

# Gasification Temperatures in Natural Draft Top-Lit Updraft Gasifiers

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# INTRODUCTION

# Background

- ND-TLUD gasifiers may be the most **ecologically sound** method of cooking and generating charcoal (biochar) for families using wood or densified fuel.
- We need to know better how ND-TLUDs work:
  - Adapt the technology to local conditions.
  - We can't over-ride the system with a fan; **we have to work with the system and its internal interactions.**

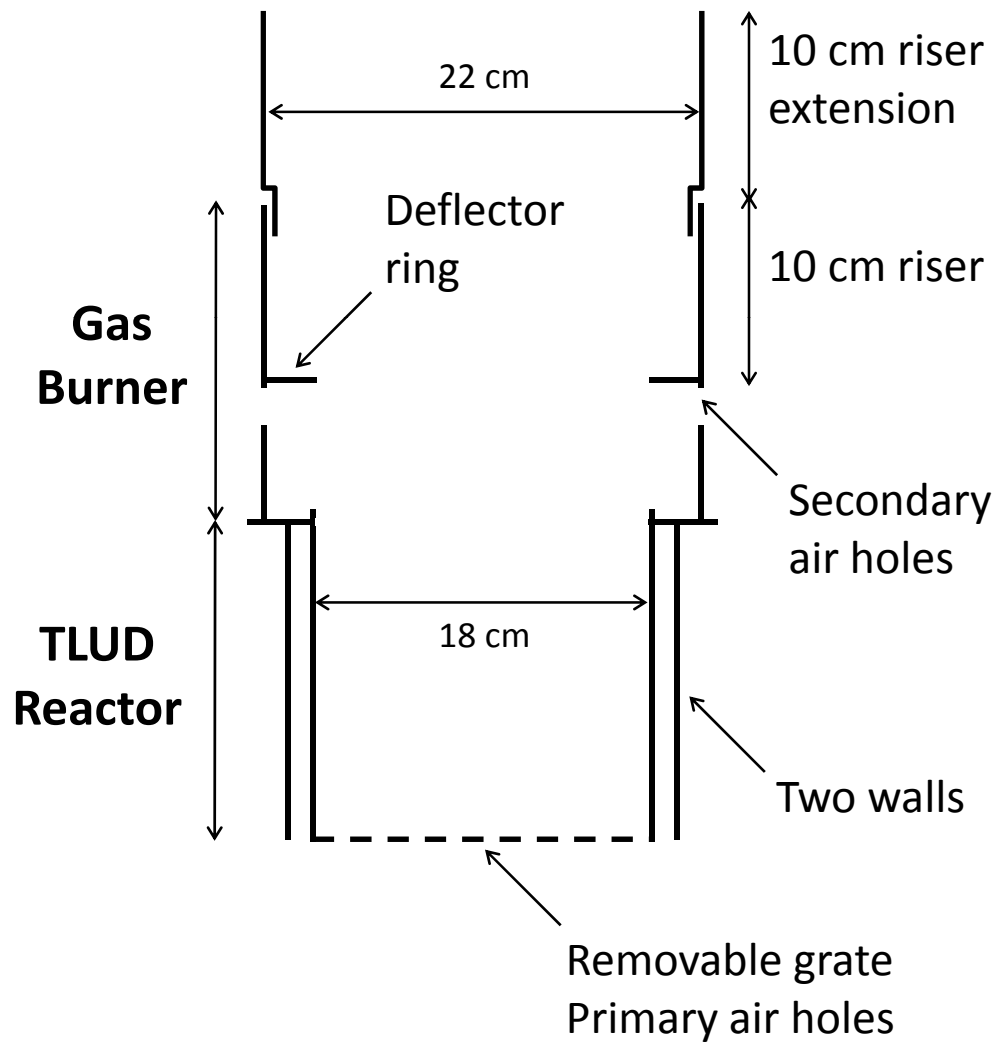
# Objective of this Study

Measure the relationship between **maximum fuel bed temperature** and **gasification rate**.

- What can we achieve using only natural draft?
- If we can measure gasification rate of a particular type of fuel, can we estimate the temperature (heat) caused it?

