THREE-BURNER RICE HUSK GASIFIER STOVE FOR SMALL RESTAURANT AND FOOD CATERING SERVICES

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Thanks be to God!!!

With the continued effort of CNC on developing gasifiers using rice husks as fuel in gasified form, a rice husk gasifier stove for small restaurants or “carinderias” as well as food catering services has recently been developed. A low-cost and clean fuel is becoming a major concern of traditional food service enterprises, particularly those who prepare food on roadsides to cater commuters/travellers. Aside from these business enterprises, food catering for parties and fiestas are having the same concern. A three-burner rice husk gas stove designed for this particular market niche was recently developed. The stove, as with the other gasifier models, uses rice husk as fuel in gasified form but with three controllable burners to regulate flame intensity in each burner during operation. The blower that supplies the needed air to gasify rice husks can be energized by using the grid or by using a battery. This development was undertaken by Carbon Neutral Commons (CNC) to provide rural people in the developing world a technology that utilizes biomass wastes, like rice husks, as source of clean fuel while, at the same, sequestering carbon and enhancing soil restoration.

Figure 1. Pictorial View of the CNC Three-Burner RHGS for Small Resto and Food Catering Services.

The rice husk gasifier, as shown in Figure 1, has a 30cm-diameter moving-bed downdraft-type reactor where rice husks are gasified with limited amount of air producing combustible gases that are rich in carbon monoxide (CO), hydrogen (H_2), and methane (CH_4). The design is a slightly small version of the cottage-industry-size stove which was also recently developed by CNC. Instead of two 20-cm burners as in the cottage-industry type, this stove has three 15cm-diameter drum-type burners attached to the gas storage pipe. The pipe helps in minimizing gas flow effect to the other burners when one is switched Off. The gas storage pipe has 3-inches diameter and is relatively bigger in size than those used for other multiple burner stoves. Also, a water-dousing device is provided for the reactor to immediately quench the burning char preventing it from further combustion thus not turning into ash. A 2½-in. electric blower, which can be energized by a 12-volt 100-AH battery with the use of an inverter, is used for the reactor to supply the required amount of air for the combustion of the rice husk fuel. The hopper, on top of the reactor, serves as feeding inlet for rice husks and the rotating sweeper at the char chamber gradually discharges char by dropping it into a water-filled bin to immediately quench the combusting char. To start the operation, rice husk fuel is lit from the bottom of the reactor. The fire zone formed after the ignition of fuel moves upward of the reactor. Continuous operation of the stove is sustained by maintaining the fire zone at the middle of the reactor. The gas produced exits from the reactor via an exit pipe passing through the particle separator that separates large char particles from the gas stream before the gas enters the burner. The gas released in the burner is lit to provide the heat needed for cooking. Each burner is provided with a valve to facilitate control of gas flow to the burner by turning the valve clockwise or counterclockwise.

Table 1. Stove Performance.

Start-Up and Gas Generation Time	10 - 17 min
Fuel Consumption Rate	12.40 – 16.96 kg/hr
Time to Boil 3-6 liters of Water	30 – 38 min
Water Evaporated	4.83 – 5.5 liters
Power Input	44.63 – 61.06 kWt
Power Output	9.52 – 13.17 kWt
Specific Gasification Rate	98.71 – 135.03 kg/hr-m^2
Overall Thermal Efficiency	21.33 – 21.57%

The performance of the stove is shown in Table 1. The stove produces combustible gases within 10 to 17 minutes from the time the igniter, e.i., rice husk premixed with kerosene, was lit at the ignition ports. During the test, the blower was set at minimum in the start-up and was fully opened when presence of combustible gas was observed in the burners. Three 25cm- diameter kettles without lid containing 6 liters of water each were used to determine the boiling time and the amount of water evaporated during the test period. Results showed that the fuel consumption rate of the stove ranges from 12.40 to 16.96 kg/hr, giving a 98.71 to 135.03 kg/hr-m^2 gasification rate. It takes 30 to 38 minutes to bring the three 6-liters water to a boil with 4.83 to 5.50 liters water evaporated after each test.

Table 2. Compositions and Heating Value of the Gas Obtained from the Gasifier Stove.

CO_2	19.26 - 20.16 %
CH_4	3.3 - 4.96 %
H_2	10.7 - 9.13 %
CO_2	12.48 - 13.3 %
CnHm	0.09 - 0.21 %
O_2	0.51 - 0.38 %
Heating Value	1195 - 1308 kcal/m^3

Based on the rice husk fuel consumed, the computed power input of the stove ranges from 44.63 to 61.06 kWt; while the power output from the heat energy used in boiling and in evaporating water ranges from 5.52 to 13.17 kWt. With these values, the computed thermal efficiency of the stove ranges from 21.33 to 21.57%.

Subsamples of the gas produced from the gasifier were taken during the test and were subjected for gas analysis using the Gasboard 3100P Gas Analyser. The percentage composition of gases is shown in Table 2 above. Combustible CO ranges from 19.26 to 20.16% while CH_4 and H_2 range from 3.3 to 4.96% and 10.7 to 9.13%, respectively. The heating value of the gas generated ranges from 1195 to 1308 kcal/m^3.

