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University of Dayton
ETHOS Conference
January 26-28, 2018

TENDING PRACTICES AND THERMAL EFFICIENCY FOR BIOMASS COOKSTOVES

Motivation

- Human Health
- Environmental
- Social Issues

Goals

Can we improve thermal efficiency of biomass cookstoves for free?

Experimental Approach

Three Stone Cookstove

Rocket Works Rocket Stove

BURN J-Stove

- Testing three different stoves while tracking emission trends, thermal efficiency, and firepower through cold start water boiling tests (WBT)

Experimental Approach

- Laboratory Emissions Monitoring System (LEMS)[1]
  - From Aprovecho Research Center, Oregon
  - Includes fume hood capable of tracking flue gas velocity, volume, and mass flow rate
  - Measures
    - CO (electrochemical cell)
    - CO_2 (non-dispersive infrared)
    - PM (gravimetric system for total mass and scattering photometer and laser light receiver for mass concentration)

- Water Boil Test (WBT)
  - Version 4.2.3 from the Global Alliance for Clean Cookstoves[2]
  - Cold start high-power phase
  - Used Douglas Fir as fuel
    - Heat 5 L of room temperature water to boiling from pre-weighed bundle of fuel
- Firepower[2]
  - Measure of a fuels burning rate in Watts
  - Affected by stove, amount of fuel used, and tending practices

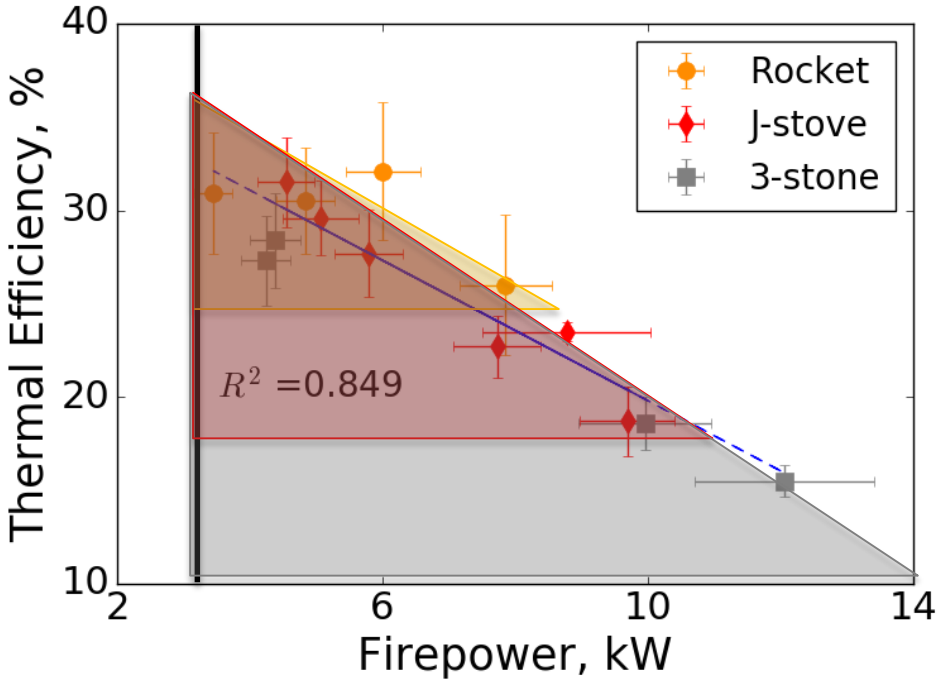
$$= \frac{Dry\ fuel\ consumed\ x\ LHV}{Time\ to\ Boil}$$

[1] "Instructions for Use of the Laboratory Emissions Monitoring Systems (LEMS)." *Aprovecho Research Center.* Aprovecho Research Center. February 2013.
[2] "The Water Boiling Test Version 4.2.3." *Global Alliance for Clean Cookstoves.* United Nations Foundations. 19 March 2014.