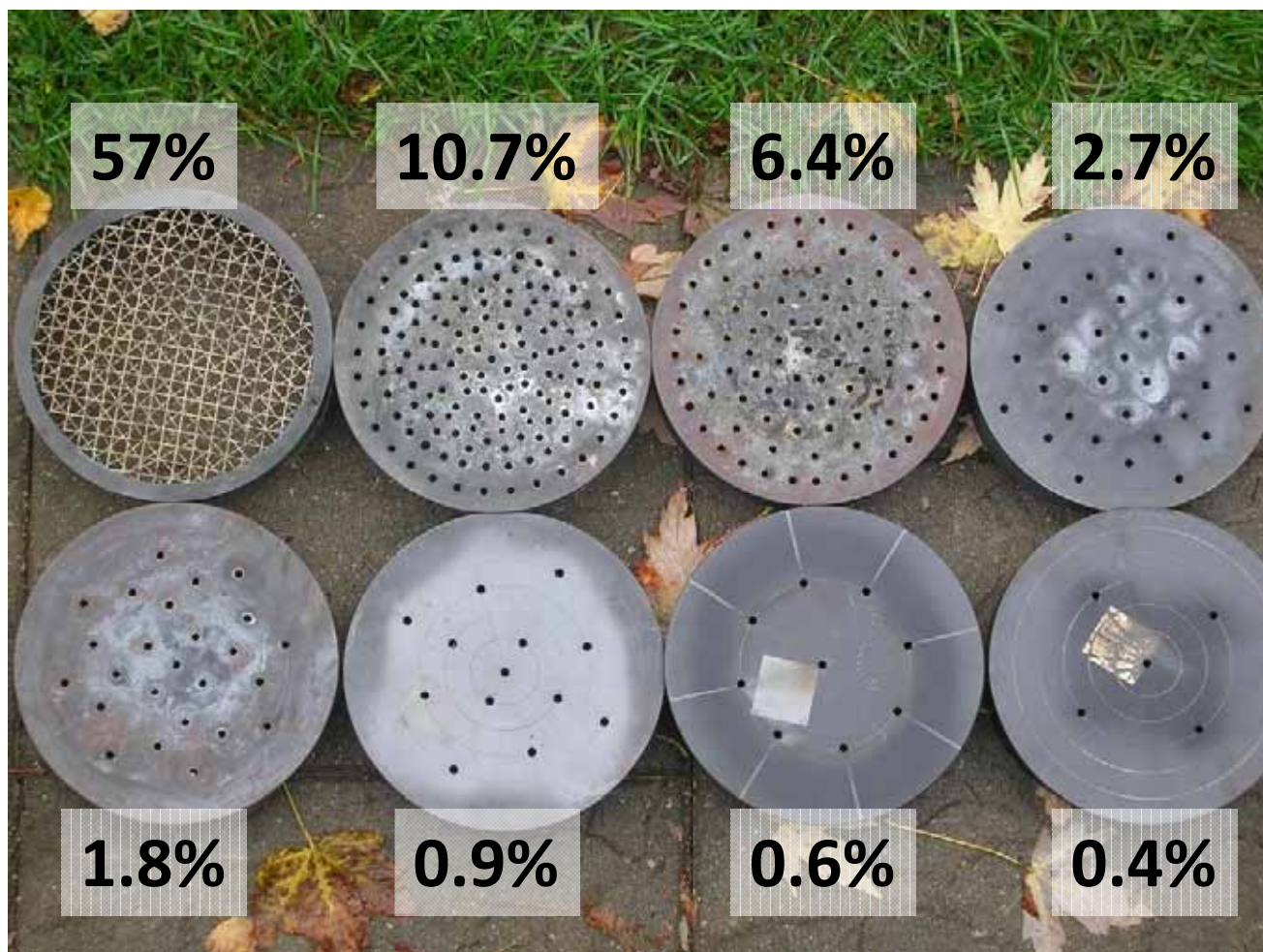
# **METHODOLOGY**

# Experimental TLUD and Burner



# Primary Air Control

Switching grates with varying grate apertures.



# ND-TLUD Reactor 32 cm Tall

Thermocouples in the center at 5, 10, 15, 20 cm above the grate.



