EVALUATION OF THERMAL RADIATION MODELS FOR FIRE SPREAD BETWEEN OBJECTS

Fire and Evacuation Modelling Technical Conference

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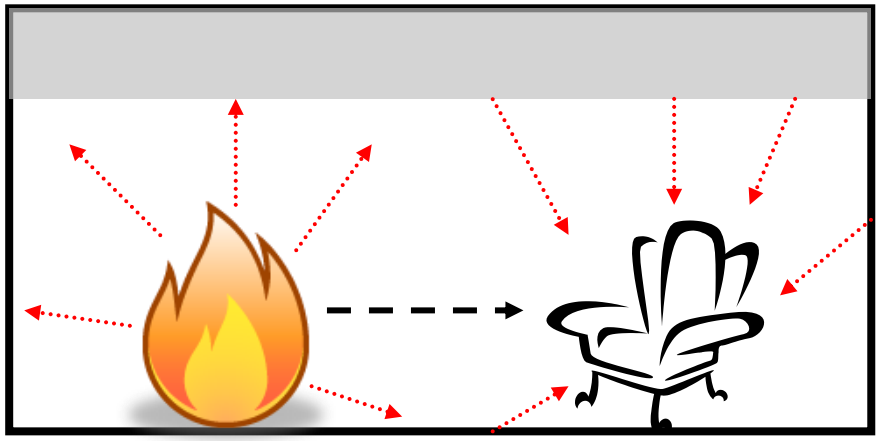
CONTEXT AND MOTIVATION

- **Zone model BRANZFIRE currently being upgraded to include risk-based modelling**
  - Quantitative Risk Assessment tool
- **Monte Carlo sampling to address inherent uncertainty in design fires**
  - Will include a radiation and ignition sub-model
- **Range of outputs – probabilistic outcomes**

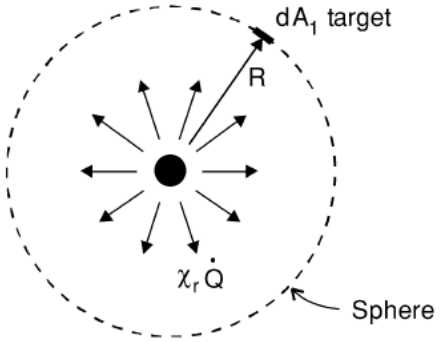
AIM

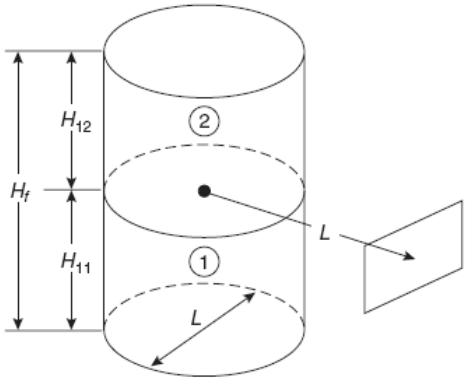
- **Evaluate the performance of thermal radiation models**
- **Will help determine if or when secondary objects ignite due to thermal radiation**
- **Direct radiation from flames only**

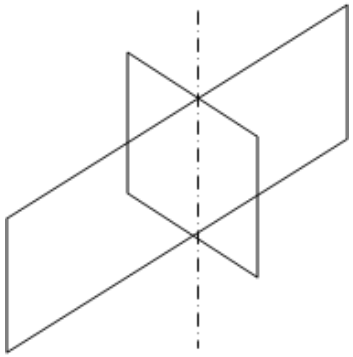


APPROACH

- **Experimental**
  - Radiant heat flux measurements taken around gas burner
- **Comparison with theoretical models**
  - Shokri & Beyler correlation
  - Point source model
  - Shokri & Beyler detailed method
  - Mudan method
  - Dayan and Tien method
  - Rectangular planar model