Stove Distinctions

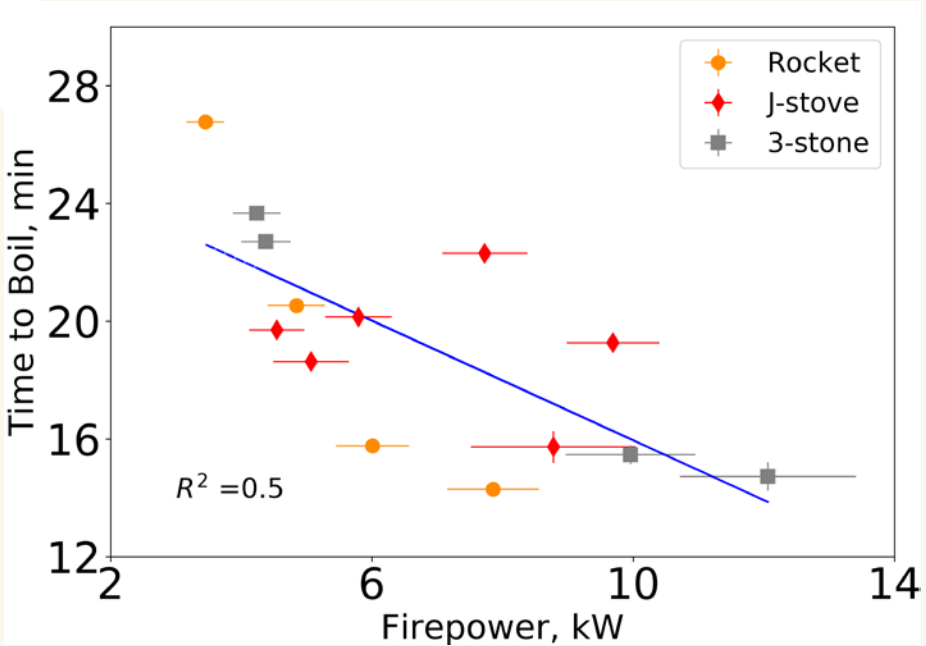
	Three Stone Cookstove	Rocket Stove (Rocket Works)	J-Stove (BURN)
Geometry	NA	L shaped	J shaped
Chimney Height	NA	~6 inches	~12 inches
Insulation	None	Thermal heat shield	Thermal heat shield
Primary Air	Limited	Available under grate	Adjustable, allows for forced air injection
Max Firepower	>12 kW	8 kW	10 kW

WBT Results



- Hypothesis: These stoves are limited by their combustion regimes (geometry has less of an effect)
- Although, geometry affects max firepower

- Time to boil inversely related to Firepower



Conclusions

- Firepower shows strong inverse relationship to thermal efficiency regardless of stove type/operator
  - Preliminary TLUD tests corroborate this trend with TLUD efficiencies following a similar trend
- Stove inlet bounds firepower upper limit

Is there a way to improve tending practices in the field to increase thermal efficiency?

Positive impact on human health, environment, and humanity

Recommendations

- Continued testing to further investigate the relationship between firepower and thermal efficiency in cookstoves using different stoves
- Quantify combustion efficiency
  - Calibration of CO and CO_2 sensors to normalize past tests to determine emissions produced
- Quantify flame premixing and leverage designs with existing technologies with greater aerodynamic flame holding, mixing, and premixing
  - Testing to further experimentally examine the relationship between flame turbulence and stove emissions

Acknowledgements

- Joshua Heyne for advising me on my thesis and the work presented here
- Sari Mira for mentoring me on cookstoves and being a great HEAT lab partner
- Thank you to Rocket Works for being a gracious host to me while in South Africa
- Malcolm Daniels for serving as an advisor both before, during, and after my ETHOS trip
- Financial support for this work was provided by the University of Dayton ETHOS Center and the GAR Foundation

Questions?