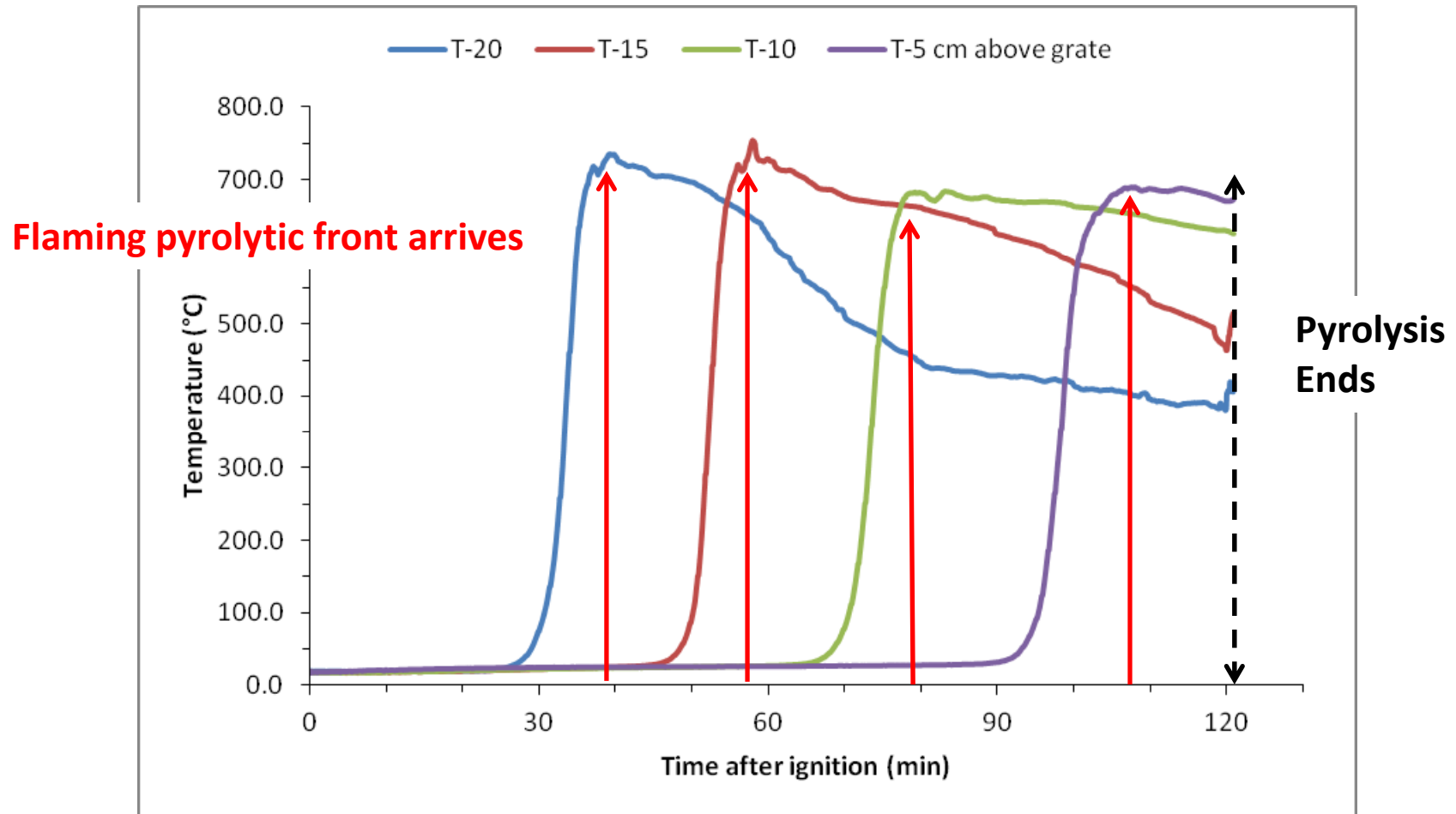


# TLUD Enclosed in a Shroud

Thermocouple data logger reading every 5 seconds



# Temperature Measurements



# Fuels: Pellets, Chips, Sticks





# Fuels: Vertical Spruce Lumber

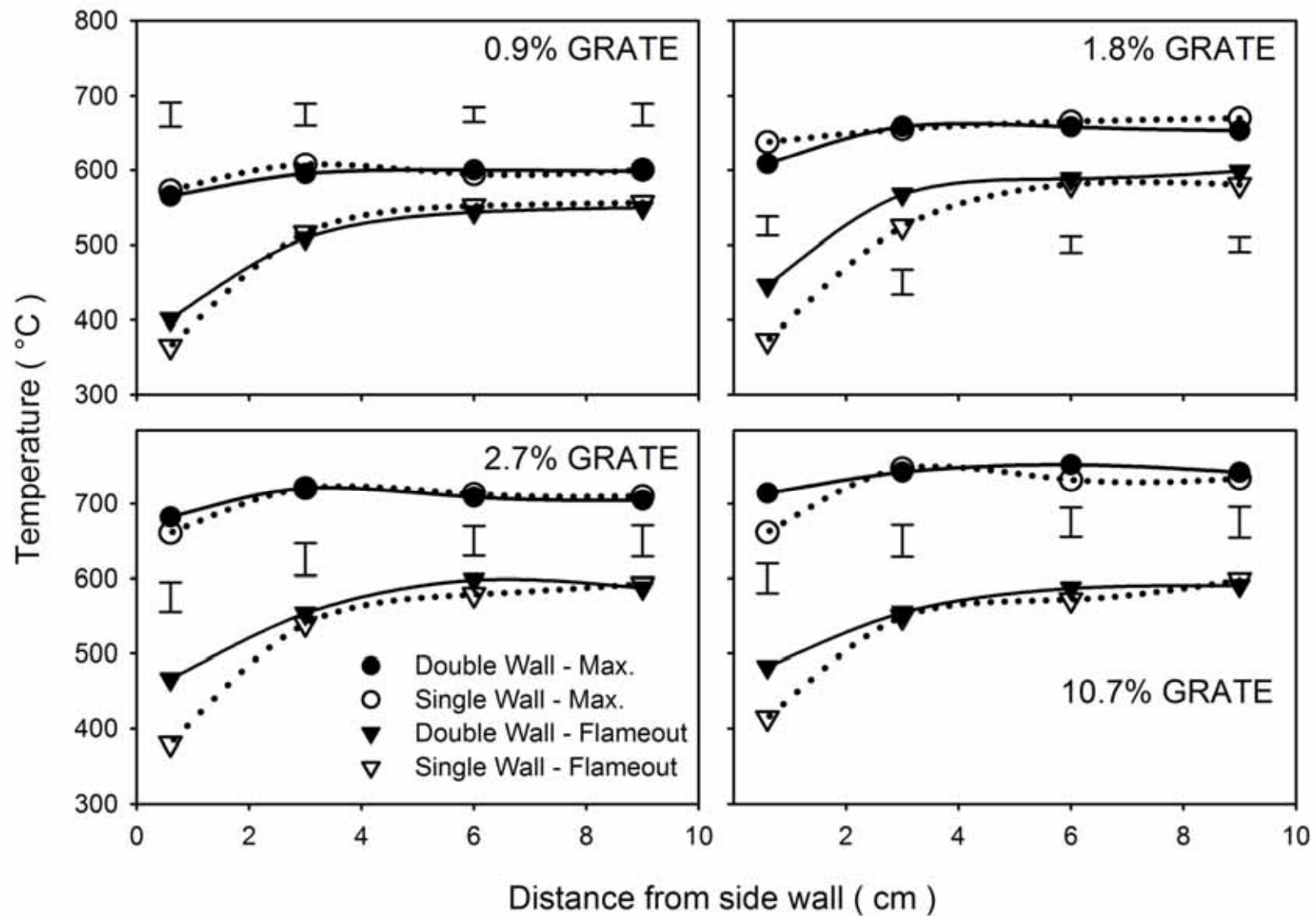


# **PRELIMINARY EXPERIMENTS**

# Preliminary Experiment 1: Temperature in the Horizontal Plane



# Horizontal Temperature 8 cm Above the Grate





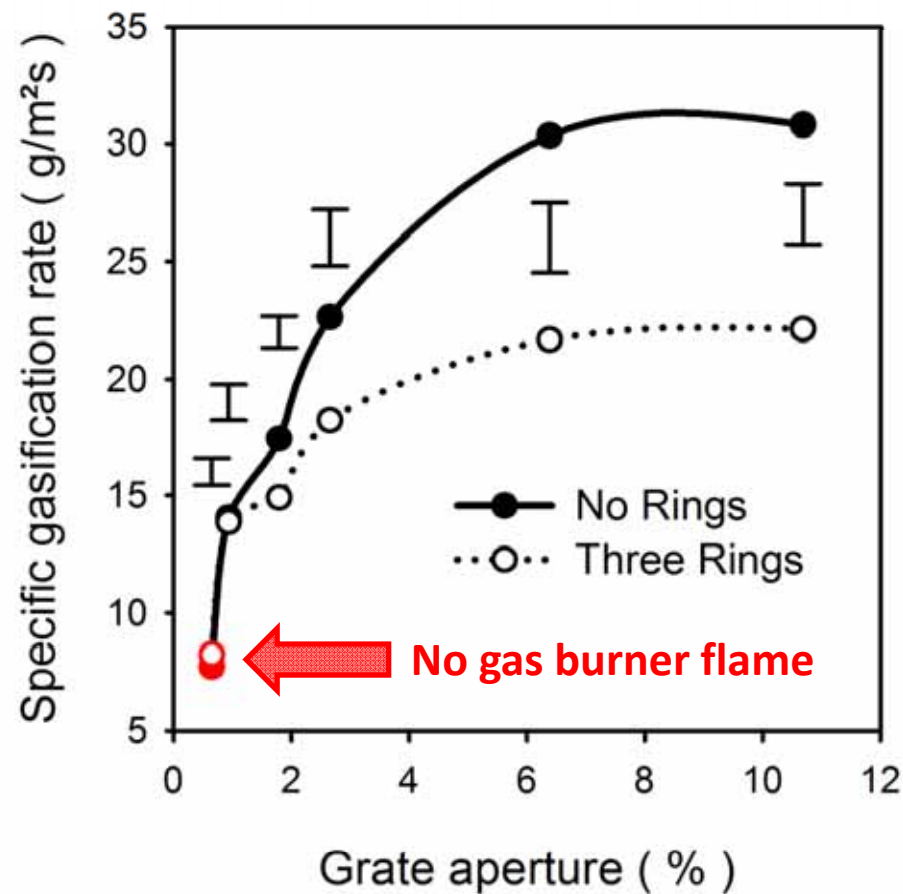
## Preliminary Experiment 2:

Fire-break rings in a fuel bed of willow chips to stop channelling



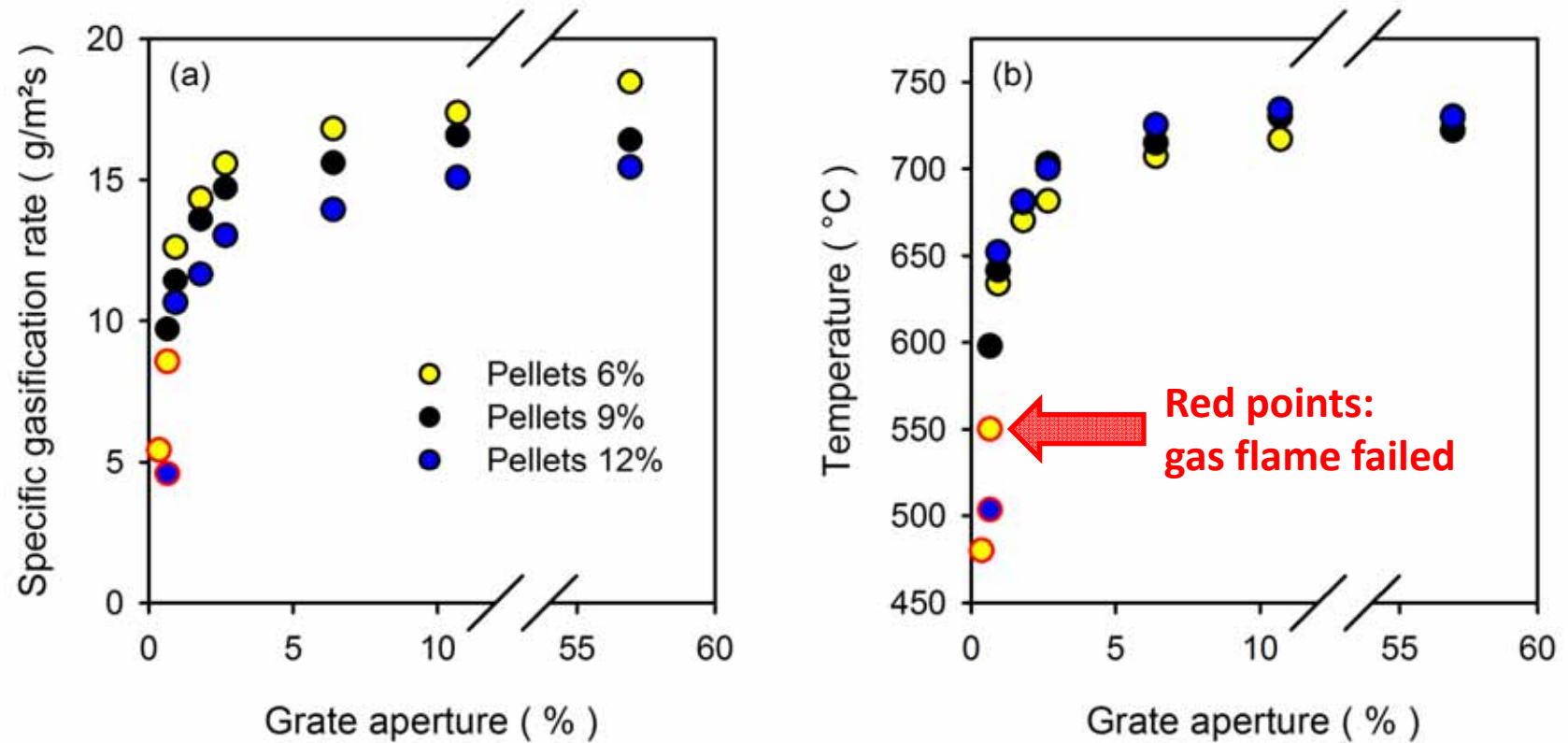


Adding three rings enforced TLUD conditions, but slowed down the reaction rate vs. no rings