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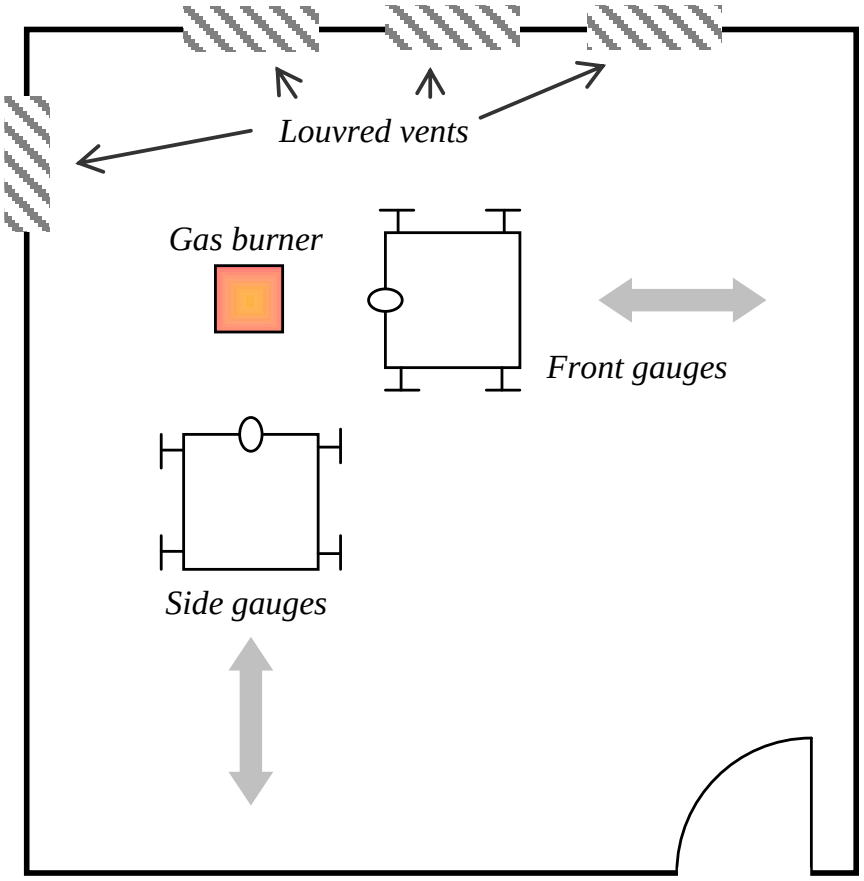
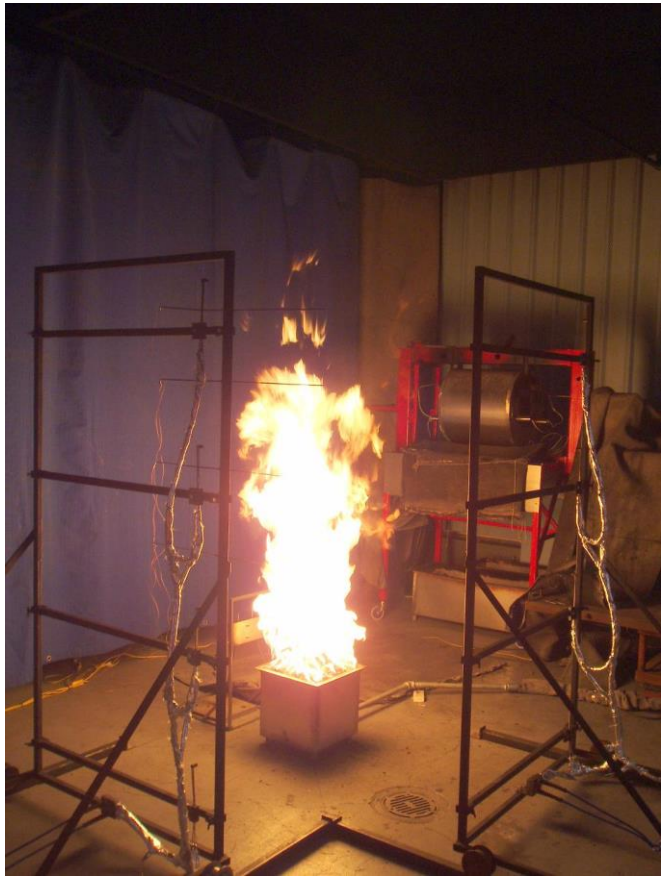
EXPERIMENTAL





