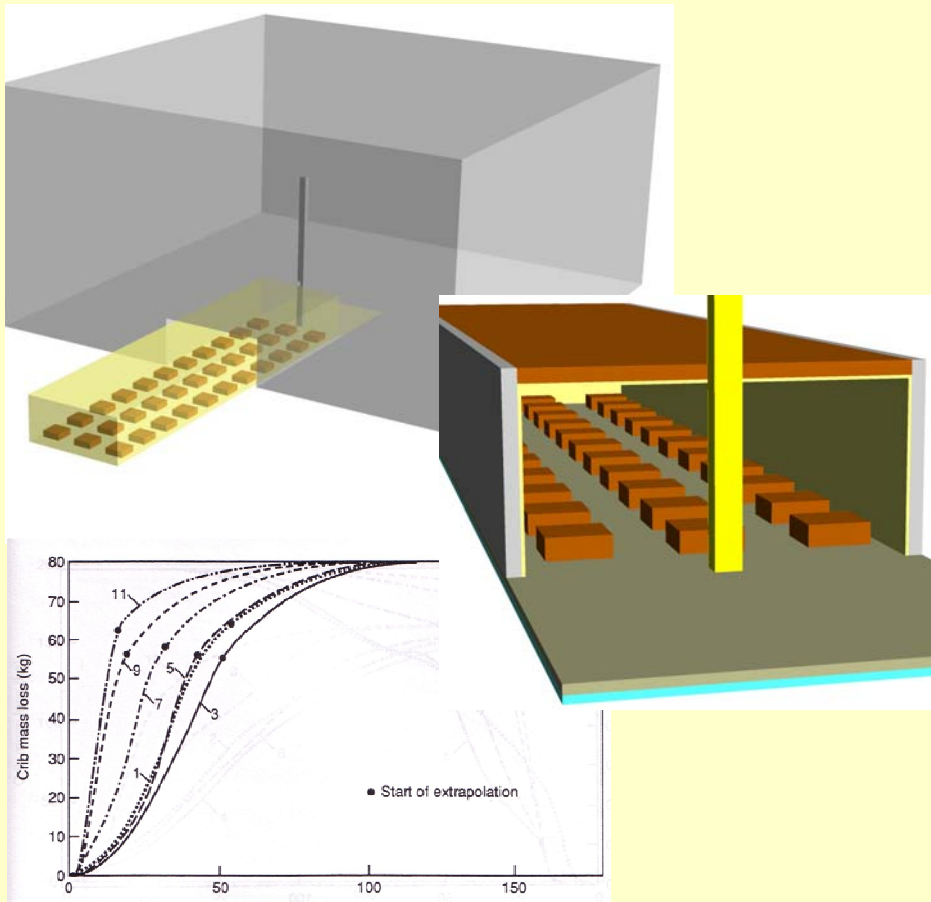
Introduction (5)

- 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



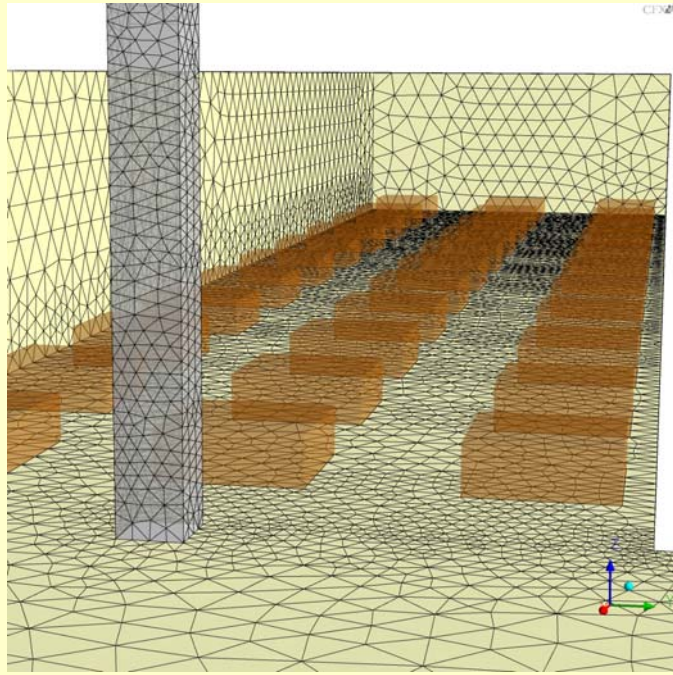
Numerical model (1)

