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On the design of biomass-fired heat-storing stoves for the heating of buildings

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Introduction

- Wood firing is a traditional heating method in Nordic countries.
- Wood is a renewable and local energy source.
- Integration of wood firing into zero-energy buildings needs to be considered.

What's new?

- Plenty of work on wood burning has been carried out by people studying fire safety.
- Can any of that work be applied in energy engineering?

Methodology

Main focus in this work

Real-life engineering

Simple models

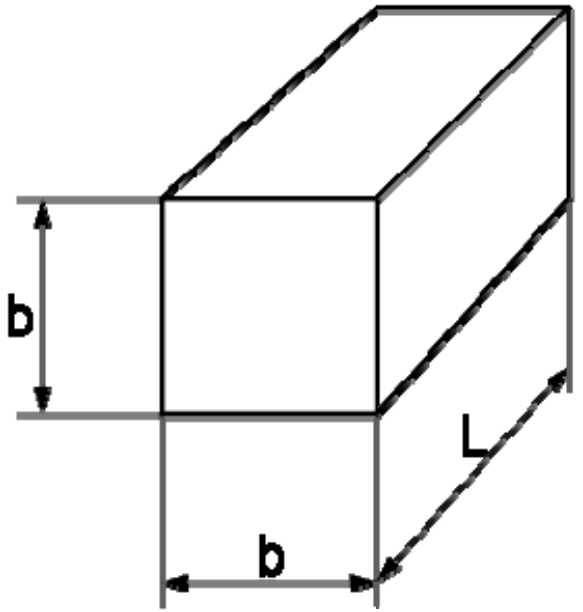
Complex models

$$\dot{Q} = at^2$$

$$\tilde{v}_x \frac{\partial \tilde{v}_x}{\partial \tilde{x}} + \tilde{v}_y \frac{\partial \tilde{v}_x}{\partial \tilde{y}} = -\frac{\partial \tilde{P}}{\partial \tilde{x}} + \frac{1}{\mathrm{Gr}}\left(\frac{\partial^2 \tilde{v}_x}{\partial \tilde{x}^2} + \frac{\partial^2 \tilde{v}_x}{\partial \tilde{y}^2}\right)$$

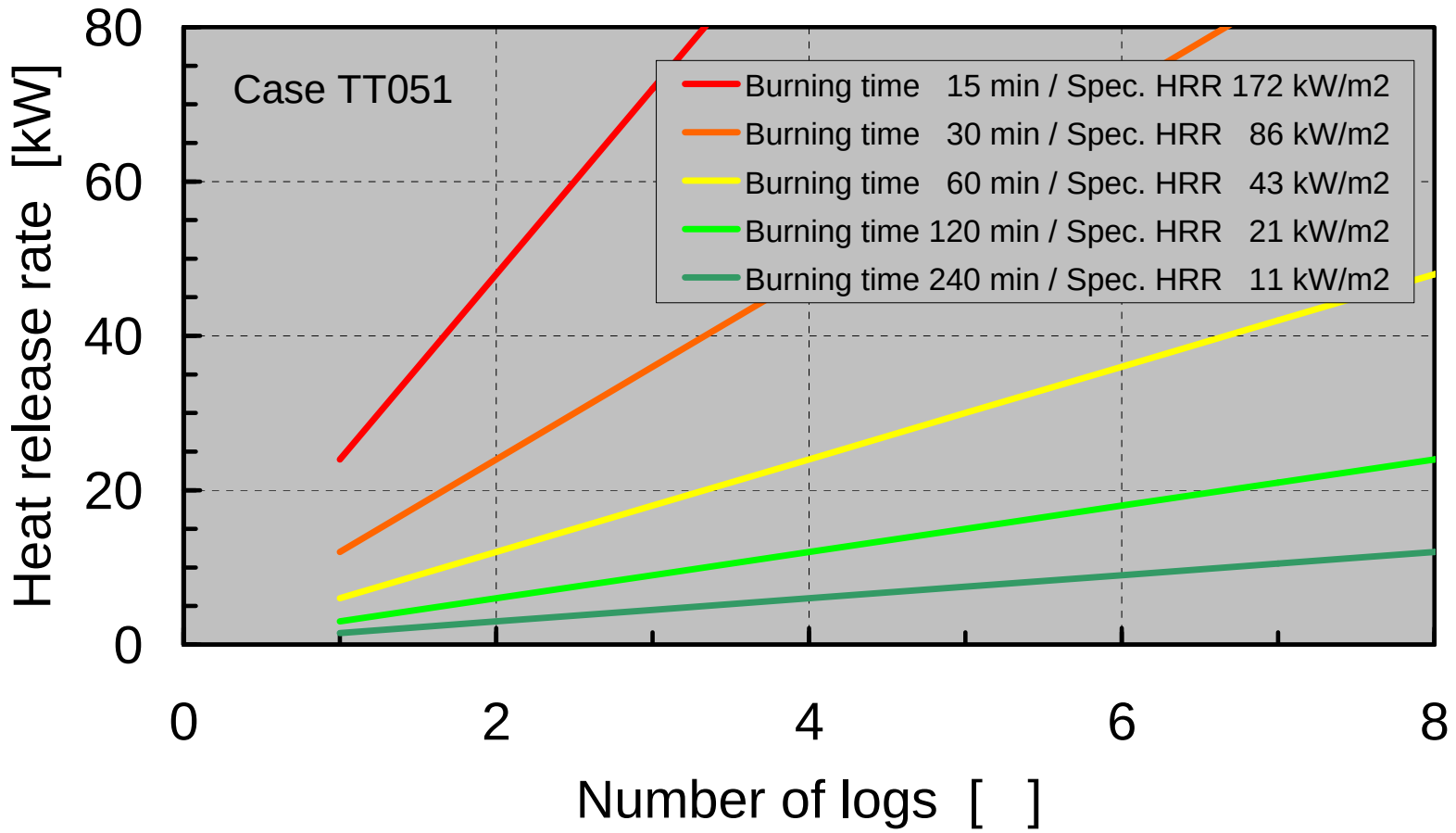
$$\tilde{v}_x \frac{\partial \tilde{v}_y}{\partial \tilde{x}} + \tilde{v}_y \frac{\partial \tilde{v}_y}{\partial \tilde{y}} = -\frac{\partial \tilde{P}}{\partial \tilde{y}} + \frac{1}{\mathrm{Gr}}\left(\frac{\partial^2 \tilde{v}_y}{\partial \tilde{x}^2} + \frac{\partial^2 \tilde{v}_y}{\partial \tilde{y}^2} + \tilde{T}\right)$$

