**Notes on experiments with a**

**Wonderwerk Test Stove**

Aprovecho Woodstove Research Center

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**Turn-down**

* The primary air is adjusted for turn-down. Reducing the secondary air is not necessary. The draft will adjust automatically to bring in whatever air is needed.
* It is best to have a single adjusting lever that adjusts everything. The test lever lets the hand move 4 times the amount of the air control. This can give good control at low power.
* The adjusting device should have a fine adjustment for lower power levels and a course adjustment for high power levels.
* Be certain that the adjusting device adjusts the full range for the flame and that no internal constriction cuts off the high end. Difficulty getting a high flame could indicate an internal constriction.
* A layer of insulation lining the inside of the outer shell of the stove, which allows the secondary air to rise next to the fuel/reaction chamber keeps the gasses and air hot, and helps improve turn-down.
* The low power flame requires that there be less restricted air flow than the high power flame, which has more draft to drive it. Anything that restricts wood gas or flame gas flow, such as a wick, Venturi tubes, pot gaps, or stationary fan must be designed with both high and low power needs in mind.
* The gap between the pot and the pot stand can be adjusted to let more or less hot exhaust pass. Releasing more will slightly reduce the heat into the pot, but will mean that for low power the stove will not need as much turn-down.

**Burner wick**

* The wick provides a stable place for the portion of wood gas not burned in the pilot flames to be burned. The pilot flames and wick flames together form the low power flame.
* The wick pushes much of the wood gas from the center to the edges for improved mixing.
* The flame must be primarily on top of the wick, which can be accomplished by placing the pilot flames above the wick. If too much secondary air gets below the wick, it will descend to the char. Here it either burns char creating an excess of CO, or dilutes the wood gas putting the flame out. Holes in the reactor wall below the wick do not help the low power flame, and can reduce the turn-down that is possible.
* Radial slits are better than drilled holes for mixing the gas and air. Secondary air travels up the space between the slits and feeds air to all of the gas passing through the slits from two sides giving excellent mixing. Round holes cannot do this.
* The wick must leave space through its slits and around the edge for the wood gas to pass for both high and low power.
* Attach the wick to the combustor for convenient use. It will be protected by the combustor legs. Doing this will avoid the cook having to deal with it.
* The wick must be mounted symmetrically, tilted or off center does not work.
* On low power the wick must be conical or domed to match the angle of the pilot flames. The pilot flames will move up the surface of the wick and ignite any gas coming through the slits. Air for this is supplied by the secondary air system.
* The center of the wick must be solid to force the wood gas out to meet the pilot and secondary air.

**Pilot flames**

* The pilot flames should be located slightly above the wick and below the secondary air entrance.
* The test stove has eight ¼” pilot holes with two 1/8” connecting holes aligned in the spaces between the pilots. This gives a good path for relight if some of the pilot flames go out.
* The flame moves to the pilot holes on the lowest flames. On the lowest power levels, theses flames are surrounded by orange flame from the mix of secondary air and wood gases that get past the pilots.
* The pilot flames ignite any gas which passes through the radial slots on the wick.
* There appears to be three burn locations for the low power flame, 1. The pilots; 2. Around the pilots for wood gas that rises between the wick, wall, and pilots; and 3. On the wick slits for wood gas that rises through the slits. These provide thorough mixing and burning which explains why the low flame burns so clean.

**High power emissions**

* Use appropriately sized openings for a proper air to gas ratio.
* Adjust the late secondary air in the combustor Venturi pipes to a proper amount. A little well mixed air can do a lot to clean the flame for tier 4.
* The wick design pushes gasses to the outside for better mixing with the pilot and secondary air. The radial slits in the wick give more open space for gasses to pass so as not to cause a flow restriction.

**Low power emissions**

* The wick design with radial slits gives good mixing.
* Provide a very small amount of late secondary air at combustor Venturi tubes.
* Creosote deposits on the reactor wall can plague low power use. They can create a plume of smoke even after the stove is emptied. Burn the char until the smoke stops at the end of each low power usage to burn any creosote deposits off the reactor wall.

**Fuel use**

* Insulate any heat loss areas on the stove and combustor.
* Cover the ends of the Venturi tubes with reflective material to reflect heat back into the stove leaving a small opening around the sides for air to enter.
* Do not use any device, such as a pot stand or mounting bracket, which conducts heat out of the stove. Rather use a device which insulates the hot interior from the outside. (Untested: Insulating a heavy cast iron pot stand outside the stove will keep it from conducting heat out of the stove. It will keep the stand hot and may increase radiant heat into the cooking surface.)
* Increased heat retention will increase the draft, the gas velocity, the gas impact on the cooking surface, and the heat transfer into the food.
* Properly size the gaps around a pot.
* Good insulation will improve the heat available for the food, reducing fuel use.

**Safety**

* Insulation to keep the heat in the stove also helps make the stove surface cooler and reduce user skin burns.
* A shorter and wider free standing stove is safer than a tall one. A tall stove will need a wide base or bracket to keep it from tipping.
* Burning as much of the particulates and carbon monoxide as possible improves both efficiency and safety.