- 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

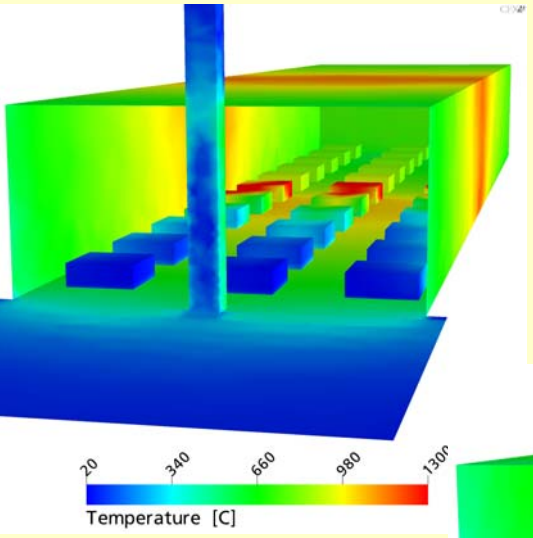


- Inflated mesh has been used in the near-wall region and a finer mesh close to the cribs, 150 000 nodes for the fluid domain, 280 000 for the solid domains
- time step 0.25s at the beginning of the simulation, 0.5s and 1s at later stages
- simulated time 105 min

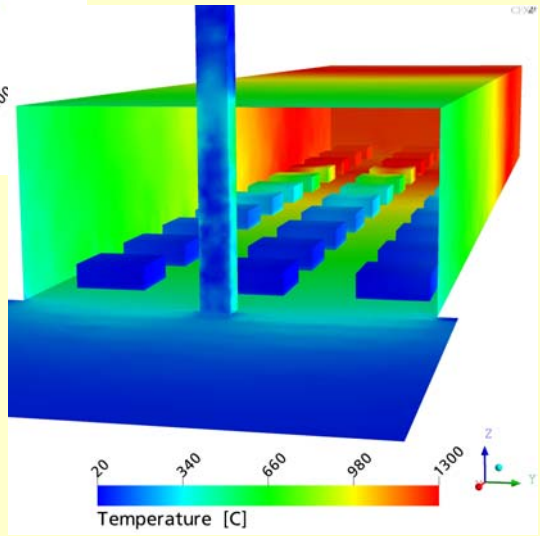
Results (1)