Firewood specification



Assume: b = 10 cm, L = 30 cm
Each log contains 6 kWh of chemical energy

Burning time vs. heat release rate



What next?

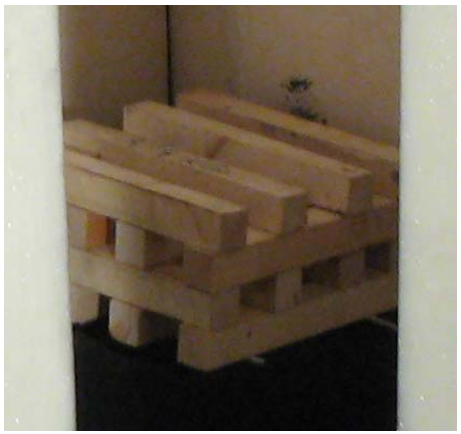
- Conclusions:
  - Normal-size wood logs cannot really be burned at a rate which would match the heat demand of the building.
  - Two things will be needed to solve the problem:
    (1) the burning rate must somehow be limited and
    (2) the stove must have significant heat storage capability.

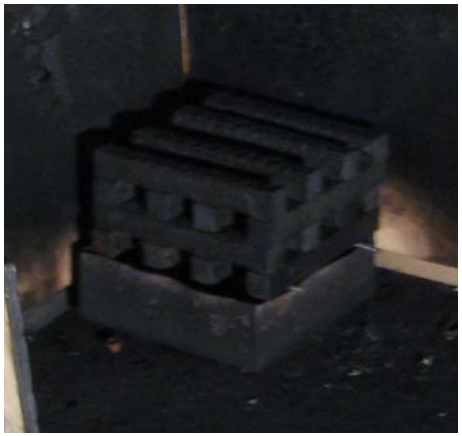
=> Study the burning of cribs to handle (1).

=> Study stoves with massive walls to handle (2).