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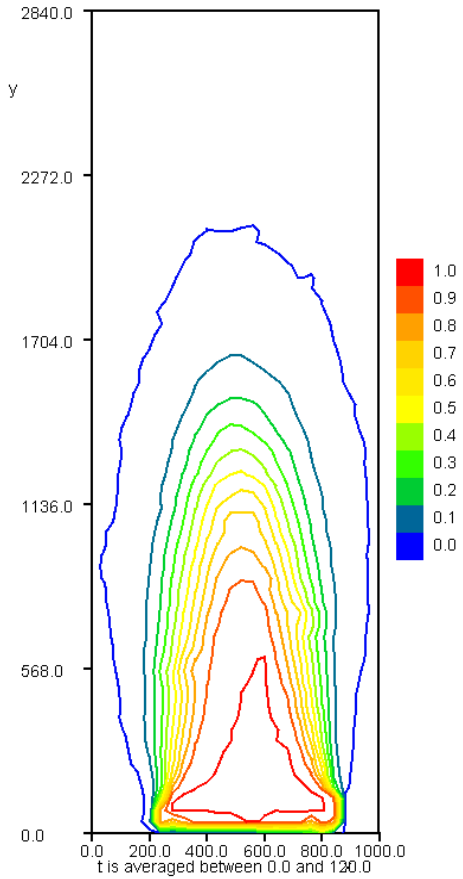
FLAME HEIGHT



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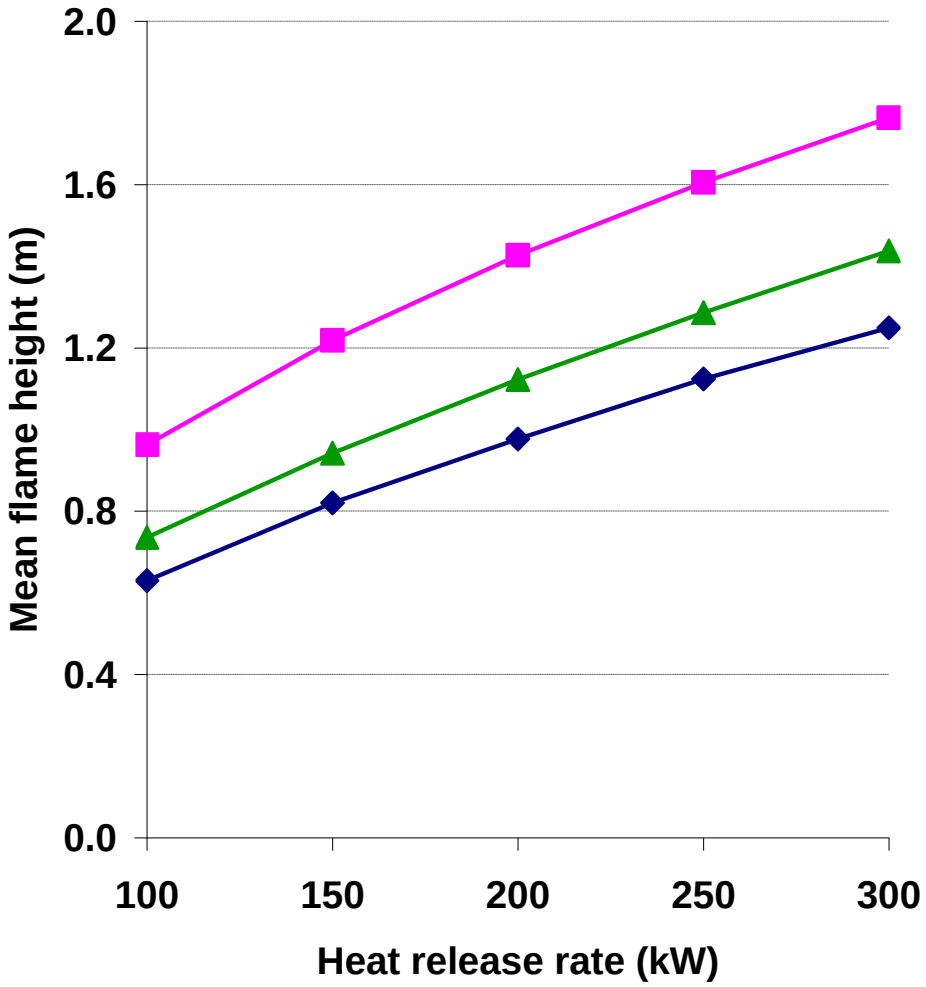