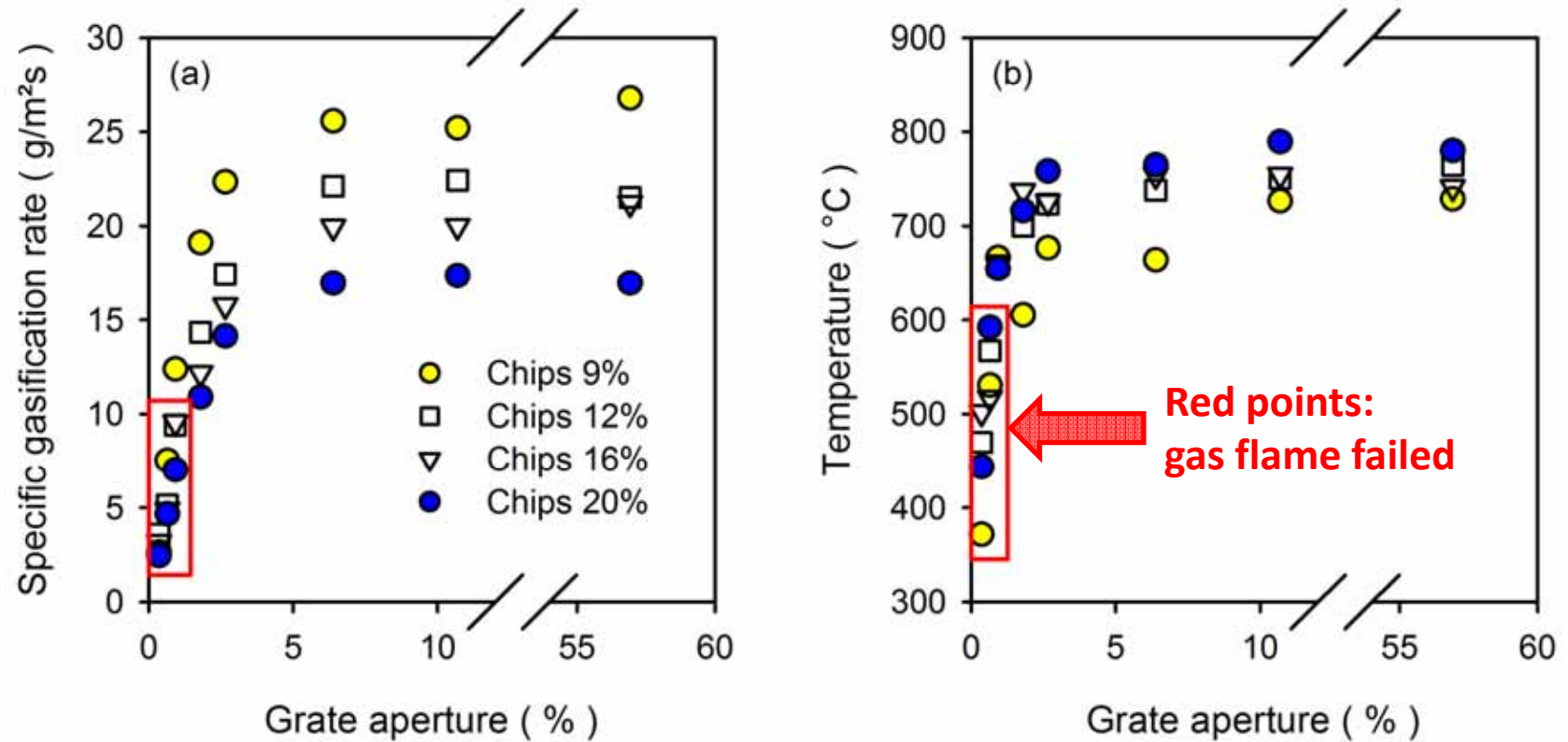
# **FUEL BED TEMPERATURES**

# Softwood Pellets



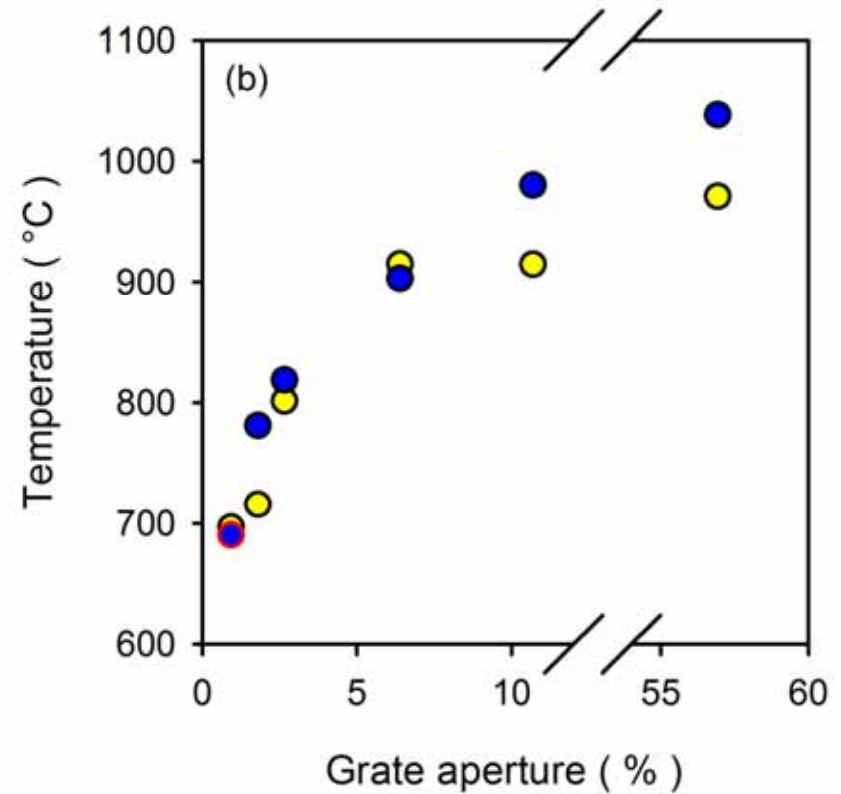
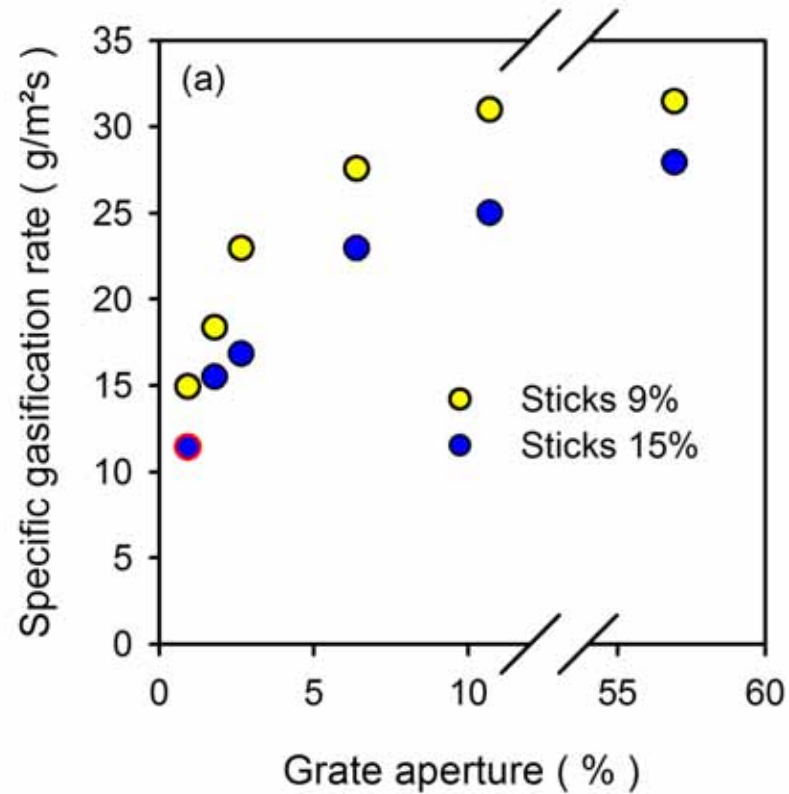
Means of duplicate trials

# Poplar Wood Chips



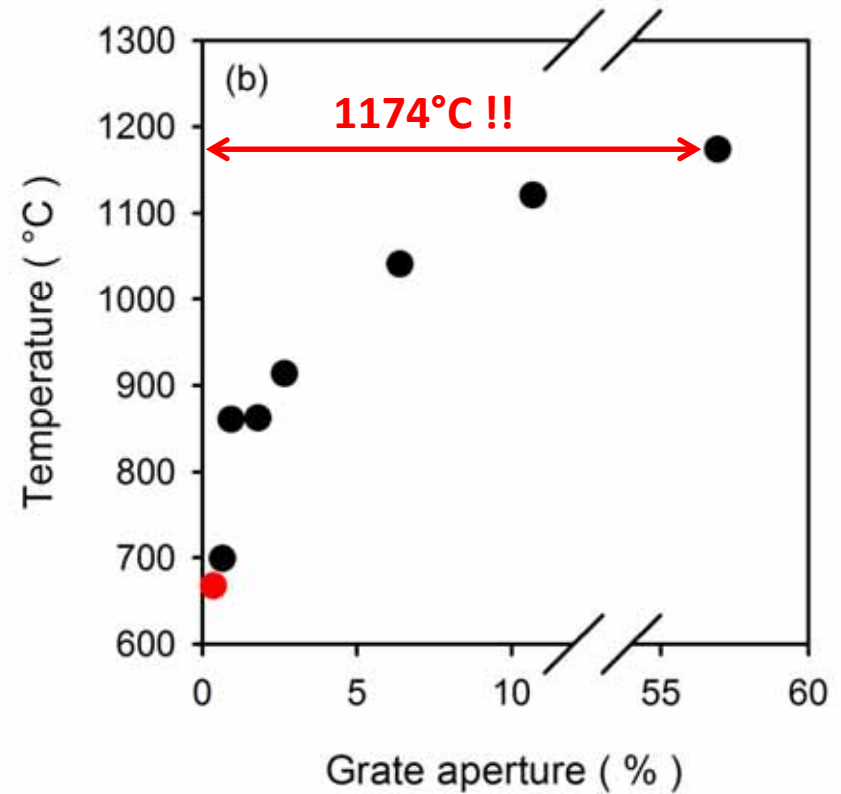
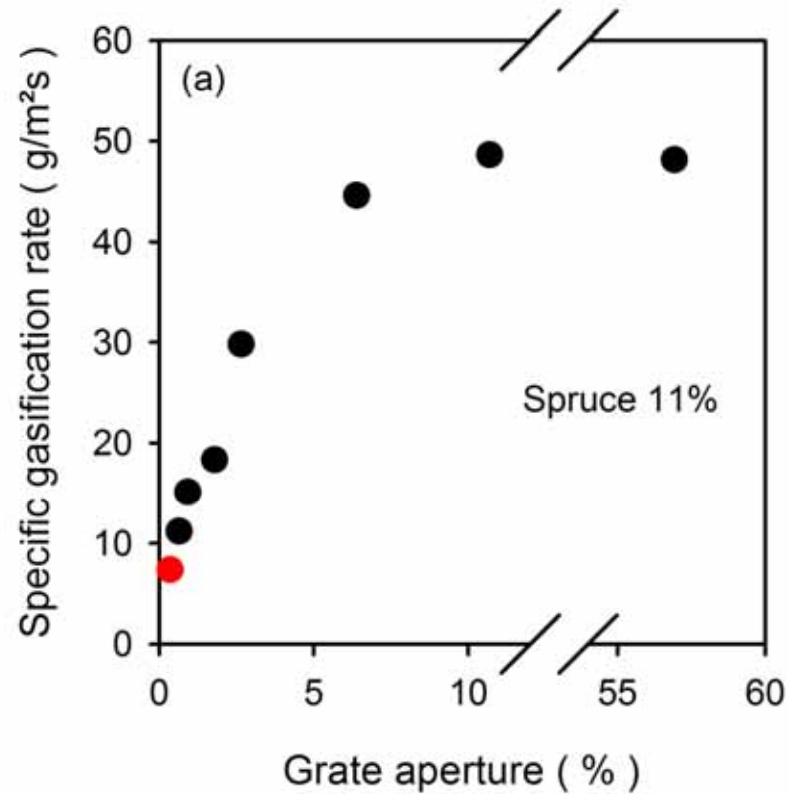
Means of duplicate trials