Wood cribs

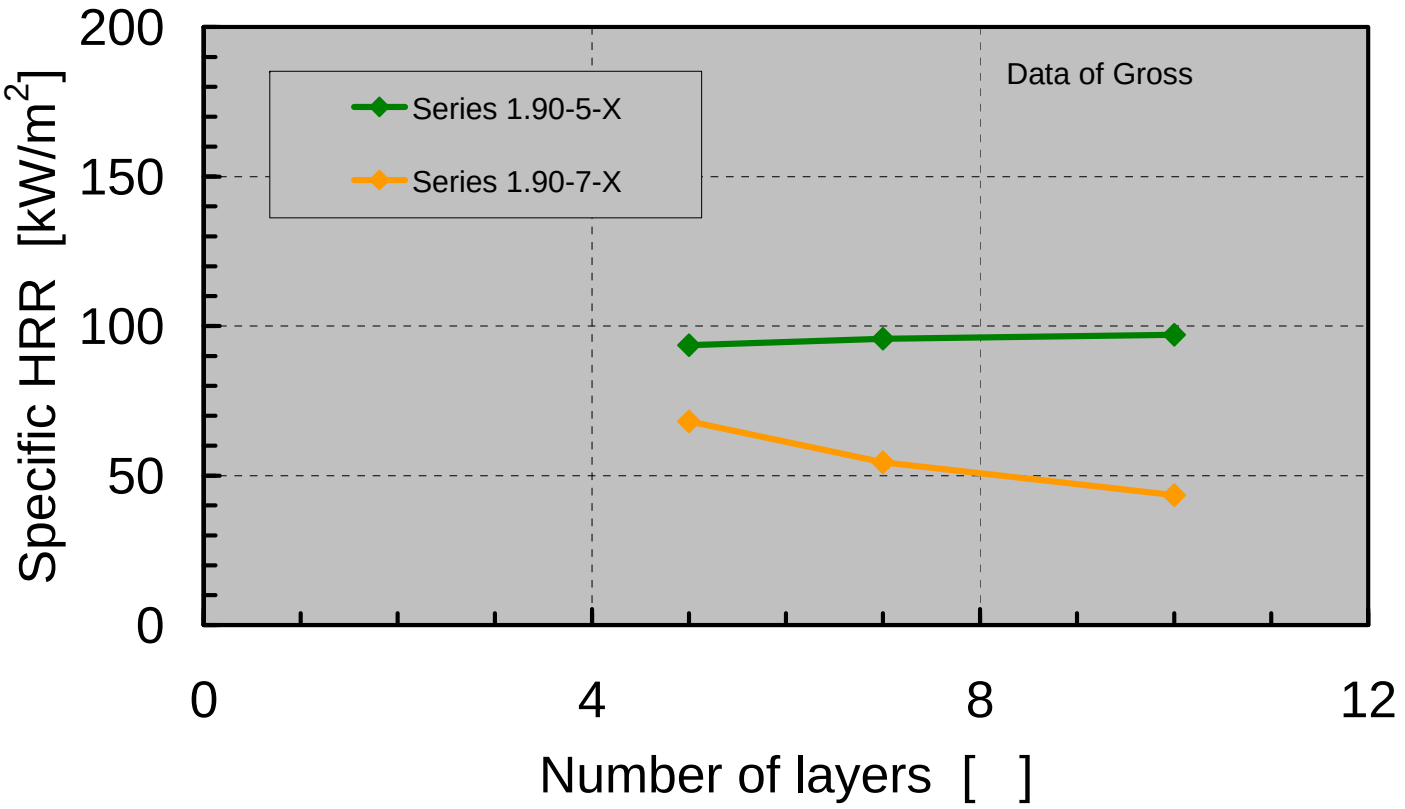
- Developed for use as ignition sources in fire experiments (repeatability).
- Can be designed to achieve desired burning characteristics (burning time, heat release rate).





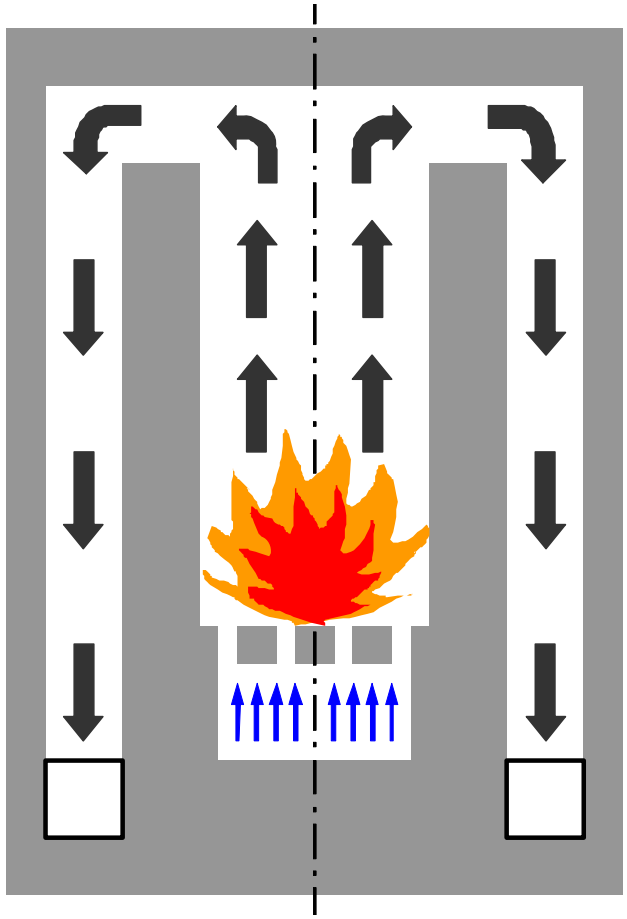
A wood crib before a fire test (left) and after the test (right).