Main flow features

Surface temperatures

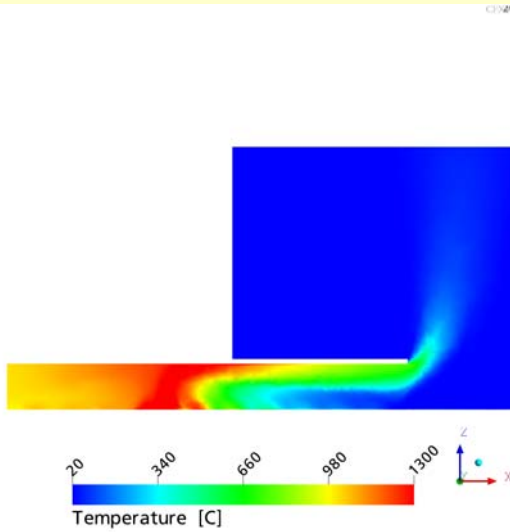


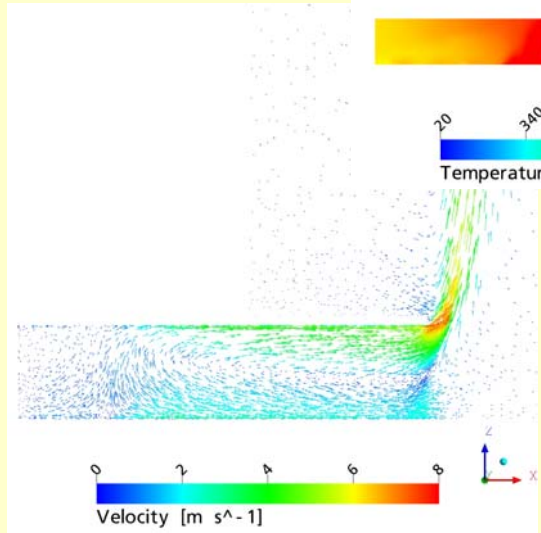
at 20min



at 40min

Temperature in a vertical plane

