
Fire Dynamics

Burning phenomena

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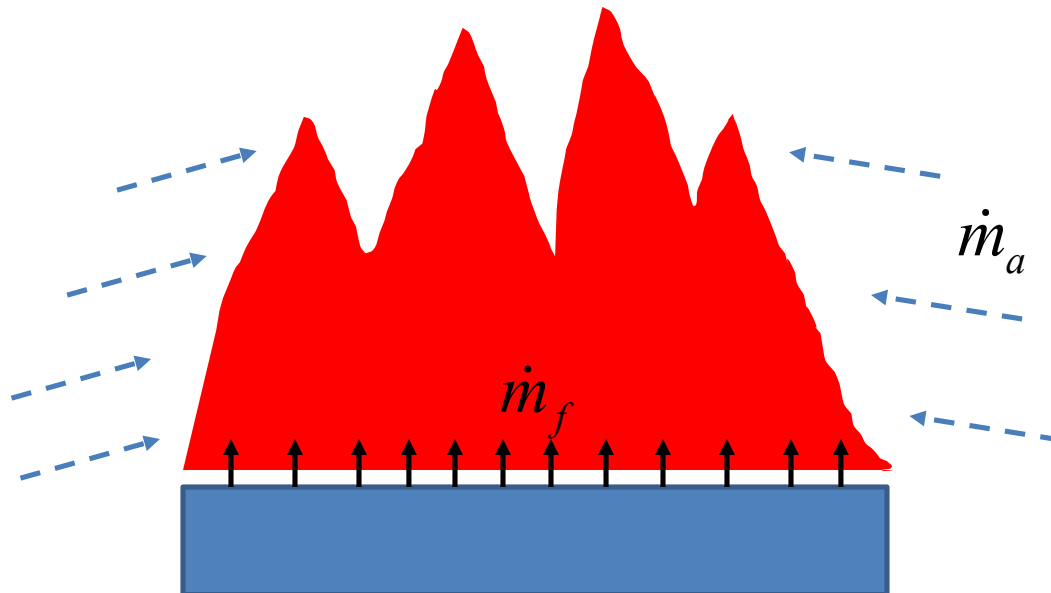
Objectives

- Understanding the influence of different fuel type, location, and amount on fire safety
 - Fuel type
 - Wood
 - Plastics (thermoplastics, thermosets)
 - Fuel location
 - Ceiling, walls, floor
 - Fuel amount

How fire size is determined

$$\dot{Q} = \text{minimum}(\dot{m}_a (\Delta H_{c,air}), \dot{m}_f (\Delta H_{c,fuel}))$$

- What influences \dot{m}_a ?
- What influences \dot{m}_f ?