The temperature profile of boiling three 6-liters of water in three separate kettles is shown in Figure 2. The temperature of boiling water was measured using bimetallic thermometers. As shown, the 6-liter water comes to a boil within 30 to 38 minutes. It was observed, however, that burner 2 boils faster the 6 liters of water than burners 1 and 3. The temperature profiles of the gas leaving the reactor and the flame underneath the kettles, on the other hand, are shown in Figure 3. Measurements were done at the same time using Type-K thermocouple wire attached to Extech Digital thermometer. As shown, the temperature of the gas leaving the reactor ranges from 200° to 260°C while the temperature underneath the kettles ranges from 500°C to a little above 600°C.

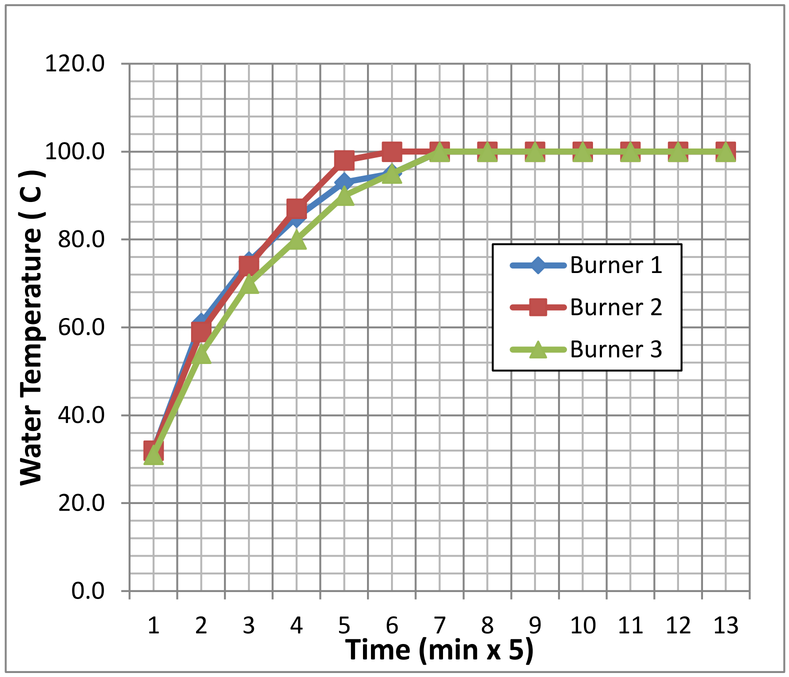

Figure 2. Temperature Profile of Boiling Water in the Stove.

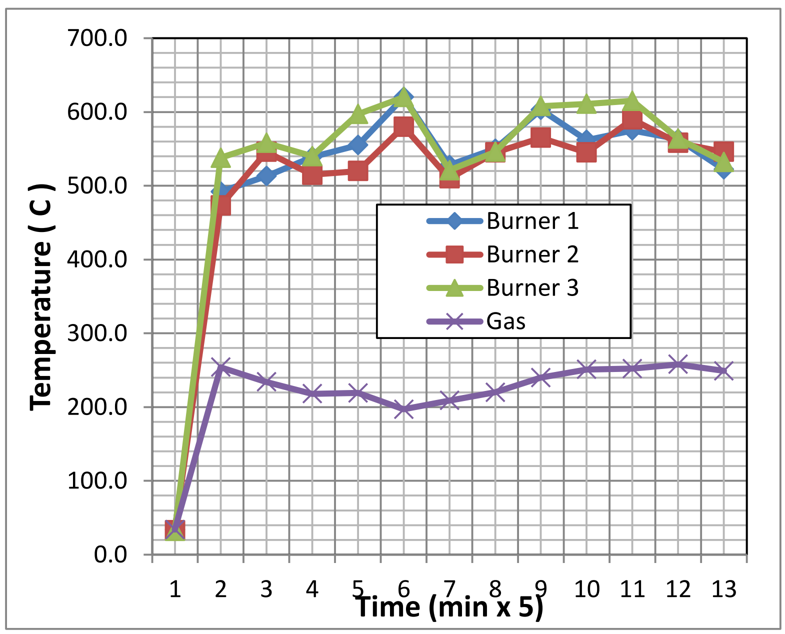

Figure 3. Temperature Profile of the Gas Leaving the Reactor and the Flame Beneath the Pots.

Furthermore, the thermal image of the stove during the test is shown in Figure 4 at the right. Thermal image reveals the hottest parts of the rice husk gasifier can be found in the reactor where the fire zone is located and in gas burners.

Figure 4. Thermal Image of the Stove During Operation.

The stove can be operated by one person who will do the loading of fuel into the hopper and the removal of char from the char bin. Wet char can be manually disposed from the char bin into a plastic sack or into a bucket using a screen-equipped scoop. The operator needs to be trained and have thorough understanding on the operation of the stove to properly attain continuous operation.

The stove can be fabricated using local skills and materials. The electric blower together with the inverter and the battery are readily available locally. The cost to produce the stove largely depends on the prices of materials and on the cost of labor in a particular locality. The stove, however, can be redesigned to further improve and reduce the cost, if needed. The benefits that can be derived from using and/or producing this stove are: (1) energy cost savings to small restaurants or catering service enterprises; (2) added income to local shops; (3) production of soil-amendment char that can improve quality of soil in the farm; and (4) helps in sequestering carbon from the atmosphere back to the soil.

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