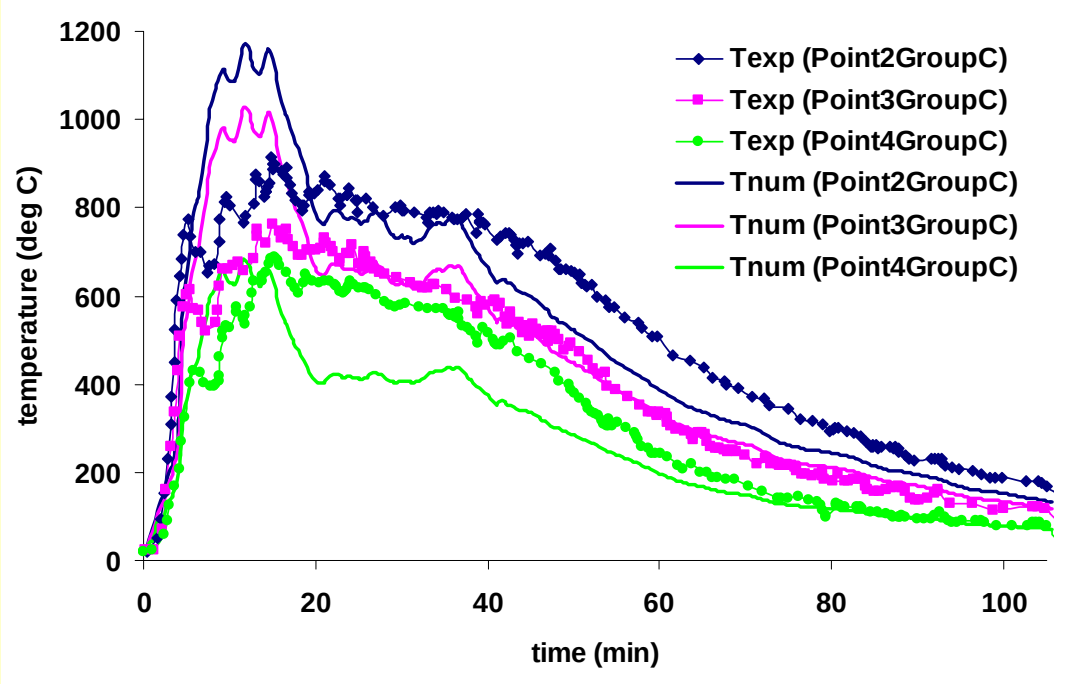


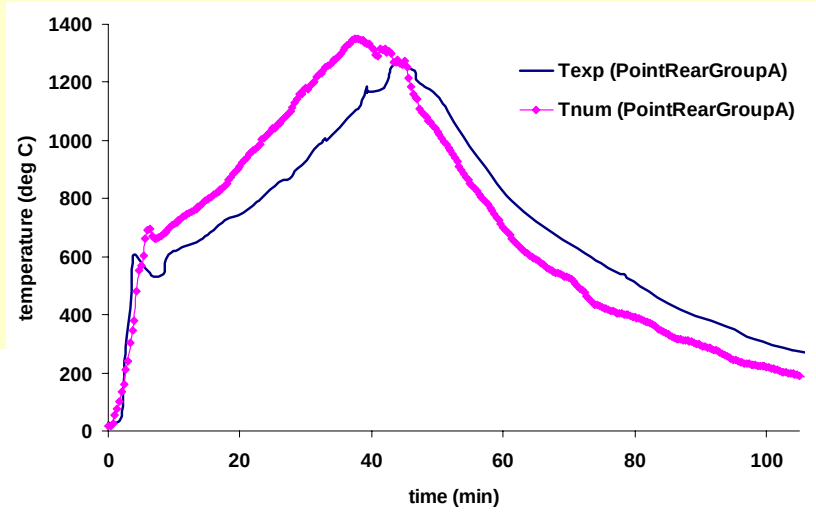


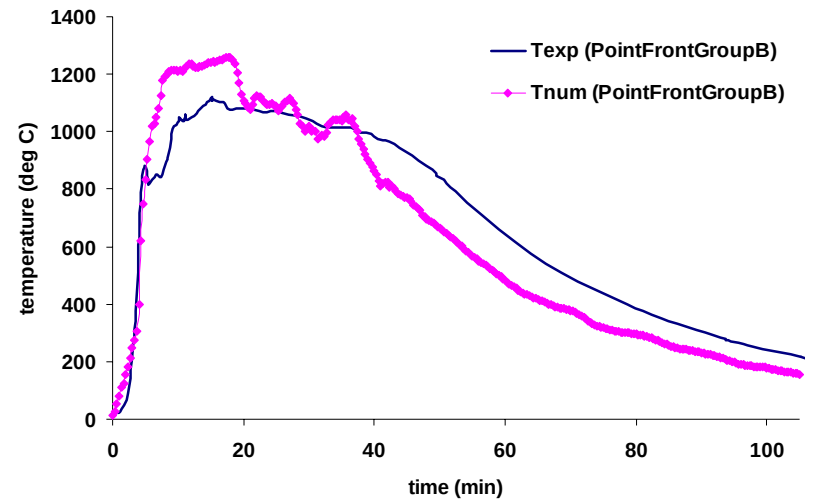
Velocity vectors in a vertical plane

Results (2)