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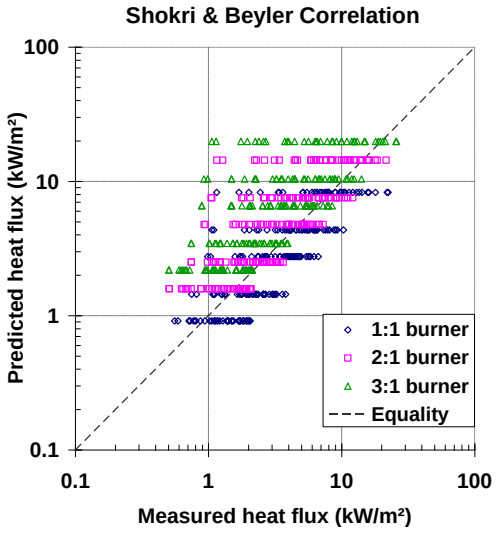
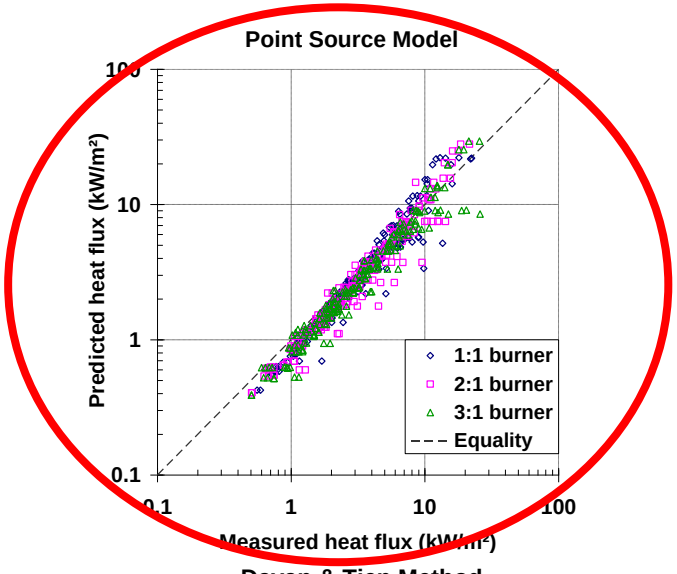
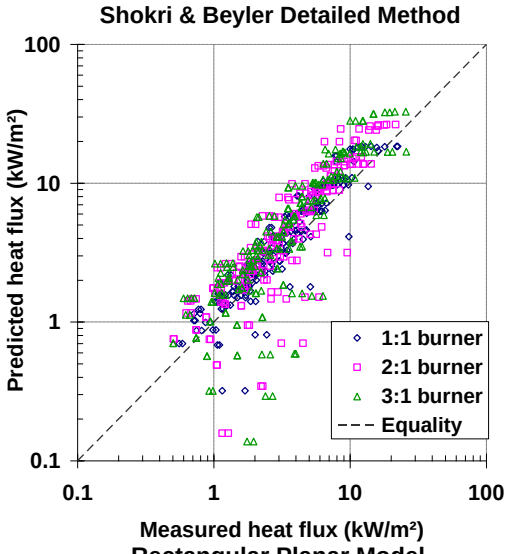
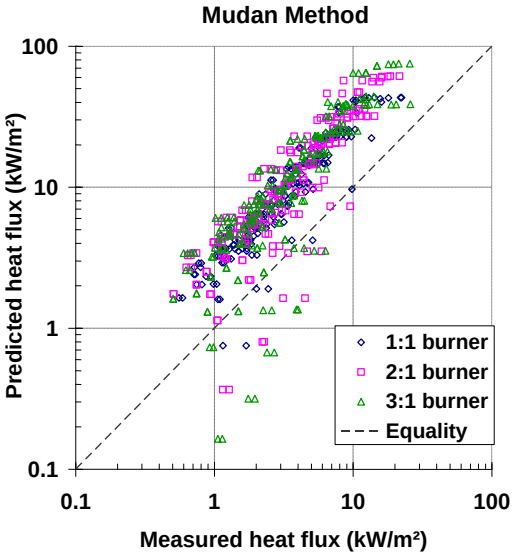
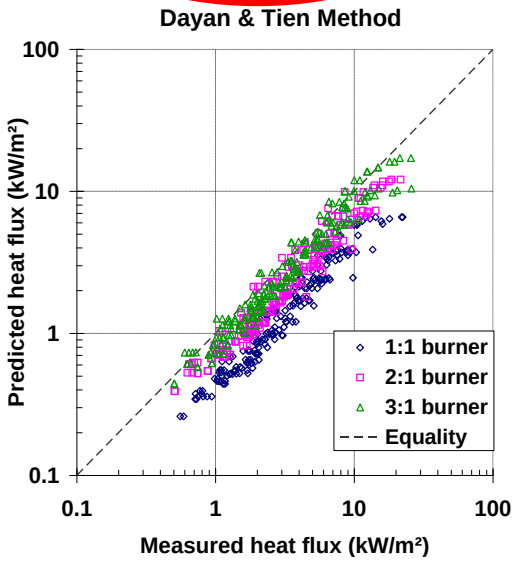
COMPARISON OF MODELS