Effect of crib design

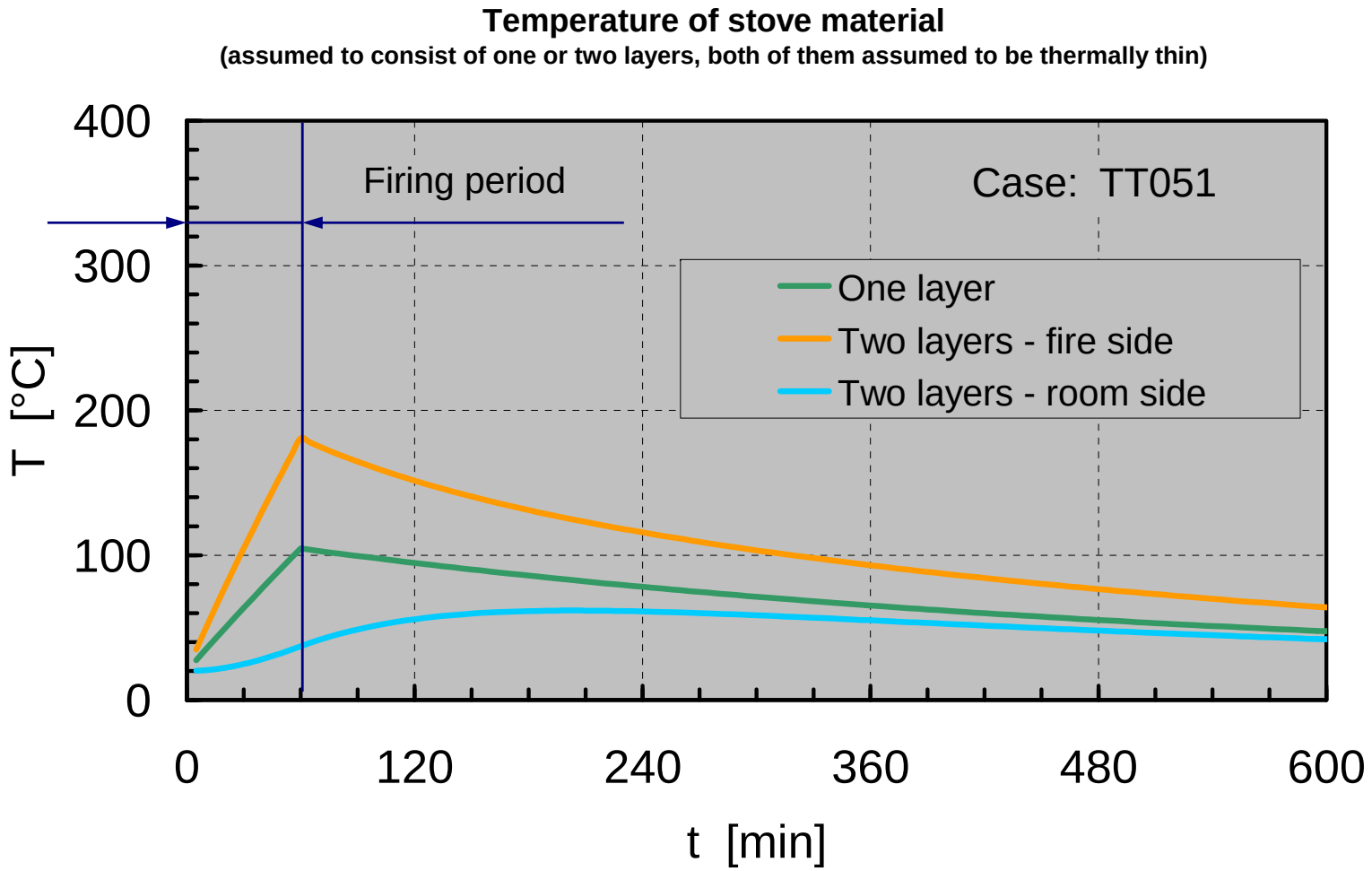


Heat storage capability

Schematic view of a heat storing stove with side channels for better utilization of the heat content of the flue gas



Temperature evolution in the stove wall



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Calculated using the lumped-capacity model (thermally thin walls). This needs to be improved.

Conclusions

- Heat storage capability is an essential feature of good wood-fired stoves.
- Appropriate fuel preparation and firing practices must be employed.
- Modeling work will be continued on heat release rate and heat storage behavior.
- Main emphasis on simple models.

Thank you for your attention!