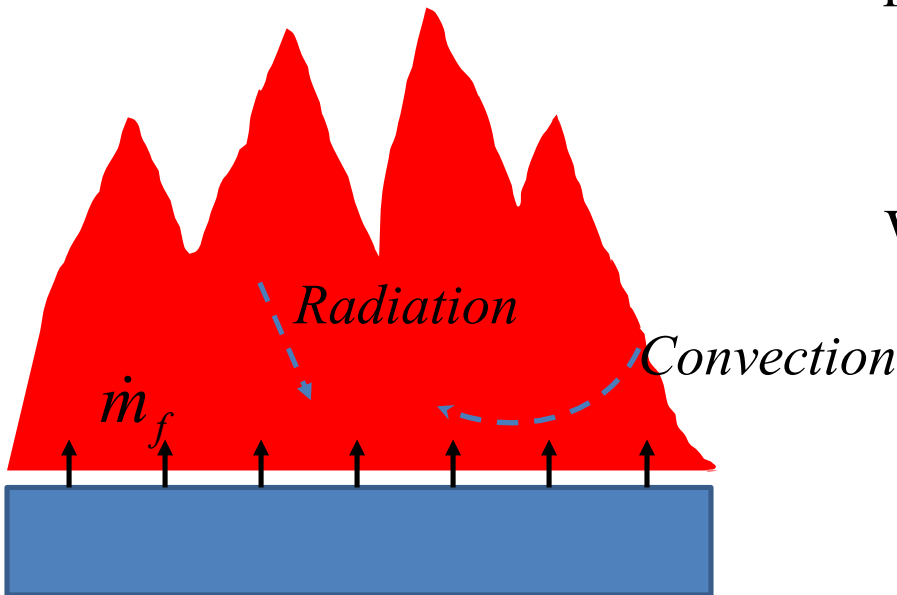


How fire size is determined

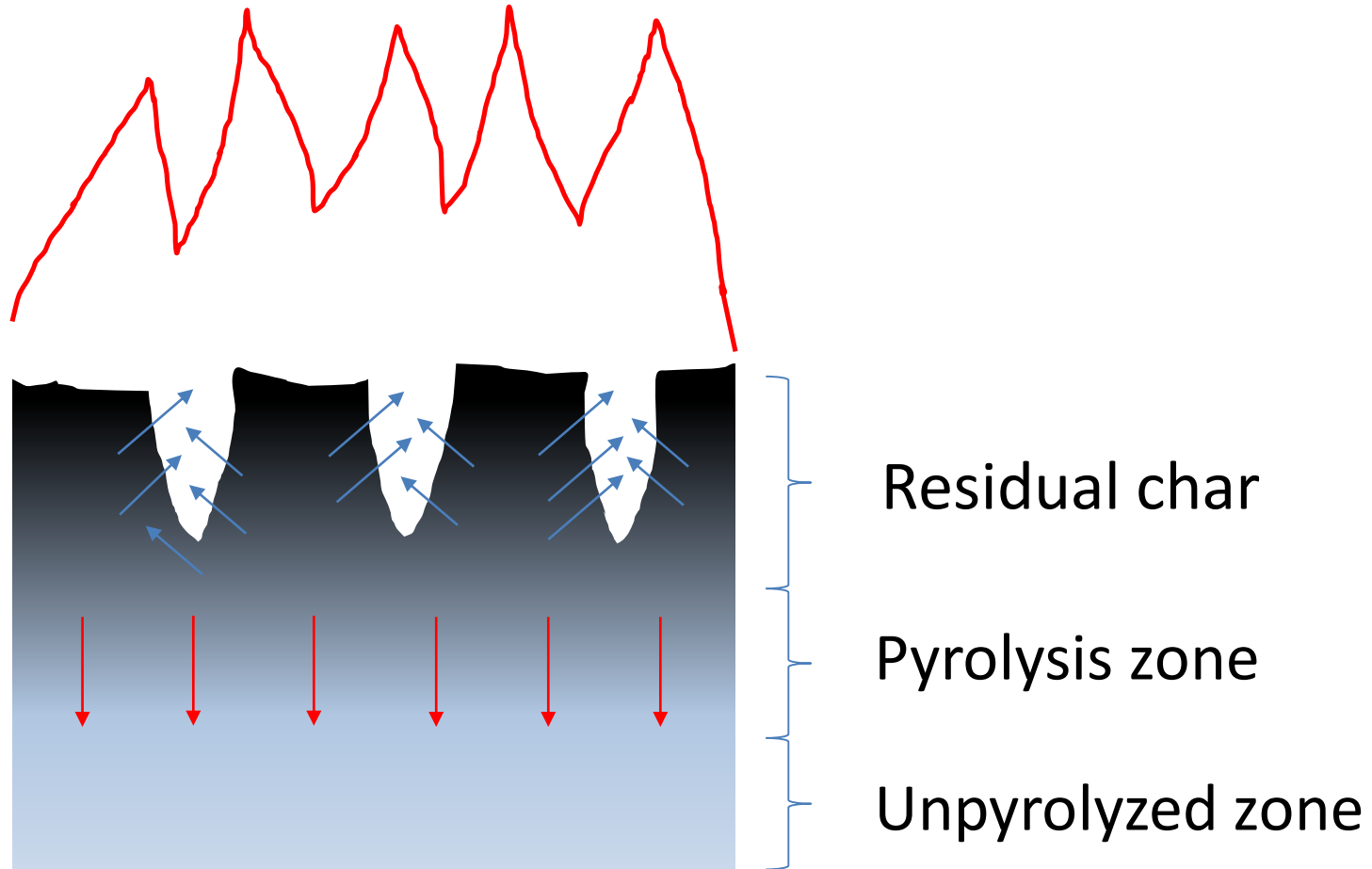
$$\dot{m}_f'' = \dot{m}_\infty'' (1 - e^{-k\beta D})$$

$$\dot{m}_\infty'' \approx \frac{\Delta H_c}{\Delta H_{vap} + c_p (T_b - T_{init})}$$

With wind, anything changes?