Temperature – time curve comparison for probes in groups A,B,C

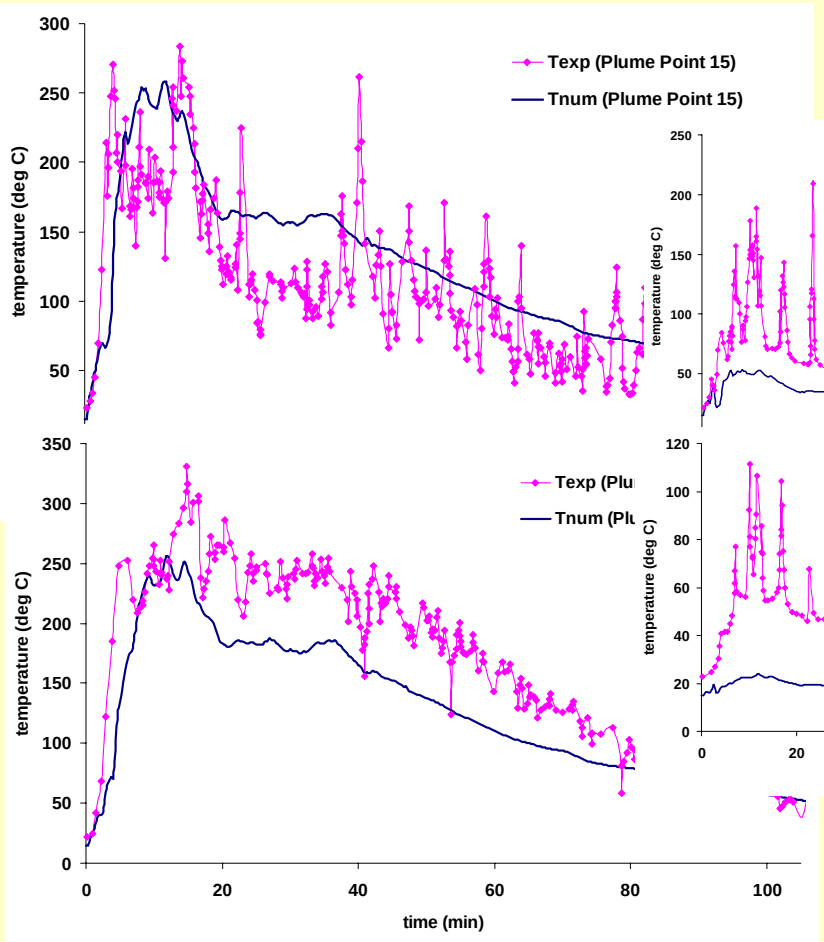


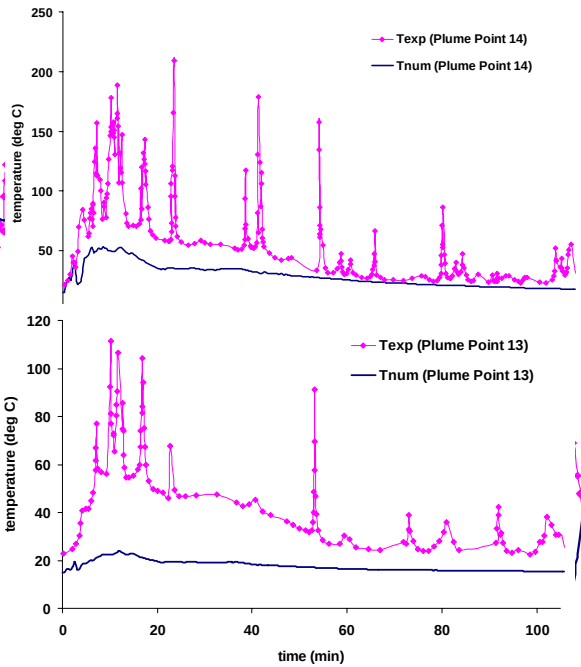


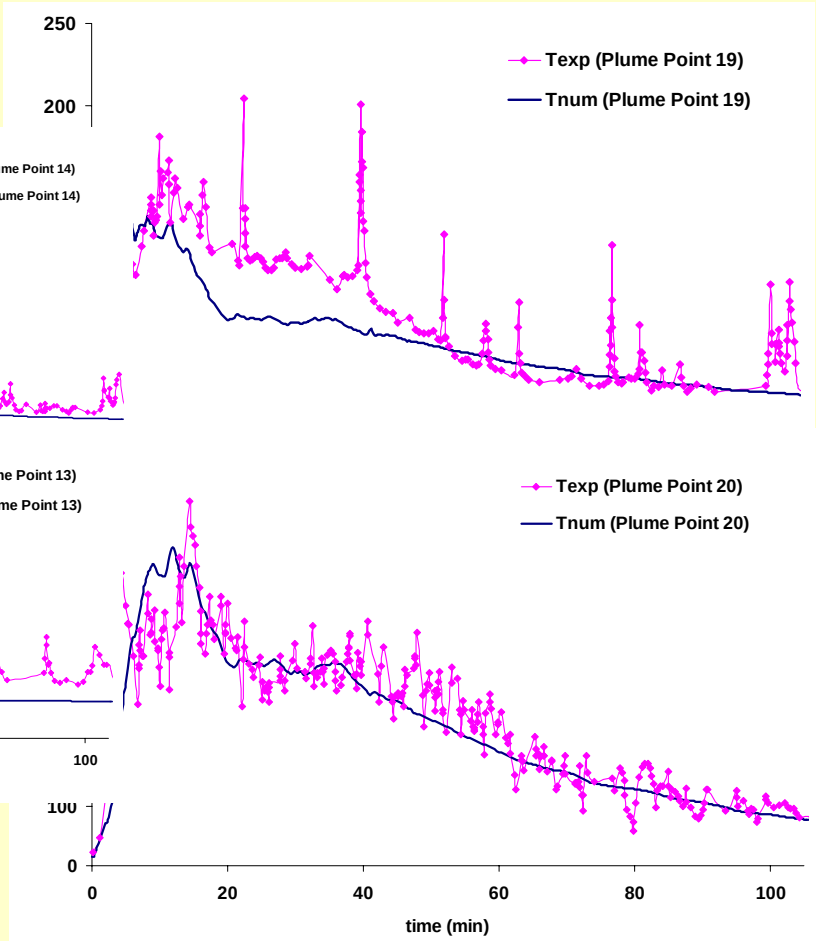


Results (3)

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