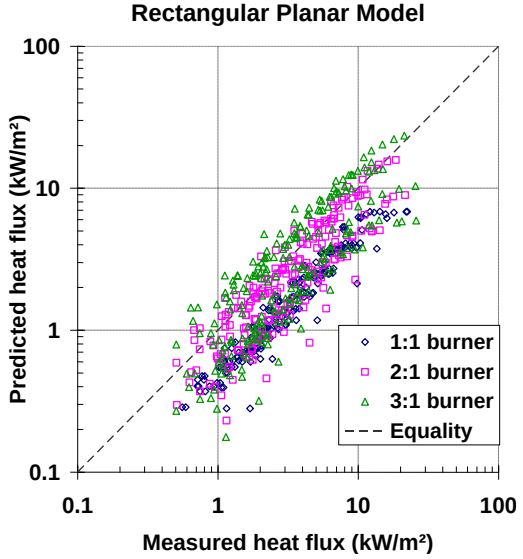












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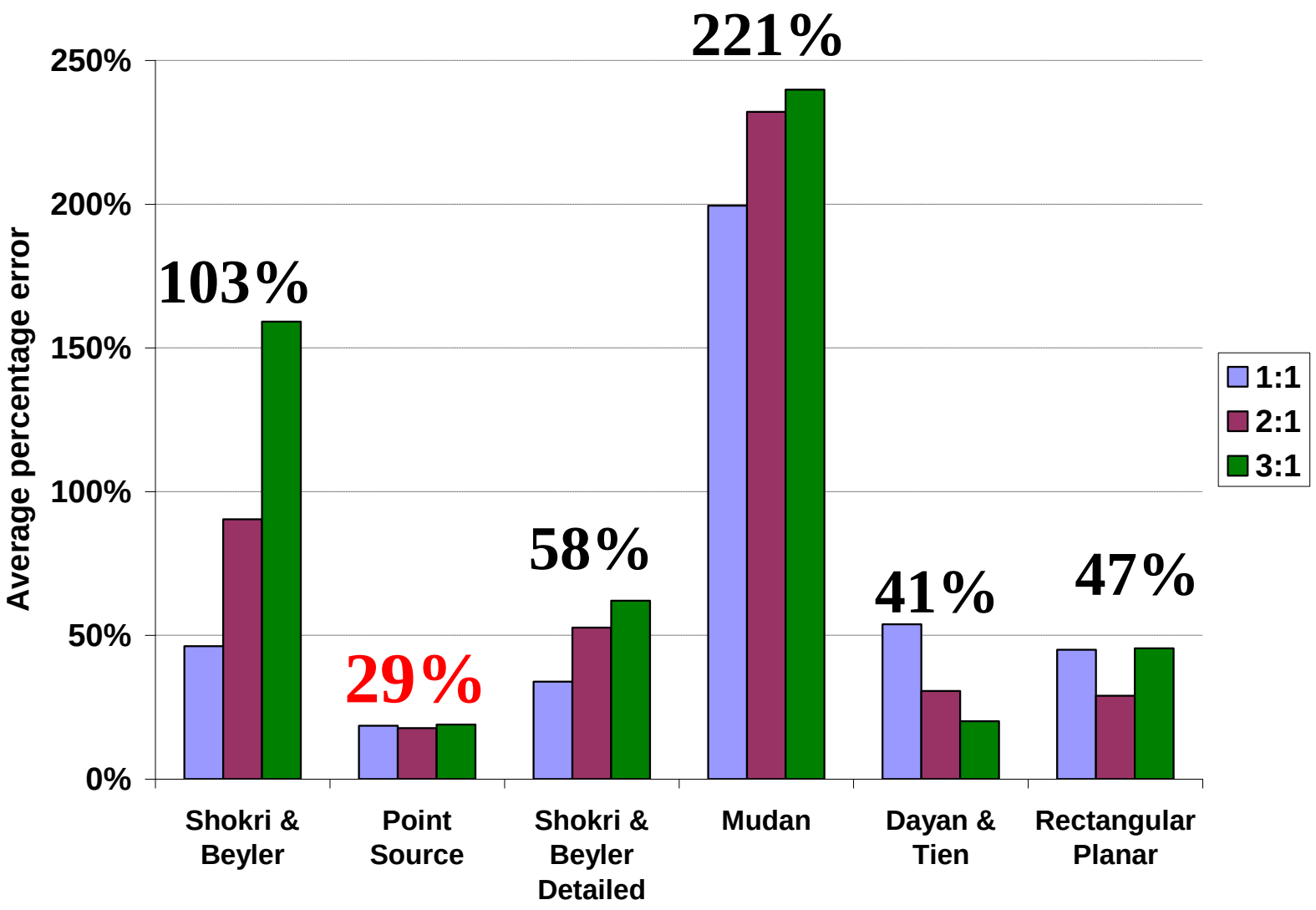

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COMPARISON OF MODELS

Average percentage error from experimental results for different target orientations

	Vertical	Horizontal
Shokri and Beyler Correlation	99%	N/A
Point Source Model	18%	76%
Shokri and Beyler Detailed Method	50%	89%
Mudan Method	224%	205%
Dayan & Tien Method	35%	71%
Rectangular Planar Model	40%	76%

COMPARISON OF MODELS

Average percentage error from experimental results for different radiant heat fluxes

	<5 kW/m²	5-10 kW/m²	>10 kW/m²
Shokri and Beyler Correlation	126%	48%	29%
Point Source Model	17%	17%	31%
Shokri and Beyler Detailed Method	46%	54%	49%
Mudan Method	205%	240%	238%
Dayan & Tien Method	36%	35%	36%
Rectangular Planar Model	44%	40%	41%

COMPARISON OF MODELS

Average percentage error from experimental results for different target positions

	Central	Offset
Shokri and Beyler Correlation	101%	97%
Point Source Model	19%	17%
Shokri and Beyler Detailed Method	48%	52%
Mudan Method	215%	234%
Dayan & Tien Method	36%	33%
Rectangular Planar Model	45%	34%

LIMITATIONS TO RESULTS

- **Single object fires within compartments**
- **Propane gas vs real objects (e.g. furniture)**
- **Heat release rates 100 – 300 kW**
- **Effective fire diameter: max 0.6 m**
- **Input parameters**

SELECTING A MODEL

- **Two important factors for selecting model for BRANZFIRE:**

Accuracy	Ease of Implementation
1. Point Source Model	$\dot{q}'' = \frac{\dot{Q}_r \cos\theta}{4\pi R^2}$
2. Dayan and Tien Method	$\dot{q}'' = \sigma \varepsilon T_f^4 \left(F_1 + F_2 + F_3\right)$

CONCLUSIONS

- **Generally, Point Source and Dayan & Tien models provide best match to experimental data**
- **Point Source model (surprisingly) proved to be the most robust, in terms of dealing with different scenarios**
- **Point source model relatively straight-forward to implement into two-zone model**

→Point Source model will form part of the radiation and ignition sub-model within BRANZFIRE

Thank you

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