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Gasifying Rocket Stove

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In the first part of June, the Aprovecho lab was contacted by USAID concerning stoves used in Darfur. I had thought for a long time that a VITA stove, designed by Sam Baldwin in the early 1980's, would be a good refugee stove. Generally speaking, increasing heat transfer reduces fuel use. Increasing combustion efficiency reduces unhealthy emissions. The VITA stove excels at increasing heat transfer efficiency.

The VITA stove is a simple cylinder of sheet metal (with grate) that surrounds a dedicated pot. The cylinder is slightly larger than the pot, creating a small channel (6mm to 14mm depending on pot size) all around the pot. Hot flue gases are forced to scrape against the sides of the pot after touching the bottom. The increased heat transfer efficiency improves fuel used, time to boil, etc. compared to the three stone fire.

In Water Boiling tests done at Aprovecho, the three stone fire used 1118g of kiln dried Douglas fir to boil and simmer (for 45 minutes) 5 liters of water. The VITA stove used 689g.

The three stone fire boiled the 5 liters in 26.7 minutes. The VITA stove boiled the water in 14.0 minutes.

However, the VITA stove produced high amounts of CO (43g during the WBT) and PM (2150mg during the WBT). The benchmarks of performance that Aprovecho uses to help define an improved stove are 20g of CO and 1500mg of PM made during the WBT. (850g of wood used.)

THE VITA saved fuel, was fast to boil but was not clean burning. However, in refugee situations perhaps folks would be more concerned with wood use? If so, then the low cost VITA stove might be an appropriate technology in that situation?

EXPERIMENTS WITH A VITA TYPE STOVE

We spent several weeks experimenting with the VITA stove concept. As can be seen in the following photograph, Aprovecho staff ended up simplifying the VITA stove, only cutting a rectangular fuel entrance in the cylinder. The VITA stove has more air holes under the grate.

We made a four post pot support that is hammered into the ground so it can't move around too much. The pot support is 12cm high above the ground. The posts are 12cm apart so the structure is square. The sticks of fire wood are supported on a bar between the posts holding the sticks 5cm above the ground. There is no grate in the last prototype tested. Sticks of wood burn above the ground, or above an insulating layer of ash.

An adjustable cylinder is made that establishes an 11mm gap between various sized pots. There are 11mm spacers inside the cylinder. Two wing nuts are loosened to adjust the cylinder until the spacers touch the pot. Then the wing nuts are tightened.

The rectangular fuel entrance, which is 12cm long by 9cm high, lines up with the posts and bar of the pot support inside the cylinder. The sticks of wood burn inside the pot support. The air flow is regulated by the size of the fuel entrance and the 11mm channel between the pot and the cylinder. The controlled air flow seems to create a slow burn, resulting in less smoke while maintaining low fuel use.

A metal shelf holds the sticks in position.

Three metal stakes are driven into the ground, attached to the outside of the cylinder. These stakes hold the metal cylinder so that the cook hopefully does not need to touch the hot exterior when vigorously stirring.

We have now run 7 Water Boiling tests of the stove configurations under the emissions hood. In each test the fuel use was as expected but PM was surprisingly low. The ends of the horizontal sticks of wood burn slowly with a darker yellow color compared to the brighter yellow in a rocket stove. The wood seems to be burning in a 'gasification' mode.

The following table shows the results of 7 tests.

Standard Performance Measures		1. Adjustable Vita sitting on Pot Support 2.5L	2. Adjustable Vita 8mm above pot support 2.5L	3. USAID Stove with Grate	4. USAID No Grate	5. USAID Larger fuel entrance Low Pot	6. USAID Larger fuel entrance Low Pot	7. USAID Larger fuel entrance Higher Pot
Fuel to Cook 5L (850)	g	607	532	639	615	553	533	556
CO to Cook 5L (20)	g	22.5	13.8	27.8	28.8	38.3	42.5	23.4
PM to Cook 5L (1500)	mg	439	364	536	386	687	479	415
Time to Boil	min	21.9	21.3	22.8	28.8	18.2	25.9	25.7

Air flow into the open combustion chamber is horizontal forcing the smaller flames to flow together, also horizontally, before becoming vertical. The slower rate of combustion seems to have a beneficial effect on the emissions of Particulate Matter.

Lowering the pot in experiment 5, and to some degree in experiment 6, had a detrimental effect on production of PM and CO. Raising the pot in experiment 6 lowered both PM and CO. Further testing is planned.

CONCLUSION

It seems possible to create low PM and low fuel use in a modified, adjustable VITA stove. The combustion is reminiscent of Gasifier stoves because the rate of burn is slower and flame color is darker. This type of slower combustion seems to produce lowered emissions of PM. However, CO is relatively high in all 7 experiments. The fuel use is lower than a standard VITA type stove, as measured during the WBT. However, time to boil is quite a bit longer.