Stove Testing in Tajikistan – December 2015

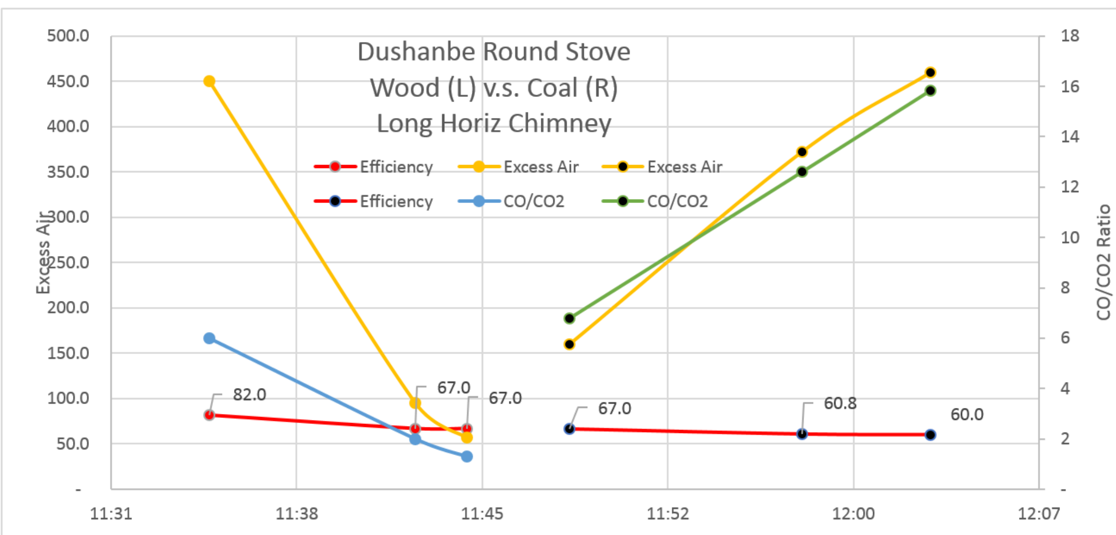
A peri-rural village was visited and the senior householder interviewed. The homestead has five heating and cooking appliances: three coal/wood stoves and two LPG cookers in an outdoor kitchen. The three solid fuel stoves are:

A shower room with a small stove used for heating water and warming the room. The owner said it was not a very good stove.

In a guest meeting room there is an old cast iron Russian stove which was in poor condition. It is used to heat that room only and cannot realistically cook anything. It has a chimney that passes through the ceiling and then the roof.

In the living room where the family spends quite a lot of time, there was the 'main stove'. It was locally made (artisanal) from thick, scrap pipe from the district water heating system. It is connected to a vertical chimney about 1.8 metres high which connects by an elbow to a 7 metre long horizontal chimney leading out of the house. There is no vertical portion after that – the exit is horizontal.

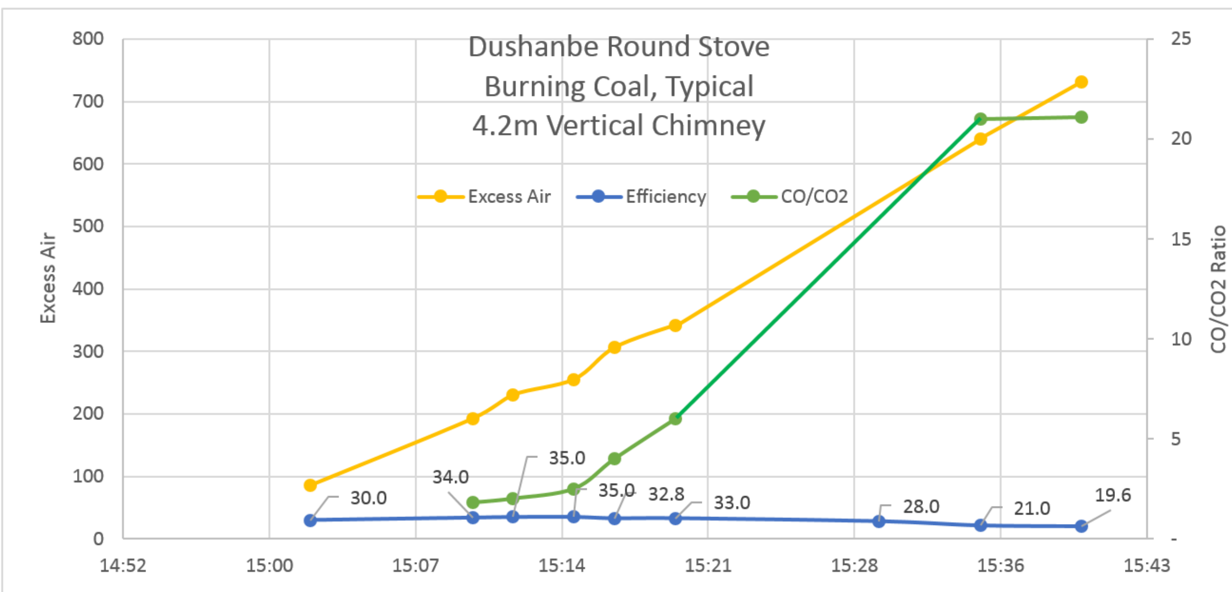
Figure 1: The locally made stove with the long horizontal chimney tested with wood and then coal.



As expected, the efficiency when the stove was cold is very high because there is little heat from the fire leaving the home. After ten minutes it settles down to about 67% efficient when fuelled with wood. As can be seen on the left set of lines, the CO/CO_2 ratio (blue) drops rapidly as the excess air ratio (yellow) drops. This indicates that there is too much air getting into the stove. There was no opening to the fire chamber – all the air getting into the stack comes from below the grate. As the fire grew in intensity and used more of the air, the excess air volume (not needed for combustion) dropped from >400% to less than 60% which is dangerously low. Even when the air was in short supply, and the exit temperature was a modest 131°C, the efficiency was no higher than 67%. This indicates the heat exchanger area was not large enough, even with a very long chimney. The burn rate increased, using the available oxygen, but the stove could not deliver the heat into the room.

We then switched to coal by adding about 1.5 kg to the fire. The immediate response was for the CO/CO_2 ratio to jump up to 6.8%. As the flaming pyrolysis stage started, the stack temperature started to drop. This would normally indicate an increase in efficiency however as the burn progressed, the volatiles burned out and the excess air climbed. In that condition the efficiency drops. The combustion efficiency, using the proxy of the CO/CO_2 ratio, rose higher and higher as the combustion conditions deteriorated. There is a strong correlation between the CO/CO_2 ratio (green with black markers) and the level of excess air (yellow with black markers). The cause is the chilling of the fire. The coal cannot burn at the same rate as the wood. As the heat dies down, the excess air overwhelms the benefit of a higher heat density in the fuel. The result is a drop in efficiency, in spite of the long chimney pipe.

Figure 2: The same stove as the one in the house, tested with a standard 4.2 metre chimney.



The first noticeable number is the very low heating efficiency: 30%. As the fire developed it rose to 35% and then, as can be seen with the yellow line, the excess air rose continuously. After about 15 minutes the CO/CO2 ratio rose above 3%, the losses from CO stated to jump. The rapid rise at 15:14 is a combination of cooling excess air and the increased loss of energy in the form of CO. The fire was then set into “night time mode”. The efficiency continued to drop settling at less than 20%. The major reason was high excess air leaking into the stove through all joints. There is no combustion chamber per se, just an open space. The burn rate in such a stove is very low and it doesn’t take much leakage to take the heat outside.

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