Design and Modeling of a Whirl Combustion Cookstove

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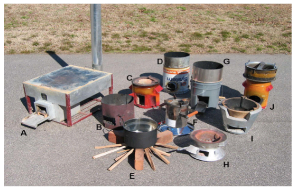
The Issue

•2-3 Billion people use biomass fro their energy needs

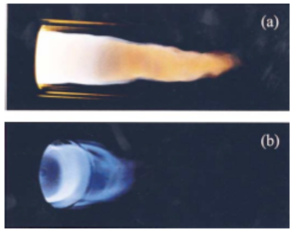
•4,500 deaths per day from indoor air pollution related to cook stoves

•Cook stoves emit 20% of all global black carbon



•Current cook stoves are usually based on the “rocket stove” design
•~$10 stoves are still too dirty
•Better versions exist, but are far too expensive for the developing world

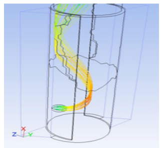
Whirl Combustion



•Tangential fuel injection results in better mixing between fuel and oxidizer, as well as longer residence time in the flue
•The high-efficiency flame has less emissions and fuel consumption
•Completely passive, with no added cost
•However, difficult to achieve with solid fuel

Prototype Design

•Computation Fluid Dynamics (CFD) allowed rapid concept development and geometry changes with little additional cost



•First generation metallic prototype showed physical proof of concept with the most basic geometry

•Second generation metallic prototype introduced a more user-friendly design, as well as modal operation (rocket mode v. whirl mode)

•First generation ceramic prototype translated the design features of the metallic prototype to a low-cost form

•Second generation ceramic prototype solidified the manufacturing process and minimized weight and construction difficulty

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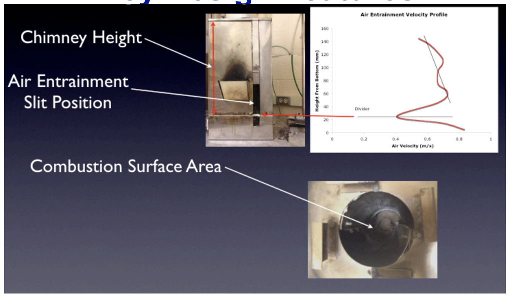
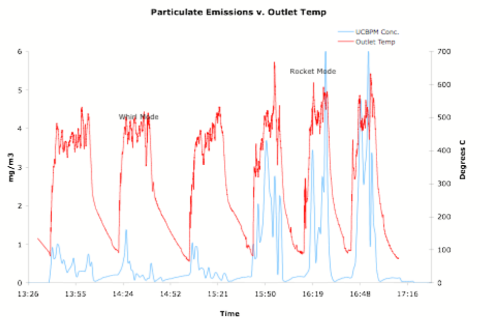
Key Design Features



•Chimney height affects air flow rate
•Slit position determines where air is entrained in relation to the fuel
•Combustion surface area is a main factor in combustion rate and therefore outlet temperature

Output Data



Average:	Whirl Mode	Rocket Mode
Fuel Use	408 g	392 g
Boiling Time	20.7 min	14.7 min
CO Concentration	39.52 ppm	107.12 ppm
Outlet Temperature	450.5^0 C	496.9^0 C
Particulate Emissions	0.37 mg/m^3	2.41 mg/m^3
Normalized Particulate Emissions	0.27 mg/m^3	2.41 mg/m^3

Figure 1: Values are averaged over three boiling tests for each mode, not including the charcoal combustion “cool-down” phase. Particulate emissions are normalized by the ratio of fuel feeding rates between whirl mode and rocket mode.