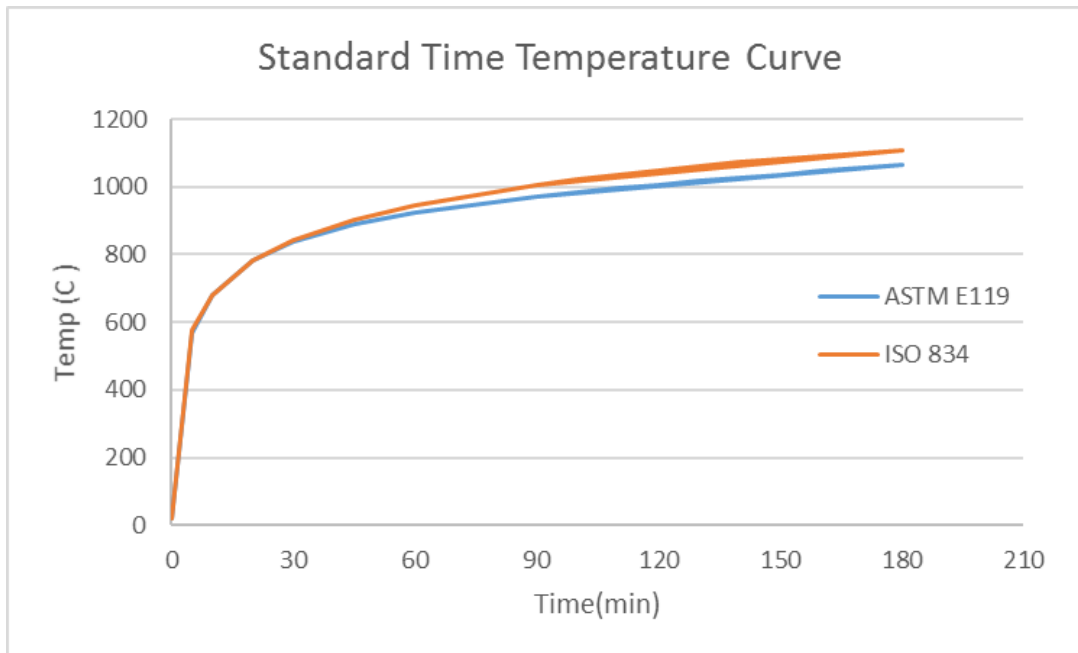


Charring of Wood



Charring rate of wood

- https://www.youtube.com/watch?v=lW72-L0_n_M (2:30-5:30)
- In standard fire furnace test (ASTM E119 or ISO 834)
 - Approximately 0.6-0.8 mm/min (relatively constant)



Charring rate of wood

- It generally decreases for wood with
 - Higher moisture content
 - Higher density
 - Lower external heat flux

Thermoplastics and thermosets

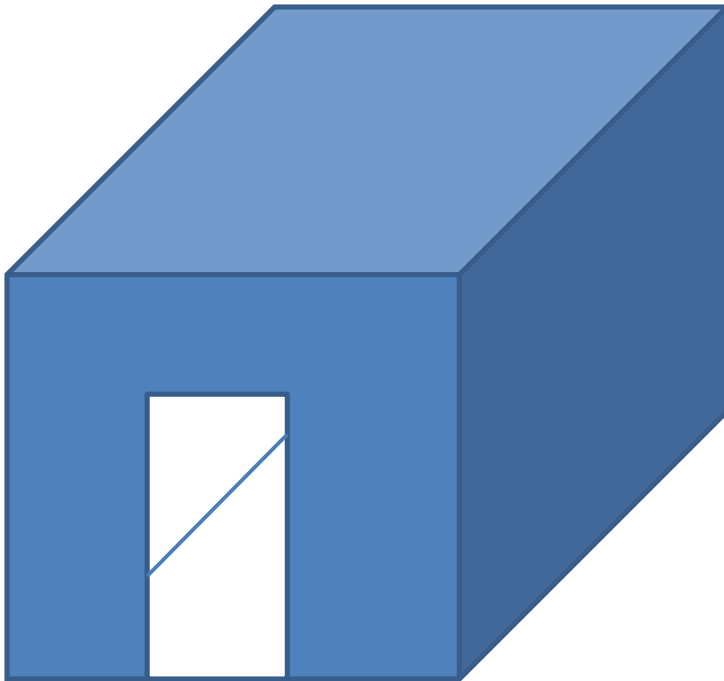
- Weak bond vs. strong bond
- Reshaped vs. fixed
- Melting vs. decomposition
- Thermoplastics
 - Acrylic, nylon, polyethylene, polystyrene, polypropylene, polyvinyl chloride
- Thermoset
 - Polyester, polyurethane, epoxy resin

Fuel location

- In typical buildings,
 - Walls
 - Floor (or based on floor)
 - Ceiling
- NFPA 286 or ISO 9705
 - <https://www.youtube.com/watch?v=snlhECzj1E8> (00:36 -)
 - To check the contribution of wall and ceiling interior finishes to room fire growth

Fuel location

- NFPA 286 vs. ISO 9705



- Standard room
 - ~3.6 m by 2.4 m by 2.4 m
 - ~2 m by 0.8 m opening
- Gas burner fire
- Fuel locations
 - Wall
 - Wall + ceiling
 - Ceiling only

Fuel location

- ASTM E84 test (Steiner tunnel test)
 - Flame spread index and smoke development index
 - https://www.youtube.com/watch?v=QkITq_Y12w
- Wood fuels vs. plastics fuels

Fuel amount

- Fuel density
 - Occupancy and space use
- Opening size vs. fuel amount
 - Oxygen availability
- Hazards from fire fuels
 - Interactive effects of fuel type, fuel location, and fuel amount