# Pieces of Hardwood Sticks



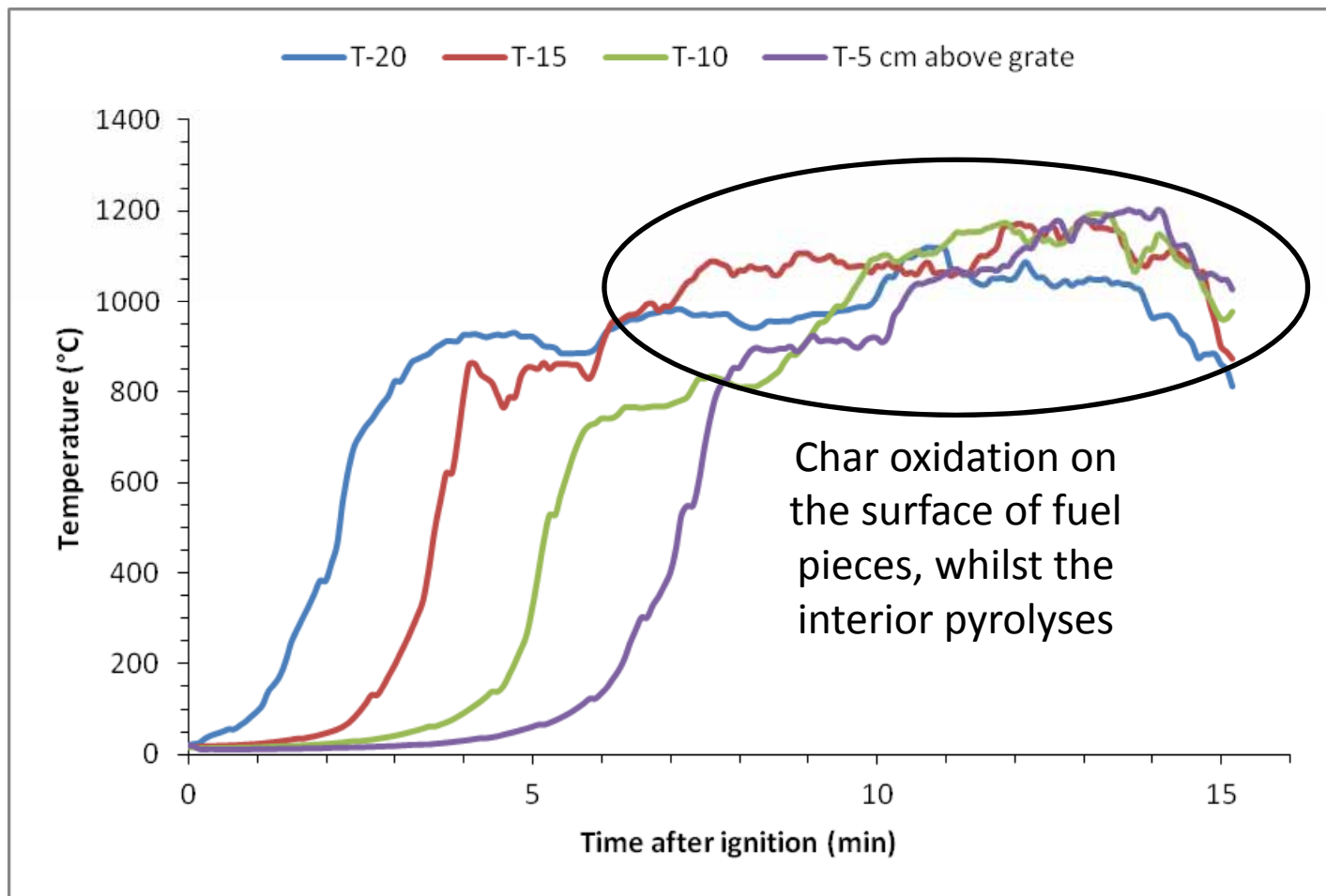
Means of duplicate trials

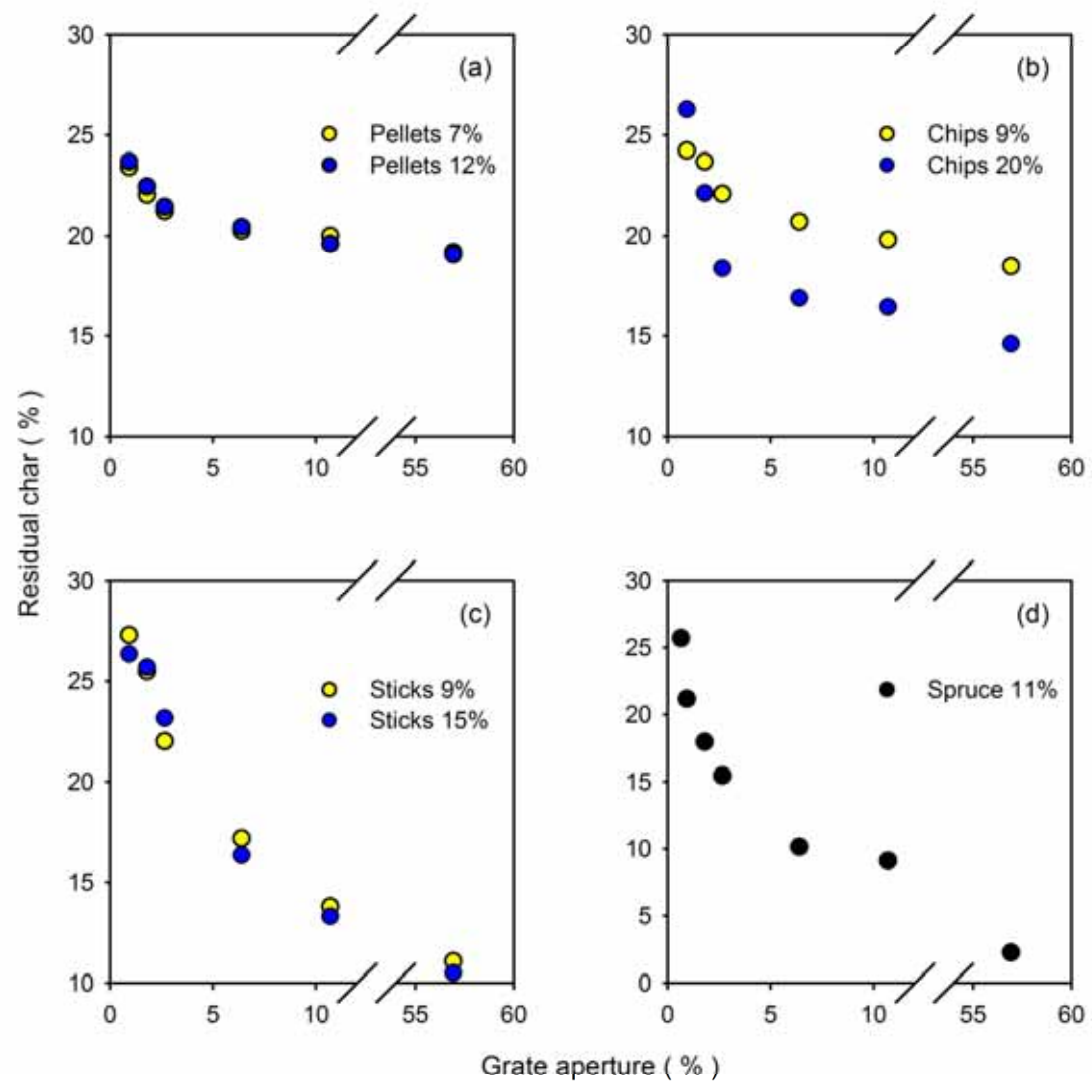
# Vertical Spruce Lumber



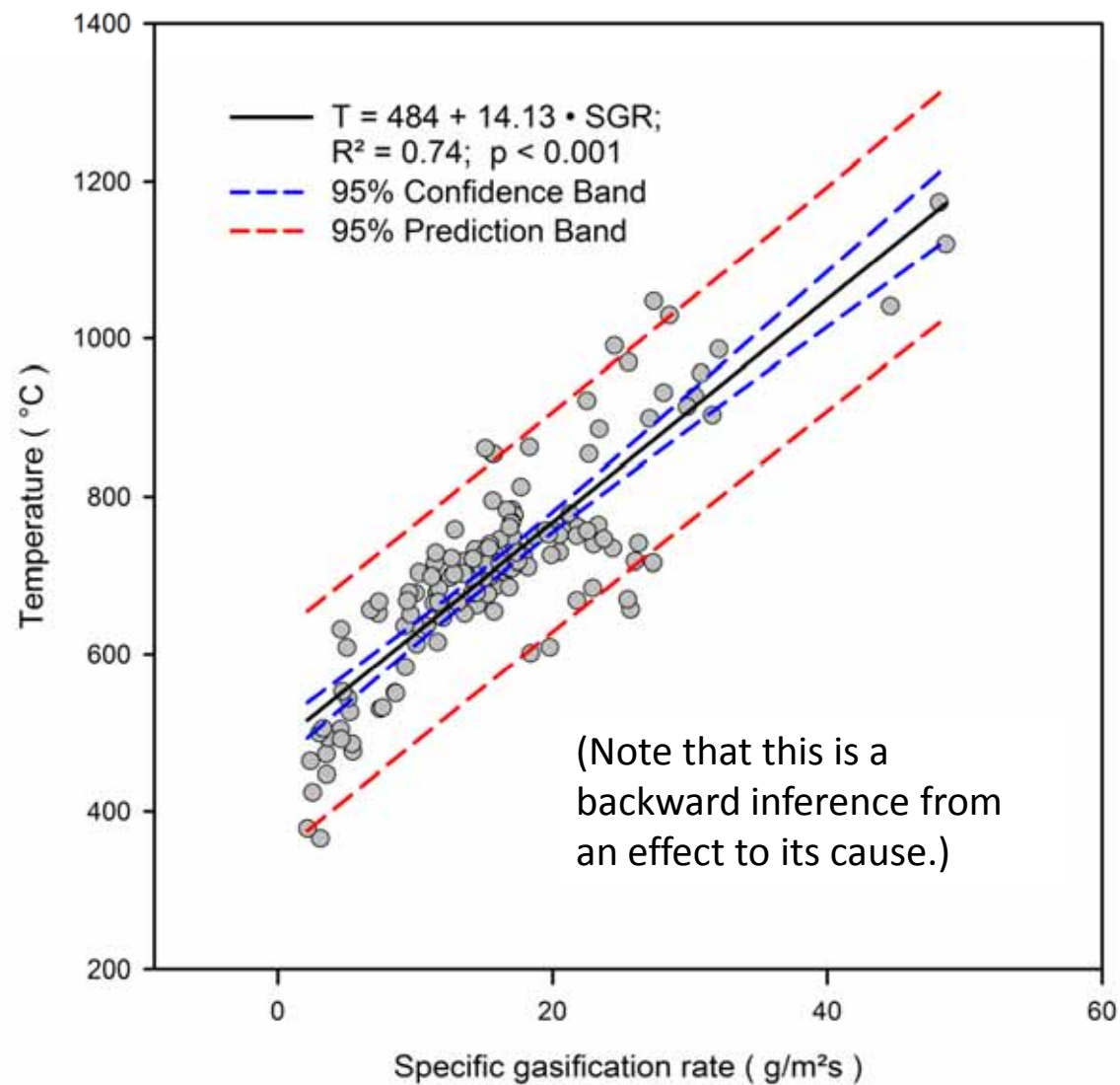
Unreplicated trials

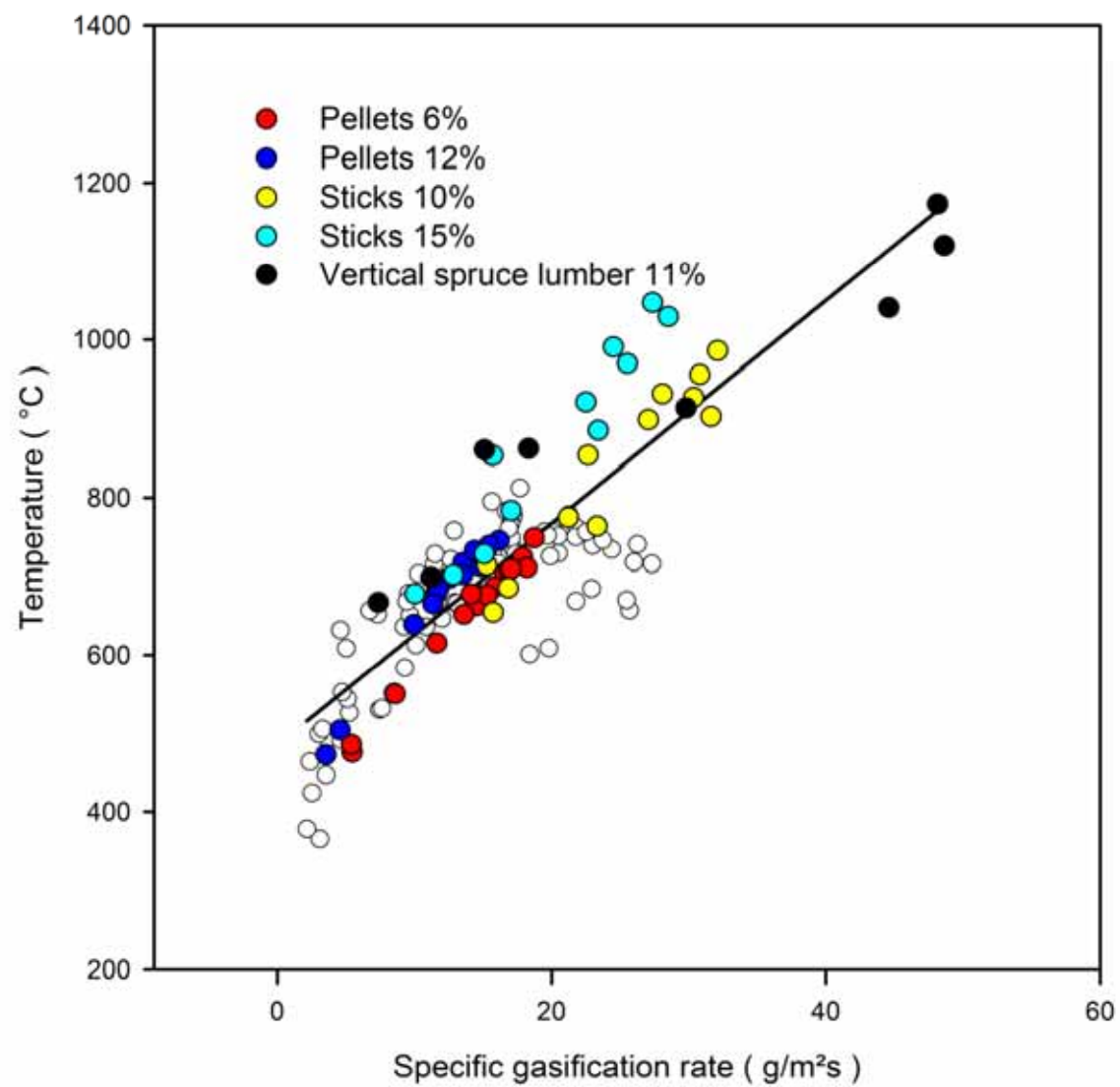
# Vertical spruce lumber gasifying on a 57% aperture grate

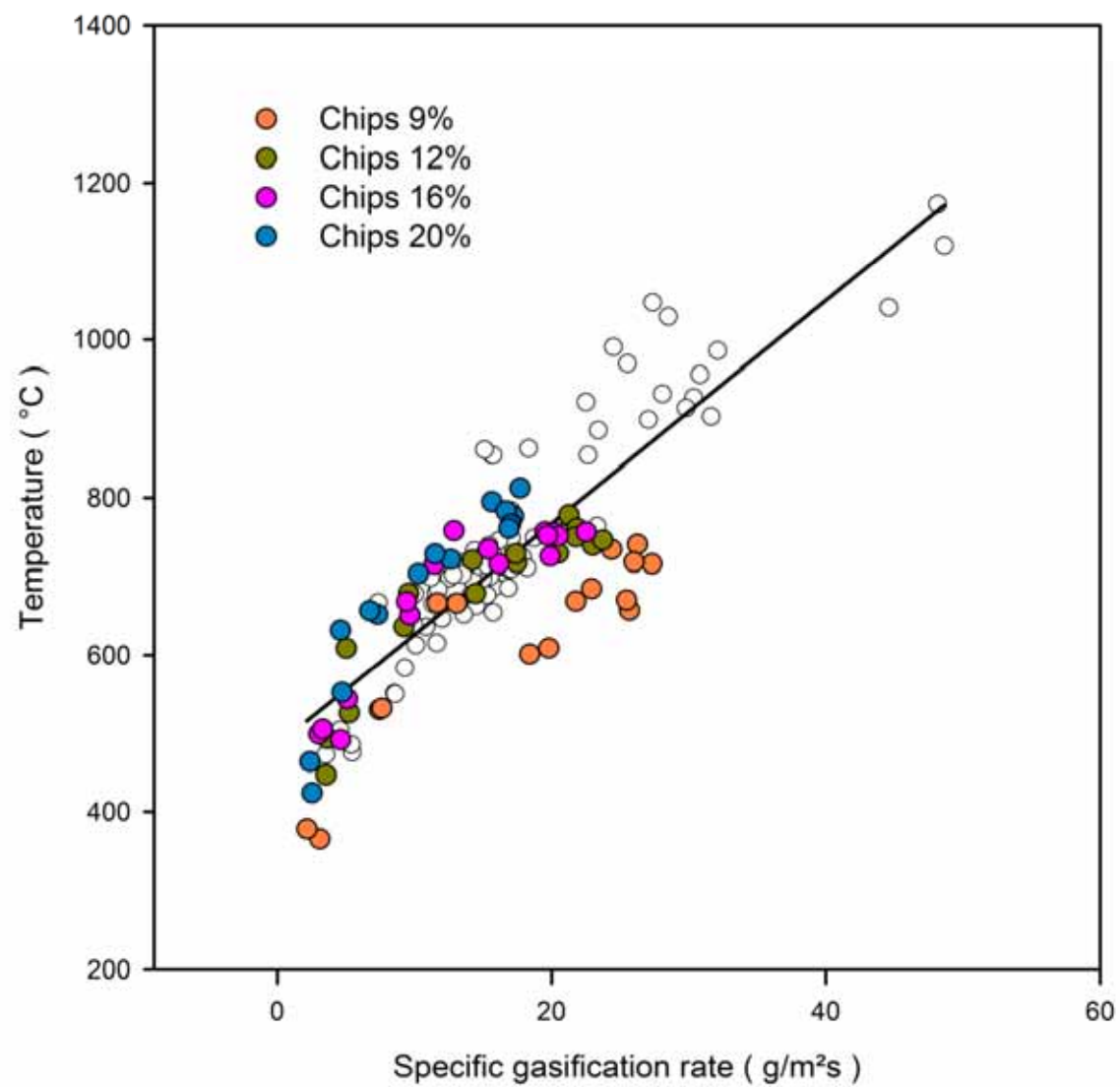












# CONCLUSIONS

# Conclusions

- There is generally a **linear relation** between gasification rate and temperature, because heat drives the velocity reaction front travelling down the fuel bed.
- If we know the gasification rate of a particular fuel, we can **estimate what the maximum temperature was**.
- The temperature for **pellet fuels** falls within a comfortable range of **600 to 750 °C**
- Fuels > 2 cm thick are capable of 1000 °C, and if vertical up to 1150 °C or more, and a **5:1 turndown ratio** of gasification.

# Implications

- Design TLUDs to prevent or withstand temperatures  $> 800\text{ }^{\circ}\text{C}$
- Design burners to function on a wide or narrow range of gasification rates.
  - Presence or absence of constrictions to gas flows
  - Ratio of primary / secondary air flows in response to pyrogas flame buoyancy.
- Need to evaluate biochar safety for PAH and dioxins over the whole temperature range.

- [bioenergylists.org](http://bioenergylists.org) for hosting the “Stoves” discussion group
- Christian Commission for Development in Bangladesh for fostering the Bangladesh Biochar Initiative

## **ACKNOWLEDGMENTS**